

Survival of the Unfit

Path Dependence and the Estonian Oil Shale Industry

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This thesis is based on work conducted within the interdisciplinary graduate school Energy Systems. The national Energy Systems Programme aims at creating competence in solving complex energy problems by combining technical and social sciences. The research programme analyses processes for the conversion, transmission and utilisation of energy, combined together in order to fulfil specific needs.



The research groups that participate in the Energy Systems Programme are the Division of Solid State Physics at Uppsala University, the Division of Energy Systems at Linköping Institute of Technology, the Department of Technology and Social Change at Linköping University, the Department of Heat and Power Technology at Chalmers University of Technology in Göteborg as well as the Division of Energy Processes at the Royal Institute of Technology in Stockholm.

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1. Introduction

1.1. Survival of the unfit?

In the last few decades the claim that technology is a product of underlying values in society has gained wide support. This position certainly contains a nucleus of truth, but the striking similarity of technological principles all around the world does, after all, point in another direction. Societies differ, but technology remains basically the same. Nevertheless, there exist examples of technologies differing from the mainstream. Such technologies are usually closely related to the overall technological paradigm and the differences are of no greater magnitude than that anyone even remotely familiar with technological principles can understand them.¹ One could claim that even though dominant technologies may not be the best ones in any objective way, they probably remain the best, or perhaps the easiest choice almost everywhere, simply because they exist. Therefore such technologies are being developed on a global scale and as a result, there exists a global pool of knowledge, which everyone can draw upon. Not being a part of this technological mainstream will give rise to problems, such as for instance where to obtain new knowledge from. Of course, knowledge can be produced locally, even in isolation, but this will lead to higher alternative costs, sometimes forbiddingly high.

Assuming that dominant technologies are the products of path-dependent processes, i.e. that they are not necessarily superior to alternatives, but remain unchallenged because they exist and are developed, we might ask whether such path dependent processes would apply to minor technologies as well. Therefore, once applied locally, a minor technology might simply phase out a globally dominant technology because of short-term gains, but thereby also causing a lock-in into such a technological strand.

The underlying thought here is, of course, that following the rest of the world is the easy option, and for any small actor sticking to such a path implies that gains can be shared

¹ Wright (1997) discusses a few relatively recent approaches to this topic, but is apparently not making a difference between artifacts and technology as a whole. It is definitely true that there is national specialization in particular products, but at the same time there are no signs of any technological trajectory other than the “mainstream”. For example, throughout the globe automobiles use oil derivatives as their fuels, even if there are some other differences between, say, European and American cars. But there is no society which would rely on steam-powered automobiles, which would certainly be an example of a different technology.

through the diffusion of technology, while setbacks in the global technological mainstream become almost a *force majeure*. Going one's own way is much riskier, especially for a small actor.

I set out working on this thesis with one all-encompassing, but rather vague question in my mind, namely is it possible to find a convincing example of a technology which differs from the mainstream, but which at the same time can be shown to be resistant to fundamental changes in the society, thereby serving as a proof that the development path of technology can be stronger than forces pulling towards the mainstream, at least in that particular case? I found such a case close to my previous professional experience. Between 1995 and 1997 I was employed by the Organization for Security and Cooperation in Europe (OSCE) in Narva, Estonia. Although I was mainly dealing with social issues, I got in touch with the local energy industry, which is based on oil shale. This industry, I soon understood, was more or less unique on a global scale. Being familiar with the extremely turbulent modern history of Estonia, it came to my mind that the Estonian oil shale industry would serve as an almost perfect case study of what a path differing from the technological mainstream would imply. I should stress that oil shale is a fossil fuel and in this respect Estonia is well embedded in the fossil fuel paradigm that holds a strong grip over the contemporary world. But within this paradigm, Estonia is different and has remained so for almost 100 years. This study will also have a certain characteristic of a historical study of the Estonian oil shale industry, which to my knowledge has not been done in modern times.² Having said this, I want to emphasize that writing a comprehensive history of the Estonian oil shale industry is not the primary task of this work.

Studying the dynamics of the Estonian oil shale sector is made particularly interesting by the fact that the institutional arrangements of Estonia have varied more than those of most other countries (at least in Europe). During the 20th century Estonia experienced industrialization, wartime economic conditions during WWI, the birth of an independent state in the aftermath of WWI, the liberal 20s, the patronage of the nationalistic 30s, the disastrous WWII, Stalinist repression, Soviet stagnation and finally from the 1990s onwards one of the freest market

² There exist several works on some particular aspects of the oil shale industry or historical analyses on various periods, but to my knowledge no comprehensive history of the entire industry from its creation to this day.

economies in the world.³ Thus we can observe a uniquely changing institutional surrounding, with at least three major breaks in the institutional development – independence after WWI, the Soviet occupation after WWII and finally re-independence accompanied by a very radical economic reform in the early 1990s. In addition to these path-breaking points in history there were smaller ones (which would most likely be considered revolutionary in a society with more benign historical experiences) such as the authoritarian take-over in 1934, the thaw after Stalin’s death in 1953 or the stagnation gradually beginning in 1964. I am setting out to claim that technological path dependence is – at least in this case – stronger than the combined effects of the institutional convulsions listed above. In brief, it is likely that institutional convulsions actually leave enough space to maneuver for a technology that otherwise would be forced to retreat from the scene, because under peaceful circumstances, such space is often absorbed by stronger actors. Against this background it is hard to agree with Paul Hirsch and James Gillespie, when they claim that:

“Stable technological trajectories are usually identifiable only because enough of the rest of the world is stable. If too many environmental arenas are in flux, there may not be enough stability to sustain technological progress.”⁴

But it is far easier to agree with the continuation of their reasoning:

“If not enough environmental arenas are in flux, excessive stability may stifle technological progress. Yet, in terms of stability, to the extent that path dependent outcomes are suboptimal, they do contain the seeds of their own destruction.”⁵

There are good reasons to claim that creating an industry around oil shale represents an inferior solution. It is environmentally hazardous, it has repeatedly experienced difficulties in gaining economic viability against competing sources of energy and raw-materials (such as crude oil) and, in the case of Estonia, there is no large global network of oil shale industries from which to draw experience. It can be argued that even for Estonia, oil shale is far from an

³ According to the Fraser Institute’s “*Economic Freedom of the World: 2007 Annual Report*”, Estonia is ranked number 8 in economic freedom in a comparison between 141 countries. No other ex-socialist country can be found close to Estonia in this comparison. Of course, one can always object to such rankings, but the fact is that Estonia usually gets a position close to the global top in all attempts at classifying economic freedom. The Fraser Institute’s report can be found at <http://www.freetheworld.com/release.html> (accessed on September 21, 2007).

⁴ Hirsch & Gillespie (2000) p. 83.

⁵ Ibid.

optimal solution. On the contrary, oil shale is oftentimes even referred to as Estonia's curse, especially for geopolitical reasons. But despite this, the industry, once in place, has several times been a sort of a refuge for Estonian science and technology (and for scientists and engineers personally) and a guarantor for uninterrupted electricity supply. In today's Estonia there is a sense of confusion as to how to proceed with oil shale and the topic is constantly high on the political agenda without anyone actually suggesting any far-reaching changes. For an outside observer the seemingly endless but rather unfruitful Estonian debate on oil shale is an indicator as good as any of a society divided between the impressions of being tied up to something that is at the same time both a lifeline and a threat.⁶

Thus, the main purpose with this thesis is to explain why an industry afflicted with numerous seemingly insurmountable problems has not only managed to survive (and is at least at present doing rather well) but done so in an extremely volatile institutional environment. When the Estonian oil shale industry is put into the context of the developments of the Estonian society, it has so far successfully been able to defend its place, contrary to most oil shale industries worldwide. In the academic debate on path dependence it is asked why and how inferior technologies can not only survive but even thrive. Others claim that such phenomena are basically illusions. I will argue that what appears to be an inferior path might, seen from another angle, actually be perceived as an adequate solution, at least temporarily. But this temporary perspective is what makes all the difference. Furthermore, the survival of the Estonian oil shale industry has been a result of its capacity to create variety in production technology, end products, and ownership structure, paradoxically even during the Soviet years. This variety has provided the oil shale industry with a certain inherent dynamism, which, I will claim, has been the key to its survival.

One particular objection should be addressed immediately; namely that Estonia utilizes oil shale simply because it is there, while there are few other energy resources. Many countries throughout the world possess oil shale deposits that are by far bigger than those of Estonia. Most of these countries are also net importers of various types of energy, especially oil. Regardless of this fact, nowhere has oil shale been used on such a scale as in Estonia. Therefore the very existence of oil shale is only a necessary condition for the establishment of

⁶ For instance, in August 2007 the Estonian parliament convened to an extraordinary session to discuss energy policy. In the words of the parliamentarian Jürgen Ligi: "It can't be overemphasized that oil shale energy is problematic, but giving it up is beyond our capacity", www.postimees.ee, August 13, 2007.

an oil shale industry, but it does not suffice as an explanation as to why Estonia has constructed an energy system dependent on oil shale. One chapter in this work takes a closer look at the failed Swedish oil shale industry in order to provide a case where the actual existence of oil shale does not guarantee survival of the industry.

In Estonia, oil shale was developed for a number of reasons and the oil shale industry always found its niche under highly volatile circumstances. The purpose of this study is to shed light on the tangle that made the survival of the oil shale industry possible and what impact various actors and processes have had. To illustrate this, a brief quotation from Maxine Berg and Kristine Bruland should suffice: *Technology is, after all, not a thing but a culture.*⁷

This work will be divided into chapters, each representing a major break with the immediate past. With this approach it will be easier to identify the processes behind change, not least because it will simplify identification of what factors remain unchanged despite dramatically different institutional conditions.

1.2. Oil shale and the industry

The focus of this work, oil shale, is a relatively unknown substance for almost everybody without an active engagement in this particular fossil fuel. Therefore it is appropriate to begin with a characterization of oil shale. There is, unfortunately, no single, universal definition of oil shale. The following definition is provided by John Dyni for the World Energy Council:

“Most oil shales are fine-grained sedimentary rocks containing relatively large amounts of organic matter from which significant amounts of shale oil and combustible gas can be extracted by destructive distillation. Included in most definitions of ‘oil shale’, either stated or implied, is the potential for the profitable extraction of shale oil and combustible gas for burning as a fuel.”⁸

The definition above implies that the line between what substances are called oil shale and what are not, is usually an economic one. Another definition, also originating at the World Energy Council, is given by Walter Youngquist:

⁷ Berg & Bruland (1998) p. 14.

⁸ Dyni (2004).

“The term “oil shale” is a misnomer. It does not contain oil nor is it commonly shale. The organic material is chiefly kerogen, and the “shale” is usually a relatively hard rock, called marl. Properly processed, kerogen can be converted into a substance somewhat similar to petroleum. However, it has not gone through the “oil window” of heat (nature’s way of producing oil) and therefore, to be changed into an oil-like substance, it must be heated to a high temperature. By this process the organic material is converted into a liquid, which must be further processed to produce an oil which is said to be better than the lowest grade of oil produced from conventional oil deposits, but of lower quality than the upper grades of conventional oil.”⁹

Estonia is at present by far the biggest producer of oil shale in the world and the only country in the world almost entirely dependent on oil shale in its energy system, producing both electricity and oil and numerous chemicals.¹⁰ It should be pointed out from the very beginning that despite Estonia’s intense use of oil shale, its total reserves are indeed minor on a global scale. Nevertheless, the Estonian oil shale is one of the richest in the world, i.e. allowing for the highest yield of energy. The Estonian experiences are of particular interest when taking into consideration that the global reserves of oil shale exceed the total amount of coal, lignite, and brown coal taken together.¹¹ Estonia is thus an extraordinary case, but is it a marginal one in the sense that it should be counted as a deviation from the rule only, and thus have little relevance for the understanding of technological development in general? In my opinion, it is definitely not far-fetched to assume that under other circumstances, energy systems of the Estonian kind could have been a part of the global mainstream. Estonia has developed an energy system which from a theoretical perspective could have developed in many other places as well, but for various reasons never did. Far-reaching plans in this direction have been made in several countries at different times, but in the end they have, as a rule, come to naught. One important reason for this has been the availability of other energy sources. Oil shale, sometimes referred to as the “elusive energy”, has been the energy source for times of crisis. There are two fundamental objections to the wide-spread use of oil shale; namely economy and ecology, on which more later. Studying the emergence and development of the Estonian oil shale industry will shed light on the factors shaping an energy system and as this

⁹ Youngquist (2001).

¹⁰ Today, Estonia imports almost all of its gasoline, but in the 1930s Estonia was self-sufficient in this respect, too.

¹¹ Veiderma (2003). Another assessment is provided by Youngquist in WEC (2001): “*If a technology can be developed to economically recover oil from oil shale, the potential is tantalizingly enormous. If the containing organic material could be converted to oil, the quantities would be far beyond all known conventional oil reserves.*”

work hopefully will do, provide insight into the vast array of economic, social, technological, political and environmental factors, which together build this kind of complex human-created systems.

The object of study in this work is the Estonian oil shale industry. By this is meant that the entire industry is in focus, not any particular firm, mode of production, product, or interest group. The reason for choosing this approach is that the institutional arrangements in Estonia underwent such dramatic changes in the 20th century that few, if any, institutions survived throughout the century. But despite this fact, there is a clearly recognizable path of development if focus is put on the industry as a whole. If, for instance, focus were instead to be put on one of the main shale oil producers in the 1930s, the general picture would become increasingly obscure as shale oil lost its dominant position in the whole oil shale industry in the post-WWII period. Instead, other products and electricity generation based on oil shale became dominant. Now assume that a particular interest group from the early times would be in focus. WWII and the purges of the Stalinist period claimed a huge toll among those employed in the oil shale industry and consequently this thread could have been broken.¹² Nevertheless, the industry as such survived and by applying a perspective where the industry as such is the object of study, an unmistakable development path can be observed despite the profound changes.

To sum up, the reasons for choosing Estonia as a case study are rather straightforward.

First, the Estonian oil shale industry is the only remaining oil shale industry in the world that is of significant economic, social and political importance. Its main product today is electricity. Several attempts at developing oil shale industries elsewhere for various purposes have failed and where such have survived, they remain on the fringes of the economy.

Second, the Estonian oil shale industry – soon 100 years old – has survived and developed despite extremely turbulent historical developments. Or it could rather be said that it survived because of these developments, namely because in a society with a peaceful history, the oil shale industry would probably have been regarded as being of less value?

¹² But not entirely. As will be discussed in greater detail later on, enough people survived to continue the operations of the industry and to pass on their skills to a new generation.

Third, Estonia is a small country, which simplifies the task of analyzing the development of its energy system as a whole. Identifying processes behind the development of the energy system is therefore less complicated than would be the case otherwise.

Fourth, the Estonian unique dependence on such a fossil fuel as oil shale can to some extent serve as an allegory for the global dependence on other fossil fuels. This study will aim at contributing to a better understanding of how and why human civilization has such difficulties in breaking with an energy source which few people would fully embrace, while it is detested by many on strong grounds. It can not of course be claimed that unequivocal answers to such a problem can be found by studying the Estonian oil shale industry, but because of its isolation and uniqueness, it nevertheless serves as a highly interesting example.

1.3. Further questions

In the course of this study several other questions have emerged as a kind of a by-product, which are interesting in their own right, though.

When studying the material behind this study, it became obvious that in recent years there has been renewed interest in the oil shale industry around the world, mainly because of increasing concerns about global oil supply. As a result, some observers claim that we might be witnessing the return of a technology that not long ago was ruled out as something of the past. The renewed interest in oil shale technology could also be interpreted as a sort of competition to traditional oil. If oil prices or political conditions in the oil producing countries change in an unfavorable direction, there is always the possibility of exploiting the gigantic oil shale resources of the world. This situation is similar to those monopolistic markets where the monopoly faces low barriers of entry and can maintain its position only by responding actively to market demands. Were the monopoly not to do this, competitors would soon emerge. This observation is in fact a derivate of Schumpeter's discussion on monopolistic competition. What actually differs is that while Schumpeter approached the question of individual firms as monopolies¹³, we can instead look at the mode of production as a monopoly, especially as a result of the location of the oil deposits and the low costs in the past. If there is a tendency towards persistently high oil prices (an assumption that should not be taken for granted) and if the seemingly relentless political instability in the leading oil

¹³ Schumpeter (1975/1942) pp. 99-102.

producing countries will continue, new entrants in the form of alternative methods for oil production might enter the market. This growing interest in oil shale has a strong opposing force in the growing awareness of the damage inflicted on the earth's atmosphere through the emission of green-house gasses. Thus, I want to stress that there is no underlying aim in this work to promote the cause of oil shale. The only point made here is that there is at present no short-term risk that the world is running out of oil as such, but maybe only running out of cheap oil from traditional sources. Arguing for a break with the fossil energy system should therefore not be based on the assumption that there will be no more oil in the near future. There are still enormous quantities of recoverable oil in oil shale around the globe.

Beyond the question of the importance of the oil shale industry to Estonia, one may identify the more general issue of accumulation of particular knowledge. Given certain prerequisites, such as the existence of a particular raw-material or immediate physical possibilities (such as abundance of sunshine if solar cells are to be used on a large scale), to what extent can a society develop technology different from that of the surrounding world? To what extent can knowledge, valuable in a certain context, be accumulated in order to solve crucial problems (like electricity supply) and to what extent can we observe the law of diminishing returns setting in, i.e. the further gains from additional knowledge becoming ever smaller? And how much will focusing on technology that can be seen as locally preferable hamper other developments, i.e. keeping pace with the world outside? In the case of Estonia this issue becomes highly relevant, as there is a direct exclusion effect because of the small size of the country. Focusing on one technology leaves very little room for the development of other technologies. In other words, a lock-in occurs.

Focusing on a development path under extremely changing conditions will hopefully help to understand the essence of how an industry adapts to changing surroundings. The very structure of the political system probably does not have any major impact on the explanatory power of evolutionary economic theories.¹⁴ It can be claimed that neoclassical economic analysis would not contribute to an increased understanding of the development of the Estonian oil shale industry, especially during the four decades of Soviet rule. First of all, there was no real market. Second, there was no profit motive in a traditional sense. Third, it is highly doubtful whether the production function could be applied, mainly because the inputs

¹⁴ The idea of broadening the scope of the analytic framework of institutional economics to encompass planned economies as well has been put forward by Bromley (1989).

(of capital and labor) were oftentimes not decided by the management or the owners of the enterprise, but by a bureaucratic structure. The Hungarian scholar on socialist economies, Janos Kornai calls this structure not a centrally planned economy, but a centrally managed economy.¹⁵ Moreover, firms in such economies faced what Kornai labeled “soft budget constraints”, a phenomenon allowing firms to circumvent financial constraints in a number of ways.¹⁶

This work is not, however, primarily a study of the Soviet economic or industrial policy. The Estonian oil shale industry is not solely a product of Soviet policy, but still there is no doubt that what exists at present is to a large degree shaped by the Soviet Union. It is a widely held belief that local innovation was more or less non-existent in the Soviet Union. Nevertheless, several sources on the Estonian oil shale industry paint a different picture. There were numerous obstacles to innovation and change, and these tendencies could often be traced to rigid structures. But innovative activity as such existed. In the Estonian oil shale industry (as well as in Estonia in general) important elements of a non-Soviet culture survived, although certainly not untouched by the surrounding reality. This survival was the result of path dependent processes, in both technology and institutions. The Estonian oil shale industry remained in many respects a child of the Estonian Republic in the 1920s and 1930s, but curiously, it has also remained a Soviet style anachronism in today’s free-market society.

Furthermore, a study of the development of the Estonian oil shale industry will most likely also produce an increased insight into the social role of technology, how a particular technology becomes synonymous with national aspirations during one period of time, while being perceived as a problem or even a threat when circumstances change.¹⁷ This claim is not contradictory to what was stated initially, namely that technology all over the world is interrelated. Several nations tend to focus on a few particular branches of the whole, which then are perceived as a sort of national technology.

¹⁵ Kornai (1992) p. 117.

¹⁶ Kornai (1992, pp. 141-2) divides the components of soft budget constraints into four components. First there are the soft subsidies, basically compensation for excess expenses covered by public means. Second there is soft taxation, which is a result of advance bargaining and thus not levied according to any strict rules. Third, soft credits are accessible for those with the right contacts. Full repayment is often not demanded. Fourth, soft administrative pricing is the result of the absence of market pricing, when a particular company or sector might be able to lobby the authorities for a price hike in order to cover costs.

¹⁷ This aspect is not unique for Estonia. For instance, Anshelm (2000) discusses at length the plans to develop a separate Swedish nuclear technology in the 1950s and 1960s in order to avoid dependence on the great powers for its supply of uranium. Later, nuclear power became almost an anathema in Sweden, despite the country’s reliance on it for electricity generation.

For the Estonian oil shale industry, there is simply no outside experience to imitate or to replicate.¹⁸ Thus most technological change is in this respect endogenous. This fact could be contrasted to, say, nuclear power, where most countries have chosen similar technologies and thus are able to exchange experiences.¹⁹ The “nuclear community” gains from “knowledge of scale”, an aspect more or less absent in the case of the Estonian oil shale industry.

Two sub-chapters have been included in this work, (5.1.8. and 6.1.1.), which could be called digressions from the main train of reasoning. The first of these called “A contemporary observer” is based on accounts of the journalist Osvald Tooming’s tours of the oil shale district in the 1930s. The second, called “More oil shale!” is an analysis of the oil shale industry and the surrounding society through the lens of a regional newspaper at the apogee of Stalinism after WWII. The motivation for including these chapters is twofold. First, I want to paint a broader picture of the conditions in society under which the oil shale industry developed at various points in time. This aim is directly related to the discussion on the institutional set-up forming technology, both in Estonia and elsewhere. Second, in both cases voices from those times will be allowed to speak directly to readers, allowing them to draw their own conclusions about the periods described.

¹⁸ For a theoretical discussion, see Nelson & Winter (1982) p. 112 ff.

¹⁹ For a discussion of this topic, see Cowan (1990). For a Swedish-language account, see Anshelm (2000) and Radetzki (2004).

2. Methodological Considerations

The aim of this work is to shed light on the developments of one particular sector, mainly within one country, Estonia. From this follows that the bulk of information has to be sought there. To my knowledge there has so far been no major, multi-disciplinary socio-economic analysis carried out on the Estonian oil shale industry. There are, however, a large number of technical analyses. An important source is the journal *Oil Shale* (today mainly in English) published by the Estonian Academy of Sciences, which is also the only international journal specialized in this topic. Further information can be found in various publications. Gathering information in Estonia is, as a rule, not complicated. The language of this information is, however, usually Estonian or Russian, while some older documents are written in German. English is almost non-existent. I am able to read material in these relevant languages. Older material can easily be found at the Estonian State Archive and the Estonian National Library, where there is a collection of publications from the 1920s and 30s. Some of these publications are valuable in one additional sense – they are very pedagogical. When oil shale was a new energy resource, it was not obvious it would become dominant, so the proponents of oil shale put an effort into convincing the public. Among such works, two should be mentioned in particular, namely Karl Luts' *Põlevkivi. Meie rahvuslik suurvara* ("Oil shale. Our national big resource") from 1939 and Märt Raud's *Põlevkivi ja põlevkivitööstus Eestis* ("Oil shale and the oil shale industry in Estonia") from 1925. Both authors were also professionally involved in the oil shale industry in the 1920s and 1930s and both eventually perished in the Soviet GULAG prison system.²⁰ The fact that there are few thorough accounts of the oil shale industry produced by people not professionally involved in it, raises some questions on reliability and accuracy. It is clear that such accounts are strongly in favor of the oil shale industry, but the facts presented correspond with information obtained from other sources, such as archive materials or newspaper articles. On the other hand, in the latter part of the 1930s, Estonia could no longer be considered a democratic society and freedom of the press was infringed.

²⁰ Luts was the director of the chemical laboratory of the Estonian State Oil Shale Industry. He died in 1941 in Perm oblast, Russia, from unknown causes after having been deported. Märt Raud was deported in 1949 to Krasnoyarsk, where he died in 1952. Source: Eesti Entsüklopeedia 14. Eesti Elulood.

The economic history of Estonia is by and large still unwritten. Maie Pihlamägi has studied the industrialization of Estonia as well as the foreign trade of Estonia in the interwar period. Her books *Eesti industrialiseerimine 1870-1940* (“The industrialization of Estonia 1870-1940”) and *Väikeriik maailmaturul. Eesti väliskaubandus 1918-1940* (“A small country in the world market. Estonian foreign trade 1918-1940”) are important references in this work. Another work on the topic, Otto Karma’s *Eesti Vabariigi majanduspoliitika. Kaks aastakümnet 1919-1939* (“The economic policy of the Estonian Republic. Two decades 1919 –1939”) contains a lot of information, but lacks strict coherence. A relatively recent (from 1995) analysis of the economic conditions of the oil shale industry in the 1920s and 1930s has been made by Jaak Valge in *Riikliku Põlevkivitööstuse majandustingimused ja –tulemused 1920. ja 1930. aastatel* (“The economic conditions and results of the state oil shale industry in the 1920s and 1930s”), published as two separate articles in the periodical *Akadeemia*. A more sociologically inclined study, which contains several interesting observations of the oil shale industry has been written by Vahur Mägi; *Inseneriühendused Eest Riigi ülesehituses ja kultuuriprotsessis(1918-1940)* (“Engineering organizations in the construction of the Estonian state and in cultural processes (1918-1940)”).

In recent years, a number of memoirs by former employees in the oil shale industry have been published. The main intention of these publications seems to be to collect and save information as long as these people, often belonging to the oldest generation, are still clear-headed and alive. The drawback of this quick publishing process is lack of editing, which has resulted in rather chaotic texts, without thorough fact checks. Despite this, such publications can in my opinion still be considered reliable, especially when different sources support each other. Such memoirs have been published by Ilmar Öpik (1999), Juhan Tomberg (2002), Ivar Rooks (2004) and Emil Kuhu (1999).

Today’s Estonia is an open society where, as a rule, information can easily be obtained on the Internet. This is the case with various government action plans etc. Estonia belongs to those countries with the most widespread use of information technology.²¹ In addition to this, major Estonian newspapers can be read on the net on a daily basis.

²¹ For instance, World Economic Forum’s Growth Competitiveness index places Estonia as no. 10 on a global level (see www.weforum.org for details).

Throughout this study, written material is supported by interviews. The interviews could perhaps be called unstructured, although with careful notes, because the aim has not been to conduct an interview study, but instead to find additional information in order to identify the crucial issues in the development of the oil shale industry. Furthermore, the interviews bridge the gaps in written sources. The interviews have been carried out on a rather ad hoc basis, by which is meant that I have met the person in question and we have had a free conversation on the topics each particular interviewee is specialized in. As a rule, I did not have any deeper prior information on the persons (except that they possessed valuable knowledge or experience). This method, I consider, is justified because the role of the interviews is to broaden the general picture. The interviewees can, however, roughly be divided into two categories. The first category of interviewees consists of those who have personal experience from the Soviet times, whose reminiscences are not necessarily covered by existing literature.²² The second group consists of those who are active today in some field with relevance to the oil shale industry.²³ The interviews have, as a rule, been carried out in locations assigned by the interviewees themselves in Tallinn, Kohtla-Järve and Narva. All interviews with the exception of the one with Dr Helle Martinson of the Estonian Science Foundation, were conducted in Estonian. The latter was in English. Here one particular feature should be mentioned: Estonians often have a tendency to express themselves laconically and in an ironic or even cynical manner, which tends to be entertaining for those who are accustomed to it. However, such a way of expression might be misunderstood by others. In order to avoid causing misunderstandings, I have occasionally left out the actual wording and replaced it with what is actually meant.²⁴

One issue that must be addressed in this respect is the quality of material from the Soviet period in Estonia. Due to the particularities of the system at that time, free information was not available. Because free expression was suppressed until the early 1990s, there is a wide gap in Estonian society when it comes to information between 1940 and the late 1980s. Sources from the Soviet period can of course be used, but not entirely in a similar fashion to older or newer sources. The aim of many works published during this period was to support the ruling structures. Facts that were not in concordance with the values held by the rulers

²² In particular the interviews with Helle Martinson and Ivar Rooks belong to this category, but the topic was also touched upon in interviews with Koidu Tenno, Helvi Uibopuu and Jüri Soone.

²³ Everyone except for Helle Martinson are today professionally connected with the oil shale industry or related research.

²⁴ The interviews took the form of rather spontaneous discussions, although with me taking notes. I have then referred to these notes during the writing process. The original wording can be found in my notes.

were either omitted or presented in a particular light. In addition to this, written material that reached the public was usually heavily loaded with the official lingo of the Soviet rule. As a result, it is of great importance to be able to judge what is simply official nonsensical jargon and what the underlying message might be. It goes without saying that this is a major challenge for anybody who does not have Estonian or Russian as a mother tongue and who never lived in such a society. On the other hand, the task is simplified by the fact that what actually was printed was the official policy or at least opinions very close to it, which definitely makes it easier to draw conclusions on the policy directions.²⁵ It should be particularly mentioned that a lot of the material found in archives from this period was written in Russian; evidence as good as any of the aspirations of the Soviet system to degrade other languages than Russian. As this subject will be touched upon later in this work, this piece of evidence should be taken into consideration.

Soviet statistics are a particularly difficult chapter. The sole aim was to produce an image of enormous increase in production and therefore several “tricks” were used. The Swedish-Estonian politician and writer Andres K ng lists the following: the use of percentage instead of absolute figures, repeated changes in the methods for calculation in order to make it difficult to establish time series, arbitrary exchange rates, and counting with gross instead of net production, whereby inputs are disregarded. Moreover, productivity changes are not measured, as a rule. Therefore an increase in the overall number of, say, industrial workers resulted in a seemingly increased industrial production, but at the expense of decline elsewhere in the economy. This latter development was then not accounted for in the same context.²⁶

Dr. Helle Martinson of the Estonian Science Foundation with a professional background in oil shale-chemistry, has put her personal collection of oil shale-related documents at my disposal. They turned out to be a particularly valuable entry into other relevant material. I also found her advice on how to read materials from the Soviet times very helpful, namely to skip the first section of most books, because it usually consists of an impenetrable exercise in Soviet lingo. The ensuing sections, on the other hand, tend to be factual, especially when the topic is not directly about the political system, and probably quite reliable. Dr. Martinson illustrated

²⁵ The “logic” of the Soviet censorship is described in greater detail by Veskim gi (1996).

²⁶ K ng (1971) pp. 69-70. On this topic, see also Mertelsmann (2003), who discusses statistics on industrial development in the 1940s and 1950s in Estonia.

this with a book she herself had written on chemistry in pre-war Estonia, advising me not to read the first chapter.²⁷

The Estonian State Archive and the National Library (both located in Tallinn) have been important in finding material for this work. I have not encountered any particular problems with access to material. Having said this, some material concerning Estonia cannot be found in Estonian, but as a consequence of the Soviet rule, in Russian archives. Several important decisions concerning the Estonian oil shale industry were not made in Estonia and therefore the original documentation can probably be found in Moscow. I have not attempted to find such documents, because most of the time, as a rule, secondary sources found in Estonia compensate for this shortage. For instance, when some decision made in Moscow was implemented in Estonia, documents on this implementation, referring to the original one, can be found.

Newspapers and periodicals, especially from the Soviet times, play an important role as sources. In particular I should mention the Estonian Communist Party organ, the daily *Rahva Hää* (“People’s voice”), the periodical of the Central Committee of the Estonian Communist Party *Eesti Bolševik* (until 1952) and *Eesti Kommunist* (from 1952 onwards) as well as the periodical *Tehnika ja Tootmine* (“Technology and Production”), which defined itself as “the national organ of the Scientific Committee of the Council of Ministers of the Estonian SSR and the Council of Trade Unions of the Estonian SSR.” Moreover, the regional newspaper *Rohkem Põlevkivi!* (“More oil shale!”) forms the backbone of one sub-chapter. Despite the fact that numerous articles in these newspapers and periodicals are impenetrable due to the abundance of Soviet phrases, also numerous clear and even enjoyable accounts can be found. When observing a certain caution (particularly with statistical figures), interesting features of life in Estonia during the Soviet times become vivid when reading these publications.

Even if this work makes no claims of being a thorough account of modern Estonian history, it is deeply intertwined with the topic and therefore comments are required on Estonian history. It is maybe somewhat surprising that there are relatively few comprehensive works on Estonian history, even in Estonian. A comprehensive, but rather uninspired recent work in Estonian is the joint effort by a number of Estonian researchers with the title *Eesti Ajalugu*

²⁷ The book, written in Russian, is called *Khimiya v Estonii v period burzhuznoy vlasti*, (“Chemistry in Estonia during the bourgeois regime”).

(“A history of Estonia”).²⁸ The sixth part of this work is a factual account of events from the war of independence in the aftermath of WWI to re-independence in 1991. In English a (small) number of works on Estonian history exist, most of which have been written either by exile-Estonians or other “Western” scholars. Toivo Raun’s *Estonia and the Estonians* could be characterized as a comprehensive introduction to the topic. However, of greater importance for this work has been in particular Romuald Misiunas’ and Rein Taagepera’s account of the post-WWII years in all three Baltic States: *The Baltic States. Years of Dependence 1940-1990*, which puts focus on changes in the Baltic societies during the Soviet regime. The same topic is addressed by John Hiden and Patrick Salmon in *The Baltic Nations and Europe. Estonia, Latvia and Lithuania in the Twentieth Century*. Focusing on all three of the Baltic states is a common approach justified by the similar experiences of these nations in the 20th century. It should however be emphasized that apart from this particular framework, the Baltic states are surprisingly different from each other concerning culture, language and history before the 20th century. Also their destinies during the Soviet years were somewhat different. A work that should be particularly mentioned is *A Case Study of a Soviet Republic: The Estonian SSR from 1978* edited by Tõnu Parming and Elmar Järvesoo. This book is comprised of articles on various aspects of the Soviet Estonian society written by exile-Estonian scholars, mainly active in North America. Despite widespread bitterness among exile-Estonians about the destiny of their native country, this work is surprisingly free from unsubstantiated claims and therefore it remains a sober account of facts available at the time. With hindsight, one might even blame some of the authors for having been too uncritical towards information produced in the Soviet Union.

Works on the Soviet Union from various angles are abundant. The history of Estonia coincides with that of the Soviet Union for over four decades and therefore such works have their place in this context, even if most of them do not deal with Estonia in particular. One important work is Alec Nove’s *An Economic History of the USSR*, which only briefly mentions Estonia, but paints the broad picture of the circumstances.

The past is often traumatic in today’s Estonia, a fact that might have an impact on recent studies. However, I have not identified any attempt to outright distortion of facts. On the contrary, surprisingly often I have encountered a serious wish to come to terms with the past.

²⁸ Vahre (ed.) (2005).

For this reason, for instance, I have found Magnus Ilmjärvi's account on the destruction of the independent Baltic States in the eve of WWII, *Silent Submission*, highly interesting, although I take a critical standpoint towards his conclusions concerning the oil shale industry. This is nevertheless only a minor aspect of his work. Many Estonian sources published after re-independence in 1991 explicitly call Soviet rule colonialism. I have no intention to argue against this view, but regarding the oil shale industry, the picture is more complex. I have addressed this topic on a few occasions in this work.

Information and data on present developments in the oil shale industry and related environmental spheres can, as a rule, be found in the large amount of various documents, articles, booklets etc, which are readily available at libraries in Estonia and on the Internet. In addition to such material, I have made interviews with people being in such positions in both administration and academia that they can be expected to possess further knowledge. Because I had the opportunity to visit Estonia several times during my work with this thesis, I each time conducted a few interviews and looked for written material. Thus, I was often able to find written support for statements made in interviews and vice versa.

Estonian names, both of persons, geographical locations and companies, are, as a rule, written in the Estonian form. This is not as self-evident as it sounds. Many places in Estonia used to have parallel names in German, which can be found especially in older documents. For instance, the area where most oil shale mining takes place has the German name *Kochthal*, from which probably the Estonian names Kohtla-Järve or Kohtla-Nõmme are derived. Moreover, incorrect spelling of Estonian geographical locations and even persons occur every now and then when transliterated over Russian (Estonian, contrary to Russian, uses the Latin alphabet). So, for example, one can find the Estonian capital Tallinn spelt with only one n at the end, which is the Russian form. The town of Sillamäe in North-Eastern Estonia can incorrectly be referred to as Sillamjae, which is the result of double transliteration (From Estonian to Russian to English). In Russian, names of individuals are usually written with two initial letters and the family name (such as V.I. Lenin). This was transferred to Estonia during the Soviet years, and as a consequence it is difficult to trace the given names of authors in printed material from that time, unless they are otherwise well known. Therefore, unfortunately, many authors referred to in this work are mentioned in this way only. It should also be pointed out that there is a different way of transliterating Russian into Estonian than into English. I have tried to use the English standard as far as I know, but when a person with

a Russian name occurs as the author of an Estonian text, I have of course used the name found in the article. Hopefully this will not cause too much confusion. For instance, the Russian family name Tyagunov can also be found in the Estonian form Tjagunov, when referred to as the author of a particular text in Estonian. Finally, there is a letter in Estonian, õ, which lacks its counterpart in most other languages. It sounds like something between the double e in “see” and the u in “sure”. In the reference list, I have often made a translation into English of Estonian titles in particular. Such translation (hopefully) serves the purpose that readers without knowledge of Estonian can get at least an idea what sort of works have been used.

The Swedish oil shale industry is described in numerous government reports (especially in the “SOU” series). Further information can easily be obtained from Arkivcentrum Örebro, where documents related to the Swedish shale oil industry are kept. Similarly to the Estonian oil shale industry, the history of the Swedish oil shale industry remains to be written.

3. Theoretical framework

In this work, I will use the concept of path dependence as an explanation why the Estonian oil shale industry has managed to survive, while similar industries elsewhere have either been closed down or become marginalized. In the case of Estonia, it will be shown that in the aftermath of WWI, Estonia had a number of options for its energy system. For reasons that will be described in detail later in this work, oil shale got the upper hand *despite* concerns about its suitability. In the following decades oil shale remained the prime energy source for Estonia, *despite* being simultaneously a threat to both Estonian national sovereignty and even the existence of the Estonian language and culture. Naturally, there have been strong arguments in favor of preserving the oil shale industry, but there is no doubt that the negative aspects have from time to time been of tremendous significance. Therefore, in order to explain the survival of such an industry, the concept of path dependence, albeit in a somewhat modified version, opens up an interesting perspective on the development.

In this chapter, I will initially define the object of study (i.e. the Estonian oil shale industry) as a socio-technological system, consisting of both people and artifacts as described in chapter 3.1. (“A systems perspective”). The tool I put forward for understanding the changes this system has undergone is called path dependence, which is thoroughly discussed in chapter 3.2. My intention here is to move from the general to the more specific aspects of path dependence and to some extent also from the abstract to the more concrete. There are a number of reasons for this, the most important of which is that because of the widespread use of the concept of path dependence, there can not be said to exist one clearly identifiable meaning of the concept any longer.²⁹ I take some time to identify various aspects, including objections to the entire concept of path dependence as such in chapter 3.2.1 (“Definitions and criticism”). The following chapters focus on aspects of particular explanatory value to the concept of technological path dependence. In chapter 3.2.2. (“Co-evolution of technology and institutions”), I claim that technological path-dependent processes do not take place in an

²⁹ In the 1980s, when the concept was introduced, there existed only one or two (by now famous) definitions. With time passing, a veritable plethora of definitions has emerged.

institutional vacuum, but they both shape and are shaped by their institutional environment, creating so called socio-technological systems. In the following chapter 3.2.3. (“Knowledge as a path-dependent process”), I claim that the prime mover of technological path dependent processes is knowledge embedded in existing technology, but also new knowledge created in human interaction with technology. The difficulty of breaking away from path dependence and lock-in is analyzed in chapter 3.2.4. (“The scope for remedies”).

Finally, the reader for whom a lengthy discussion on the various aspects on path dependence is superfluous, is advised to proceed directly to chapter 3.3. (“A summary of the theoretical argument”).

3.1. A systems perspective

By system is meant an entity separable from its surroundings, in at least some respect. Within the system, several components interact, thus creating a force driving the system in a certain direction or maintaining it in a certain state. In any complicated system, identification of the components is essential in order to develop any fundamental understanding of the processes within the system. There is no clear-cut definition of a system and the concept has developed over time, but it has also had its periods of ups and downs with regard to popularity.³⁰ A definition of a technological system is provided by Robert Adams:

“Technological systems have several obvious characteristics, and some that are less obvious. They are complex, hence usually decomposable into hierarchies of subsystems that may be independently subject to intervention and modification – or breakdown. They persist in time, following a life cycle of varying duration from birth to maturity, and in most cases ultimately on to slow senescence and disappearance. They must have boundaries of some sort, as implied by the criterion of “interconnectedness”, although these may need to be left loosely defined and somewhat dependent on the perspective of the viewer.”³¹

In the case of the Estonian oil shale industry, the sheer number and variety of the components that can be identified does not allow for limiting this work to any particular branch of social sciences, technology or economy. Therefore the basic characteristic of this work is interdisciplinary, and it shares some similarities with the tradition of studies of large technical

³⁰ An overview of various systems approaches has been written (in Swedish) by Ingelstam (2002).

³¹ Adams (1996) p. 23.

systems, although not coinciding with it. Technically it would of course be possible to single out a particular aspect, say economic issues, and draw conclusions from that field. Applying such a method would, in my opinion, not contribute to the overall understanding of the processes that produce and maintain the present system and it would therefore have a rather limited explanatory power. My starting point is that only an approach allowing a wide range of perspectives will make it possible to understand why and how a technological system emerges and evolves – and remains. Having said this, I want to emphasize that approaching this topic from a broad angle is under no circumstances an idea I would claim to be my own. Already in the Soviet times it was a well established viewpoint that the Estonian oil shale industry had become a complex structure where several factors interacted. In the 1970s, the scientific community of Estonia analyzed the oil shale industry by applying various models based on a systems approach, including at least technology, economy, social issues and ecology.³²

However, the systems perspective used in this work is at least one leap away from the multi-disciplinary approach discussed above, because the system itself gains the role of an actor. A few years prior to the introduction of the concept of path dependence, Devendra Sahal discussed phenomena which now could be labeled path dependent and suggested analyzing technological change from a systems perspective.³³

Using the systems approach in industry studies is championed by Bo Carlsson, according to whom:

“By taking a systems approach, we explicitly recognize also the importance of nonmarket-mediated interaction, a form of external economies, especially in the form of knowledge spillovers. Such externalities (spillovers) are pervasive; they are not rare exceptions. They constitute an important part of the dynamics of technological systems”³⁴

Carlsson continues:

“Another implication of taking a systems approach is the explicit recognition of the role of institutions – or what may be called the context or framework of economic activity. Thus,

³² Tenno (1978) p. 40.

³³ Sahal (1981).

³⁴ Carlsson (1997) p. 2.

the support systems for R&D, technology and innovations, the educational system, physical infrastructure, the organization of labor, capital, commodity, and service markets, etc. need to be integrated into the analysis.”³⁵

Studying industrial dynamics from a systems approach allows for the definition of the concept of technological systems as introduced *inter alia* by Bo Carlsson and Rikard Stankiewicz. A technological system is, according to them:

“/.../a network of agents interacting in a specific *economic/industrial area* under a particular *institutional infrastructure* or set of infrastructures and involved in the generation, diffusion, and utilization of technology. Technological systems are defined in terms of knowledge/competence flows rather than flows of goods and services.” [italics in original]³⁶

Following this line of thought, a technological system can be said to consist of an interwoven structure of design space, actor networks, and competence blocks. By design space is meant the various available technological capabilities. But without a proper contextual environment, or the organizational and institutional set-up (i.e. the actor network), the technological capabilities will not develop. Moreover, technological solutions need to gain acceptance in the market to be further developed, whereby competence blocks are created, which in turn are the combination of actors and functions required for an industry to emerge.³⁷ This definition of a technological system, by and large, corresponds to the concept of *industry* as used throughout this work, albeit with some important modifications. First, the concept of markets has to be interpreted in the broadest sense possible. The Estonian oil shale industry has operated under conditions resembling markets only for a lesser part of its existence. However, even during the years of Soviet rule when market conditions were not present, some selection mechanisms existed, which should justify this approach. Second, all flows of not only goods and services, but also people and ideas were restricted during the Soviet period, although never entirely non-existent. Therefore such a notion can, albeit carefully, be used in this context. Third, the organizational and institutional framework changed dramatically throughout the period under study. These changes were oftentimes totally exogenous to the system, from which follows that the technological system was forced to react and adjust unilaterally. In this context, it should be mentioned that the concept of *competence blocks* seems to be derived from the

³⁵ Ibid.

³⁶ Carlsson & Stankiewicz (1995) p. 49.

³⁷ Carlsson, Holmén, Jacobsson, Rickne & Stankiewicz (2002) pp. 13-6.

concept of *development blocks* as described by the Swedish economist Erik Dahmén. Development blocks consist not only of industry, but also physical infrastructure, financing, markets, and politics. In this perspective, development takes place to the extent that pieces of the entity exist and are in place. Thus, the existence of an otherwise viable technology alone does not necessarily grant expansion if, for example, funding is wanting. But development may also be slow or absent due to technological shortcomings if particular pieces thereof are missing. This phenomenon is often recognized in everyday language when some branch is said to have great potential, despite relatively little having happened yet. A potential not lived up to, is a sign of some missing element(s). The development block will gain momentum only when the missing pieces are in place, because the block as a whole is developing, it is a system rather than a collection of separate units.³⁸ This concept of development blocks is not used as such in this work, but it is mentioned here, because it can be claimed that if some important element had not been present, the Estonian oil shale industry would perhaps never have taken off. Therefore, for example, the very existence of oil shale in Estonia does not explain the present dependence on it.

3.2. Path Dependence

3.2.1. Definitions and criticism

There is no universally accepted, all-encompassing definition of path dependence, but a commonly used broad definition is that it is a concept allowing for history to enter the social sciences and especially economics, which in its neoclassical guise is remarkably free from considerations of the influence of the past. In contrast to general equilibrium economics, path dependence theories would claim that each outcome is unique and there is no necessity underlying it. An often quoted definition of path dependence is presented by Paul David:

“A path dependent sequence of economic changes is one of which important influences upon the eventual outcome can be exerted by temporally remote events, including happenings dominated by chance elements rather than systematic forces. Stochastic processes like that do not converge automatically to a fixed-point distribution of outcomes, and are called non-ergodic. In such circumstances “historical accidents” can neither be

³⁸ Dahmén (1991).

ignored, nor neatly quarantined for the purpose of economic analysis; the dynamic process itself takes on an essentially historical character.”³⁹

Nonetheless, it should be stressed that using the concept of path dependence is not synonymous with the discipline of history. While history, at least traditionally, tries to embrace those past processes that are recognizable, path dependence presents a downscaled version of history by focusing on those processes and events that are relevant for understanding a certain development path of a particular subject. This difference is described in the following concise way by Paul Hirsch and James Gillespie:

“The discipline of history focuses on complex forms of change, synthesis, and interaction within societies over time, and the basic questions focus on evolution and transformation. Path dependence focuses on factors that trigger change, particularly those of a technical nature, and how these changes interact with and are synthesized into the existing economic structure.”⁴⁰

However, if by path dependence is meant solely the introduction of history into social sciences, the entire concept risks inflation, because in social sciences basically any phenomenon has roots in the past. A more sophisticated definition would be to interpret path dependence as an explanation for why some particular solutions or arrangements gain the upper hand instead of others. This approach becomes particularly relevant when analysing why inferior solutions are chosen instead of superior ones, i.e. a sort of market failure, as suggested by Paul David and Brian Arthur.⁴¹ But path dependence has been met with criticism for its alleged lack of empirical evidence, despite its theoretical attraction.⁴² Moreover, the concept of path dependence has been criticized for being deterministic, because it tends to give past developments explanatory precedence over active choices made in the immediate temporal vicinity of the object of study.⁴³

With the concept *technological* path dependence, focus of the analysis is usually put on those technologies that have prevailed and the subsequent question becomes why these particular technologies and not some others have come to dominate. It can not be unequivocally claimed

³⁹ David (1985) p. 332.

⁴⁰ Hirsch & Gillespie (2000) p. 77.

⁴¹ David (1985), Arthur (1989).

⁴² Liebowitz and Margolis (2002/1990) and Liebowitz and Margolis (1995).

⁴³ Garud & Karnoe (2001) p. 2.

that those technologies we use today would be the best ones in some objective sense, but instead they should be regarded as the outcome of certain processes and decisions that have been made at various points in history, leading to the emergence of present technology. These processes can be altered at any time, although the costs can sometimes be forbiddingly high, or they can continue if we conceive the present state of technology sufficiently satisfactory. The point is that history matters; we can not move up and down the production possibility function of neoclassical economics at our own will, because we are facing real-life restrictions. Of course, we can only speculate about the merits of technologies never properly used, and we can by no means claim that something we do not really know would be clearly better than what we actually have. But at the same time, in a somewhat contradictory manner, we must address the questions of how to prevent such technologies from prevailing that we with our best judgment today would perceive as inferior and how to promote superior technologies. This issue is definitely not limited to mere speculation. Evidence is mounting that emissions of carbon dioxide alter the global climate. The steps taken today to abate this process will probably be decisive for how people in the future can cope with the situation. If we do nothing today, tomorrow's people will probably face an even bigger challenge, but if we embark on a path limiting emissions and developing suitable technology, the task for tomorrow might be more manageable. But once again, we can not say anything with certainty, only with some non-numerical likelihood.

The emergence of the concept of path dependence is usually associated with Paul David's by now classical account of the development of the QWERTY keyboard system in typewriters, which makes a claim to explain how inferior technologies can get the upper hand. According to David, the dominant arrangement of keyboards – beginning with the letters QWERTY – was initially motivated by the particularities of the first typewriters, but even if these have long ceased to be produced, the keyboard remains, mainly because of users simply having got used to the arrangement and thus there is little incentive to change the arrangement despite claims that other arrangements would be more efficient. Attempts to change the arrangement of keys have failed. The underlying point is that once some particular technology or practice has gained the upper hand, it may turn out to be surprisingly long-lived, even in a rapidly changing environment and despite efforts to change. QWERTY has even survived the switch from typewriters to computers.⁴⁴

⁴⁴ David (1985).

David's account of events has not gone unchallenged. Stan Liebowitz and Stephen Margolis have pointed at insufficient evidence, which casts doubt over the accuracy of the story as told by David. Liebowitz and Margolis do not claim to have refuted the concept of path dependence, but instead they argue that evidence for its existence is inconclusive.⁴⁵ The controversy between David on the one side and Liebowitz and Margolis on the other has been interpreted by Peter Lewin as a resurgence of the debate between Austrian and Keynesian economics. The consequences of accepting David's account would provide a strong case for government intervention in technology development, Lewin argues, while Liebowitz and Margolis would represent a typical free-market approach despite not being proponents of the neoclassical paradigm.⁴⁶

The debate on whether path dependence occurs or not in a free-market setting is nevertheless beside the point in this work. When focus is laid on an entire energy system, the question of how technologies would have competed in a free-market setting becomes more or less superfluous. Probably nowhere has a modern energy system developed without significant participation of government or at least some governing structures.⁴⁷ But does it then make sense to use the concept of path dependence at all? As was initially claimed, there is no unequivocal definition of path dependence and the meaning given to the concept in this work follows a slightly different approach. First, there is no single measurement as to what is defined superior technology. Instead, what appears as superior within one framework might be disastrously inferior within another. For example, fossil fuels have numerous qualities that make them superior to other energy sources, but they fail on others, such as environmental consequences and probably also on issues related to international security. Second, the distinction between short and long term has to be addressed. It might happen that in repeated short-term periods a particular technology seems superior, but in the long-term perspective it becomes inferior. This argument is related to Arthur's example, in which initial short-term gains tilt the choice of technology towards an inferior option.⁴⁸ But it is also possible that a relentless stream of immediate issues requiring a solution simply block the transition to other options, particularly when overall resources are limited (as they always are in some sense). In such a case, the technology in use will remain superior in dealing with the immediate tasks at hand, because it is the only one in place. It can be argued that such a technology might fail

⁴⁵ Liebowitz & Margolis (2002/1990).

⁴⁶ Lewin (2001).

⁴⁷ See for instance Hughes (1983) or Kaijser (1994).

⁴⁸ Arthur (1989).

sooner or later, but the time span between the introduction and definitive failure might in some cases be one of decades if not generations. To elucidate this reasoning with an example from a non-technological sphere, imagine a (freely elected) government that has come to power with the promise of a broad societal reform, but which remains stuck with constantly emerging new issues, each of which require immediate action, and most of which occur independently from the government. These issues might then, taken together, exhaust the government's capacity to carry out its initial plans. Or, to draw from the private sphere, is there any adult who has never contemplated breaking up from the treadmill of his or her job in order to start a new life, but has been held back by all the everyday obligations, such as the seemingly relentless stream of new bills to pay? In a similar fashion, a certain technology might fulfill the immediate tasks assigned to it, while failing to produce an outcome which in the long run would be preferred by most people. In this work I will claim that the Estonian oil shale industry is an example of such a paradox – and in order to further strengthen the case – claim that this paradox has existed regardless of the institutional framework.

As was mentioned earlier, path dependence is sometimes referred to as bringing history into economics. This should not, however, be interpreted as a sort of deterministic axiom claiming that everything is already fixed in the past and that we are simply executing decisions made at some preceding point in time. It would be a strange argument indeed to claim that a certain decision for future action is solely a result of path dependent processes and consequently that a decision made at present could not have been made differently. It would then be no decision at all, but at the same time such an argument would, strangely enough, ascribe people in the past the capacity to make decisions. Moreover, using the concept of path dependence does not imply that radical changes are impossible. There always exists at least some kind of choice, but the possibilities vary according to institutional arrangements, existing knowledge etc.⁴⁹ Douglass North addresses this aspect of path dependence:

⁴⁹ A case supporting, but also slightly contradicting this statement is the spectacular rise of Finnish telecom giant Nokia in the mid-1990's. The company broke with its multi-product, unfocused past and went entirely for telecom. On the other hand, an earlier unfortunate attempt to produce television sets created an in-house knowledge of electronics. The new company profile was developed in the wake of de-regulation of the Finnish financial markets and in particular deregulation of the telecom market. Nokia's tremendous success can thus be seen as a reaction to institutional change by sticking to existing skills, but breaking away from the path previously taken. For further details, see Häikiö (2002).

“Path dependence is a way to narrow conceptually the choice set and link decision making through time. It is not a story of inevitability in which the past neatly predicts the future.”⁵⁰

It would have been entirely beyond the realms of reality for the Estonian oil shale industry to become a multinational joint-stock company in the 1950’s. But it was possible to develop into a chemical complex. The former was never an option, while the latter definitely was. Thus the path embarked upon was clearly limited by the institutional landscape, but there was constantly more than one option present. One can neither present any figures on how many options are open and how many closed, nor even the proportion between these. But each single potential option can be analyzed in some terms of likelihood. Andrea Bassanini and Giovanni Dosi identify history as the cause for something being the way it is:

“/.../history matters precisely because another history - even holding the causal linkages of the analyzed system invariant - would have possibly yielded a different outcome.”⁵¹

In his seminal article, Brian Arthur approaches path dependence (without actually mentioning the concept) by studying why any particular technology prevails in a competitive situation.⁵² At the onset, it is impossible to judge which one of two competing technologies is superior, but at some point technological development might tilt in favor of one of them. This process of increased favoring of one technology does not necessarily have to be connected with any objective superiority of that particular technology, but instead be the result of small, random developments. But as soon as one technology gets the upper hand, the more it will be developed and the more it will be chosen in the future at the expense of the other technology.⁵³ For this phenomenon to occur, increasing returns is a prerequisite. By this is meant that each individual choice of a particular technology makes it more reasonable (or profitable) for others to follow suit. If no increasing returns are present, no path dependent process in the sense presented above will start. Or, in Arthur’s words:

⁵⁰ North (1990) pp. 98-9.

⁵¹ Bassanini & Dosi (2001) p. 41.

⁵² Arthur (1989).

⁵³ One is tempted to ask whether this reasoning is actually a variation of the theme of the famous Bible quotation “for whosoever hath, to him shall be given; and whosoever hath not, from him shall be taken away even that which he thinketh he hath” Luke 8:18, American Standard Version. Available on <http://asv.biblebrowser.com/luke/8-18.htm>.

“Modern, complex technologies often display increasing returns to adoption in that the more they are adopted, the more experience is gained with them and the more they are improved. When two or more increasing-returns technologies ‘compete’ then, for a ‘market’ of potential adopters, insignificant events may by chance give one of them an initial advantage in adoptions. The technology may then improve more than the others, so it may appeal to a wider proportion of potential adopters. It may therefore become further adopted and further improved.”⁵⁴

Related to the concept of increasing returns is that of network externalities. A typical example would be that of a telephone network. The value for every participant is increased the more new entrants there are. If only a handful of people are connected to a network, the value of participating will be questioned. A similar feature might occur with services; the larger the network, the more services there are, such as for instance software developed for computers. Furthermore, the quality of post-purchase services might depend on the size of the network and experience gained, as the case is with for example automobiles.⁵⁵ However, this process might be in motion only as long as the system is in a rapid growth phase. Liebowitz and Margolis doubt whether there is real evidence of the existence of network externalities. Instead the phenomena studied so far seem to point at technological progress or choosing to fix the time span of study at the very beginning of the development of a rapidly growing new technology instead of looking at the broad picture when also the maturing state of a technology is included. It is plausible that with increasing market penetration, network externalities will gradually disappear and the market becomes satisfied.⁵⁶ In brief, when a new technology based on some network has just been accepted, it tends to grow quickly, but with time growth slows down and the once rapid penetration rate becomes stable.

Arthur’s crucial point is that at the onset, it might be impossible to tell which technology will prevail. The process is random, and may end up in a technology with inferior long-term potential because of ostensible superiority in the immediate future. Moreover, once a technology has been chosen, it might be locked in, i.e. it is difficult to alter the path of development. In addition, the process is non-ergodic meaning that the small events that influence the process are not averaged away, but instead dictate the result.

⁵⁴ Arthur (1989).

⁵⁵ Katz & Shapiro (1985).

⁵⁶ Liebowitz & Margolis (2002/1994).

This is a process similar to that of Polya urns. Imagine an urn with two balls; say a red and a white. Pick randomly one of them, return it and add an additional ball of the same color as the one that was picked. This process will each time converge toward a certain distribution of red and white balls, but this proportion itself is a random variable. Thus every time this process is run, it will converge toward a yet another distribution;⁵⁷

“...a structure does emerge each time – but the structure that is “selected” is perfectly random.”⁵⁸

As a consequence, when transferring this reasoning to studies of technological change, Arthur, Ermoliev and Kaniovski find three key features. First, it is not possible to know a priori which technology will prevail. Second, there is no way to guarantee that the best technology will prevail, but an inferior technology might gain from increasing returns. Third, once any particular technology has become dominant after a process of increasing returns, it is difficult to change. Douglass North goes as far as questioning the assumption that competition actually takes place between technologies. Instead, it is at least equally likely that the winning technology is supported by firms possessing more successful organizational abilities and therefore the technology they promote will prevail.⁵⁹

In contrast to a Polya urn, when analyzing any real-life system, the possibility of identifying those causes that set a process of increasing returns in motion are very limited. We may identify some potentially important factors, but we certainly cannot take our assumptions for granted beforehand. It might be difficult even when a non-ergodic process has stabilized to pinpoint its actual causes and how it was set in motion. This reasoning boils down to the question whether or not we should accept the impossibility of full information about complex systems. But even if we cannot pinpoint the exact causes, the process as such can be understood, even if we are not likely to see it in progress, but only interpret it through the lens of the consequences. Does this reasoning for instance allow us to identify an ongoing non-ergodic process leading in what could be presumed to be the wrong direction?

⁵⁷ Arthur, Ermoliev & Kaniovski (1987).

⁵⁸ Ibid. p. 296.

⁵⁹ North (1990) p. 94.

The crucial issue, assuming we want to have deeper insights or influence, is to identify the relevant historical accidents. On the other hand, being able to state that there are processes in various systems that are beyond our control, we know something fundamental about the world. Moreover, we also develop increased awareness about the potential consequences of our actions, even if we have no safe information what they can be. In this manner, my aim with this work is not to present an attempt at writing a comprehensive history of the Estonian oil shale industry, but to focus on changes, both big and small, which in my judgement have been of decisive importance for the development of the oil shale industry.

Arthur points out that the non-ergodic process takes place only under a regime of increasing returns. Were the returns to be constant or diminishing, this process would not be set in motion. Furthermore, he stresses that there is no guarantee whatsoever in allowing a *laissez-faire* regime decide the outcome, thereby hoping that the superior technology would manifest itself as the sum of all individual choices. It is equally likely that the early adapters will embark on a path suiting their short term preferences, thus *de facto* levying a restriction on their successors on what technology to choose. The opposite of this *laissez-faire* solution would be “sponsored technology”, i.e. to delegate the choice to some “central authority”, but even in this case there would be a risk of choosing inferior technology.⁶⁰ This question will be discussed in detail below.

As was mentioned above, Stan Liebowitz and Stephen Margolis have taken a critical stand towards path dependence, questioning the relevance of the theory. They separate between three degrees of path dependence of which only the third implies path dependence in the sense put forward by Arthur. The statement that things are as they are today is a result of actions yesterday is trivial. They call this first-degree path dependence. There are no costs involved in breaking any such path, even if it is dependent on choices made in the past. This kind of path dependence is similar to habit.⁶¹

Second degree path dependence is a result of lack of knowledge at the time a particular choice is made and a path embarked upon. Only with hindsight can one judge whether or not an

⁶⁰ Arthur (1989).

⁶¹ Liebowitz & Margolis (1995).

inferior path was chosen. This form of path dependence is also quite trivial – the future cannot be known and still we have to make decisions.⁶²

Only path dependence of the third degree goes against neoclassical assumptions. This is the case when there is information on the long-term superiority of one technology, but some other, inferior, technology is chosen for its short-term profits. It is not clear whether this phenomenon actually exists. The cases presented so far, are, according to Liebowitz and Margolis, not enough proof, but rather stories presented in a certain light. They remain doubtful about the reasoning provided by David on the path dependence of QWERTY. Third-degree path dependence can only exist when there is somebody who is aware of the fact that an inferior technology is chosen, because if there is not, then the situation under study is second-degree path dependence. Instead, this well-informed somebody must to some degree fail to take corrective action, but may get hold of the superior technology in order to reap later profits.⁶³

Liebowitz and Margolis appear to present a strong case. If path dependence is defined as choosing an inferior option while there is knowledge of something better it might be truly difficult to find empirical evidence for this phenomenon. However, allowing for situations when certain paths are closed for institutional reasons, including the choice of a superior technology, we might still be locked in to this sort of path dependence. It can be argued that this can be boiled down to a question of transaction costs; were there no transaction costs, somebody somewhere would take steps to correct the situation. Such transaction costs might include organizing producers, users and the general public. Once costs for maintaining the technology in place become higher than the costs for adopting the competing technology, someone will introduce the new technology as long as there exists credible information about the superiority of the competing technology.⁶⁴

It is nevertheless likely that investment in a technology, with enormous long-term potential but no obvious profitability in the short-run, will not take place simply because of the time horizon. The case of renewable energy sources serves to illustrate this claim. Few people would disagree with the statement that the world needs to cut back on emissions from fossil

⁶² Liebowitz & Margolis (1995).

⁶³ Liebowitz & Margolis (1995).

⁶⁴ Lewin (2001).

fuels and invest in renewable technologies if present standards of living are to be maintained. Renewables are a superior technology when summing up factors like environmental impact, power production potential, long-term fuel supply etc. But they still face a shortage of investment and are usually heavily subsidized by governments. Were development left to market forces alone, crucial initial steps to develop renewable energy sources would perhaps not have been taken, because the short and even medium term profits are highly uncertain and the gains perhaps non-pecuniary, at least from today's horizon or as long as clean air is no tradeable commodity. But with investment wanting today, the advent of profitability will constantly be postponed in the future. Because of this, investors do not find reason enough to pour their resources into renewable technology instead of those technologies that are more profitable at present.⁶⁵

Furthermore, there is also the aspect of paradigms.⁶⁶ The concept of paradigm refers to a set of ideas, values and tools by which the solution to a problem is searched for. Naturally also the solution usually also becomes part of the paradigm. Related concepts in the study of technological development are technological regimes or trajectories (on which more later). So far, in today's oil-dependent world, further investment in technology related to the "oil-paradigm" has been likely to generate bigger profits than investment in technology related to a (possible) future "green-paradigm", although for some time already no educated person could honestly deny having information about the likely consequences of mankind continuing on the present path. Liebowitz and Margolis claim instead:

"Thus, in order for third-degree lock-in to occur, there must be agents who know enough to make correct choices but who fail to take advantage of the implied profit opportunities, and at the same time, adopters who generally know nothing more than the payoff going to the next adopter. These are very restrictive conditions."⁶⁷

⁶⁵ Observe that this is not to claim that renewables will never replace fossil fuels. But at present the steps taken in this direction require government intervention, because market forces will not do it alone. For a discussion on this topic, see Sandén & Azar (2005).

⁶⁶ The concept of paradigm is, of course, imported from Kuhn (1996/1962), who describes it in the following way: "*The study of paradigms /.../ is what mainly prepares the student for membership in the particular scientific community with which he will later practice. Because he there joins men who learned the bases of their field from the same concrete models, his subsequent practice will seldom evoke overt disagreement over fundamentals. Men whose research is based on shared paradigms are committed to the same rules and standards for scientific practice. That commitment and the apparent consensus it produces are prerequisites for normal science, i.e., for the genesis and continuation of a particular research tradition*" (pp. 10-1).

⁶⁷ Liebowitz & Margolis (1995) p. 216.

This sounds perfectly reasonable as long as environmental issues are not included in the account above, because as soon as the environment becomes a term in the overall equation the validity of the pure profit motive has to be questioned, that is, not fully integrating external effects in the calculations. We may choose a technology producing short-run profits, but at the very moment we make the choice we are likely to be aware that that technology is environmentally hazardous and will face a decline of future profits at some point in the future. Still full-scale switching to this environmentally sounder technology does not take place. This is the concept of path dependence in a nutshell. Lars Magnusson and Jan Ottosson present a few objections to Liebowitz' and Margolis' claim, namely that the selection process of, say, the best technology itself is path dependent and originating from social conditions and that choices might be based on the belief that the chosen path is superior.⁶⁸

It should be added that the institutional landscape is not given much attention either by Arthur, or by Liebowitz and Margolis. Although not explicitly mentioned, in their reasoning this landscape can be assumed to lack noteworthy restrictions. In any real-life setting there will always be numerous factors influencing the path taken, such as politics, values, geography, dispersion of natural resources etc, which can never be totally excluded from an analysis based on empirical evidence. It is easy to imagine restrictions on the implementation of a particular technology, which in itself might be superior, but which for political reasons is rejected. Such political reasons might be only implicit. One might suspect that there are certain societies, which could be called technology leaders, where gaining acceptance for some particular new technology is crucial – whatever the origin of that technology – if it is to become universally accepted. Such societies would presently be the European Union, the United States and Japan, while China or India may become such societies in the not too distant future. In brief, it can be concluded that approaches not addressing the institutional and cognitive framework are of limited value when analyzing a case such as the development of an energy-related industry. Therefore, when analysing processes that take place in the real world, one should perhaps talk about partially random developments.

Mark Roe has presented a typology of path dependence, according to which three types of path dependence are labelled 'weak', 'semi-strong' and 'strong'. The first type, weak path dependence occurs when a certain observable feature clearly is the result of past

⁶⁸ Magnusson & Ottosson (1997) p. 3.

developments, but there is no reason to assume it to be inferior from other outcomes. Weak path dependence is therefore close to the trivial statement that most structures we encounter in society have a unique past. Semi-strong path dependence implies recognized inefficiency, but there is no urgent need to change things as they are. Semi-strong path dependence has led to an outcome that is not optimal, but acceptable, in particular because of the costs of change. The strong form of path dependence, however, describes a situation when the costs of change would be lower than the inefficiency caused by the path chosen, but still the situation is not remedied. Such a phenomenon can occur when there is either a lack of information or when there are influential groups in society maintaining the status quo. In the case of information, it is oftentimes even hard to conceptualize the alternatives to the path taken. Choosing a certain path might also create a pressure group connected with the path ranging from politicians to investors to employees, which effectively block attempts at addressing the inefficiency built into the current state. According to Roe, the failure of many path dependence theorists to integrate this reasoning has opened the concept of path dependence to criticism.⁶⁹

In addition to the reasoning above, one particular aspect of real-life situations should be explicitly mentioned, namely that there are probably plenty of examples of arrangements- both institutional and technological- which can be labelled inferior even if there is no alternative that would unanimously be accepted as superior. Imagine an unsatisfactory situation from which there are several escapes, but no agreement on which one to choose. In this case, the probability of sticking to the existent arrangement will increase, because it is seen as a compromise, while each single alternative implies uncertainty to a degree that only broad consensus might overcome.

This reasoning can be illustrated the following way: assume a technology A is established and functioning relatively well, but there are widespread concerns about its drawbacks (such as external effects or long term perspectives). Assume also that there are three alternatives, B, C and D of which at least B and C are widely recognized as realistic, while technology D is more radical and consequently there is broad scepticism as to whether it can be applied. All technologies are mutually excluding (perhaps because of limited resources, which is often the case, especially in a smaller society). Moreover, now assume that adherents of each alternative technology find all other alternatives a worse option than to maintain status quo,

⁶⁹ Roe (1996).

perhaps because implementing any other technology would definitely shut out their own favored technology. There is also a minority preferring technology A. Now, unless any competing technology gains support from a majority (of, say, relevant decision makers), A will remain in place. Even if supporters of B and C might agree, they will perhaps not be joined by the supporters of the radical solution D, who rightly or not fear that implementing either B or C will postpone D more than if A is maintained.⁷⁰

In order for A to be replaced, adherents of competing alternatives would first have to agree upon a particular alternative, which in most cases is likely to be time consuming. Ultimately change may take place, but at a pace that most people involved would find unsatisfactory. Of course, with increasing resources for testing various alternatives, more convincing arguments in favor or against each technology can be produced and therefore shorten the time needed for a change.

3.2.2. Co-evolution of technology and institutions

Economic and technological processes are evolutionary in character. New ideas, solutions, techniques, methods replace older ones, sometimes gradually, sometimes in a revolutionary fashion. Such processes – famously named “the perennial gale of creative destruction” by Joseph Schumpeter⁷¹ - take place not in a vacuum, but within a framework defined by institutional arrangements, which erect an outer wall encompassing the entire space of economic and technological activity, but also to various degrees interfering within that space.⁷² But what are institutions, actually? In this context the most common reference is perhaps Douglass North, who defines institutions as the *rules of the game*.⁷³

“Institutions, together with the standard constraints of economic theory, determine the opportunities in a society. Organizations are created to take advantage of those opportunities and, as the organizations evolve, they alter the institutions”⁷⁴

⁷⁰ For a real-life illustration of this reasoning, let A be present fossil energy technology, B nuclear power, C cleaner fossil technology and D renewables.

⁷¹ Schumpeter, J. (1975/1942) p. 84.

⁷² The concept of this sphere is borrowed from Karl Polanyi, who describes the market embedded in institutions. Polanyi (2001/1944).

⁷³ North (1990) p. 3.

⁷⁴ North (1990) p. 7.

North distinguishes between formal and informal institutions. The latter are based on cultural traits and are, as a rule slow to change, while the former could be simplified as codified rules.⁷⁵ Institutions restrict available choices, which simplify decision-making:

“The computational limitations of the individual are determined by the capacity of the mind to process, organize, and utilize information. From this capacity taken in conjunction with the uncertainties involved in deciphering the environment, rules and procedures evolve to simplify the process. The consequent institutional framework, by structuring human interaction, limits the choice set of actions.”⁷⁶

There is a vast literature on institutions, which cannot be recapitulated here. It should suffice to mention just a few, more or less related perspectives provided by Bart Nooteboom, Richard Nelson and Bhaven Sampat, Geoffrey Hodgson, and Paul Pierson. The reason for treating institutional change superficially in this work is that the object under study (i.e. the Estonian oil shale industry) has only marginally instigated institutional change, but instead oftentimes been under pressure to adjust to such changes. Therefore institutions and institutional change will by and large be treated as exogenous factors in this study. Instead, focus will be on how institutional change has affected the oil shale industry.

According to Nooteboom’s definition, institutions are the guarantors of predictability in behavior in the economy, thus reducing transaction costs emerging from opportunism. Moreover, stable institutions also limit the need for detailed regulations, because they enhance trust in the society. People will weigh any opportunistic gains against the social costs of violating the rules (i.e. institutions). Norms stipulated by institutions become internalized by the members of society and thus they become routines.⁷⁷

Nelson and Sampat approach institutions from the perspective of *social technology*, which is how *knowledgeable people act and interact* with the accomplishing of any task is the result of coordinated action. Thus *institutionalized social technologies* become the way to reduce transaction costs and to avoid wastefulness. Institutions might also become obstacles by not being in concord with, say, new technology or situations of scarcity.⁷⁸ Paul Pierson mentions

⁷⁵ North (1990) chapters 5 and 6.

⁷⁶ North (1990) p. 25.

⁷⁷ Nooteboom (2002) p. 100.

⁷⁸ Nelson & Sampat (2001).

that institutional development is highly path dependent. Institutions affect everybody, exit is not an option like in the market, and they form peoples' lives by encouraging certain skills, certain behavior and social identities.⁷⁹

Many of the aspects on institutional change could be applied to basically any type of society. For instance, the rise of the industrial state took place in concurrence with major institutional breaks.⁸⁰ But the forces put in motion by the industrial revolution - the rapid advances of technology - created a changing field of interaction between institutions and technology. For the past 200 years it has been increasingly difficult to separate institutional development from technological.⁸¹ It is indeed hard to imagine a society exhibiting both today's technology and pre-industrial institutions.⁸² But we are left with the question which one is the prime mover, technology or institutions? Is new technology forcing institutions to change or are institutions de facto selecting the technology needed? Or do they co-evolve, both reshaping each other?

An observation put forward by Matthews is that institutional change is oftentimes more complicated a process than technological change, because technology is more prone to the effects of selection mechanisms than institutions.⁸³ This means that a bad technology is likely to be punished sooner than a poor institution, while good technology will be more easily rewarded than efficient institutions. But on the other hand, investments made in a particular technology can be of such a magnitude that the costs of change can be deterring. This is rarely the case with institutions.⁸⁴ But technological change in general faces fewer obstacles than institutional change for several reasons; the need for consensus is less typical, technical objects are less complicated than people, pure science supports technology more than social issues, and finally, in the end nature has the final say whether technology works or not.⁸⁵ This cannot be applied to institutions.

⁷⁹ Pierson (2000).

⁸⁰ The Enlightenment preceeded the industrial revolution, and one might ask whether the latter would have been possible without the former. The idea that mankind could improve its lot by economic activity was a radical shift in thinking.

⁸¹ It can be asked whether the concept of national innovation systems is an attempt to definitely weld technology and institutions together.

⁸² Yes, there are societies in today's world trying to combine these two, but with poor outcomes, at least with respect to the general well-being of the population or parts of it.

⁸³ Matthews (1986).

⁸⁴ But it could be asked whether the costs actually are an institutional issue, not a technological one. Technology does not pay for technology – institutions (in some sense) do, but are they prepared for the resulting social strain. Some institutional set-ups might be far superior to others in handling such transformations.

⁸⁵ Matthews (1986).

In the end, it is the institutional construction of a society that decides the capacity to adopt new technology and to foster long-term growth— or to reject inferior solutions. Technological change shapes institutions and vice versa. Moreover, institutional change is not tailor-made from the onset, but the result of numerous trials and errors, learning from mistakes.⁸⁶

Technological development can be perceived as dwelling within a larger mental framework, a paradigm, in a similar fashion to how the philosopher Thomas Kuhn describes “normal science”. A breach with this sort of normality is what Kuhn calls a scientific revolution.⁸⁷ Similarly, technological development can also be claimed to take place within a technological paradigm, the overturning of which is nothing short of a revolution. But technological development perceived as a mindframe is closely related to what was previously said about informal institutions being sets of values and cultural traits, which change only slowly even if formal institutions undergo significant change. Similarly, the mindframe or paradigm need not change even under periods of rapid technological change. We are, by and large, still stuck with the same fossil paradigm that came into being more than a century ago.

Following Giovanni Dosi, a technological paradigm can be identified on the basis of the “generic tasks” which it is focused on, the material or technology it has chosen to use, the physical and chemical properties and finally the broader technological and economic issues it must address. Technological paradigms tend to exclude other technological possibilities:

“The efforts and the technological imagination of engineers and of the organizations they are in are focused in rather precise directions while they are, so to speak, “blind” with respect to other technological possibilities.”⁸⁸

Within a technological paradigm there can be several technological trajectories, which, in Dosi’s words, are:

“the “normal” problem solving activity defined by the paradigm⁸⁹ or similarly a: ”model” and “pattern” of solution of **selected** technological problems, based on **selected** principles derived from natural sciences and on **selected** material technologies.”⁹⁰

⁸⁶ Nelson & Sampat (2001).

⁸⁷ Kuhn (1996/1962).

⁸⁸ Dosi (1982).

⁸⁹ Dosi (1982).

⁹⁰ Dosi (1982).

The more sets of technologies a trajectory excludes, the more powerful it is. But switching away from a powerful trajectory is difficult, especially if no alternative trajectory has reached the same level on its “technological frontier”. The technological trajectories can either complement or exclude each other.⁹¹ There are, Dosi points out, difficulties in judging the qualities of different trajectories. This can only take place ex-post, but still comparisons between various trajectories are hard to make. Only within a trajectory or within a technological paradigm does a comparison become fruitful.⁹² Which technological trajectory is chosen depends on various factors, but to some extent the decision is political. Key determinants are the economic interests of organizations financing R&D, and the previous record of a particular technology and institutions, for instance the government.⁹³ An interesting question is how experiences from two or more different trajectories can be combined. In a study of the use of new biotechnology in the Scandinavian forest industry, Staffan Laestadius arrives at the conclusion that attempts at such mergers of trajectories can be repulsed through lack of mutual understanding despite promising perspectives.⁹⁴

The historian Thomas P. Hughes has introduced the concept technological momentum, by which is meant how *social development shapes and is shaped by technology*.⁹⁵ Hughes defines technological systems as consisting of both social and technical components interacting, developing a sort of motion, which is called momentum. Moreover, technological momentum is *time dependent*, so that the older and more complex the technological system grows, the more it shapes its environment rather than vice versa. The technological system, which evolves, or has a momentum, is also built up by knowledge (including acquired skills), special purpose machinery, processes, large infrastructures and particular organizational arrangements. In addition to this, education is often directed towards satisfying the needs of a technological system. Shaping the technological system is easier when it has not yet become

⁹¹ Dosi mentions nuclear or oil power-generation as examples of powerful trajectories (p. 154). However, he does not elaborate on what sets of technology these trajectories actually exclude, but one can assume that those two trajectories have excluded most other potential technologies. This has only changed in recent years, when renewable energy sources have become the topic of the day.

⁹² Here Dosi seems to equate trajectories and paradigms, which runs contrary to his previous definitions, according to which a trajectory is something within a paradigm. Thus it should be possible to compare two trajectories within the same paradigm, while comparing trajectories within different paradigms might be more complicated. When defining nuclear or oil as sources for power generation as trajectories, we can compare them with respect to their power generating capabilities within the paradigm focused on maximal energy production. If we the shift to a “green” paradigm, i.e. focusing on environmental issues, the criteria for comparison change and the trajectories are assessed otherwise.

⁹³ Dosi (1982).

⁹⁴ Laestadius (2002).

⁹⁵ Hughes(1998) p. 102.

entrenched by political and economic interests, although it is, of course, never entirely impossible to change the direction of the momentum at a later stage.⁹⁶ The economic historian Mats Bladh has commented on this interpretation of momentum that it tends to become something rather mystical, a process characterized by the absence of humans.⁹⁷

A specific case of coevolution of technological and institutional change is what Hughes has introduced as large technical systems or LTS. An LTS is comprised of both technological components and social factors, such as organizations or laws. Each component has its role in an LTS and if any component is removed or altered the LTS will change accordingly. At the very core of an LTS lies technology, but as a consequence of its size, the LTS is not only shaped by the surrounding society, but also vice versa. Examples of LTS abound, but typical examples could be the railway system, the telephone or nowadays perhaps better the information-telecommunication network, the traffic network, electricity etc.⁹⁸

The LTS is constructed by a number of people, having various roles. Few are both technical inventors and creators of organizations, and these two roles tend to be more separated the more the LTS develops. Such system builders have:

“The ability to construct or to force unity from diversity, centralization in the face of pluralism, and coherence from chaos.”⁹⁹

It can be questioned whether individuals can be seen as playing decisive roles in the construction of an LTS, which because of its sheer size would diminish the likelihood of prominent characters dominating the process. Nevertheless, the fact that an LTS usually develops as a result of collective efforts, while individual achievements remain in the background, does not necessarily exclude the possibility of prominent individuals being a crucial part of the success (or failure) of an LTS. Such questions can only be solved case by case when studying each particular LTS. With increasing scale, a comprehensive and detailed insight into the entire system becomes less and less possible for any individual. At this point the system can only be seen as the result of actions of a collective.

⁹⁶ Hughes (1998) pp. 103-112.

⁹⁷ Bladh (2006).

⁹⁸ Hughes (1997).

⁹⁹ Hughes (1997) p. 52.

One particular aspect of an LTS is that its existence gradually becomes self-evident and taken for granted, especially when it operates without disruptions. But serious malfunctions in an LTS will likely stir up strong emotions in society¹⁰⁰ (it probably suffices to mention the LTS of electricity). However, the user or the consumer has more or less been omitted from the concept of LTS. This omission is remarkable considering that Hughes uses the construction of electric networks as a case in point and that production and consumption of electricity have to be equal in order to maintain the functioning of the system. Therefore the system has to be in balance between input and output.¹⁰¹

This work is not intended to be an example of an LTS, but the approach stemming from Hughes contains several observations which are of utmost importance when studying path-dependent phenomena in their institutional surroundings. If path dependent processes in large infrastructure processes are to be understood, it does not suffice to refer to examples stemming from rather minor occurrences under allegedly institution-free circumstances.¹⁰²

Institutions and technology interact regardless of the political system of a society. Thus it is important to stress that institutions and technology co-evolve even in the absence of political democracy or market economy. The very mechanisms of this interaction may vary, but the fundamentals remain basically the same. The fact that societal arrangements other than market economies have produced inferior outcomes does not have any major impact on the explanatory value of this assumption. According to Daniel Bromley, institutions are the *choice sets of independent economic actors*, defining the scope of action for anyone within the sphere of the institutions.¹⁰³ This reasoning applies both to individuals and groups. Thus institutions are not only the formal ones (like laws, organizations or executive power) but also codes of conduct generally adhered to in society. For one or the other reason, the influence such institutions have on economic activity has been taken lightly in traditional economics. Institutions define the actions possible for any actor in the society. This encompasses the choices that can be made, the relations between members of society, and regulations on what people can do to other people. Bromley continues:

¹⁰⁰ Joerges (1988).

¹⁰¹ Bladh (2006).

¹⁰² I claim that the competition between video recorders or keyboard arrangements represent minor technological issues in comparison to energy-technological systems.

¹⁰³ Bromley (1989).

“In a centrally planned economy these are the quotas of inputs, the production plans, the accounting prices, the shipping schedules, the supply of dwellings, the availability of jobs, and the like. These institutional arrangements define the space within which individuals and groups are free to exercise decision-making discretion. In a market economy institutional arrangements consist of a different constellation of constraints and opportunities – the tax laws, wage rates, contractual obligations for workers, product liability for commodities, health insurance premiums and coverage, working conditions in factories, farms and mines, and the like.”¹⁰⁴

In a market economy it is clearly the ability to make profit that is decisive for the future existence of any firm. In order to maintain this capability, the firm has to adapt to changes in the environment. From this viewpoint, Armen Alchian criticized the maximized profits approach to the firm. Firms act in a selective environment, where the decisive property for survival is not some hypothetical profit maximization, but the ability to produce profit. Also the competitors are real firms, not hypothetical profit maximizers. This implies that success is relative to the environment. Furthermore, uncertainty being a constituent feature in the world, pure luck may be more important than any calculations. If there is a variety big enough in human behavior when confronting risks, it is possible that some of this behavior will a posteriori turn out to have been optimal, although it could not have been judged beforehand. The behavior in the economy is basically twofold: either imitation of success or trial and error. Imitation or replication of success is rather obvious in an environment where the costs of failure can be disastrous. But this takes place not because the object of emulation would be a profit maximizer, but instead for being a profit maker. Trial and error, in turn, may produce innovation, which in turn produces profit.¹⁰⁵

It can be perceived as somewhat paradoxical that the institutional turmoil that Estonia experienced during the 20th century both restricted the development of the oil shale industry, but also allowed or forced it to develop various capabilities, which otherwise might had disappeared altogether. In her famous work on the firm, Edith Penrose argues that firms exist not only due to some blind selection mechanism, but they are also the products of human willpower. The capacity of firms to adjust to changing circumstances is a function of their temporarily unused capabilities (which Penrose calls services).¹⁰⁶ Following this line of

¹⁰⁴ Bromley (1989) pp. 740-1.

¹⁰⁵ Alchian (1950).

¹⁰⁶ Penrose (1995/1959).

thought, it could be claimed that several capabilities were embedded but not directly visible throughout the existence of the oil shale industry, which from time to time turned out to be the best match with prevailing institutional aims. This aspect might be of great importance in understanding how the oil shale industry adjusted to the selection mechanism, which was rarely the market as such, but an institutional arrangement.

3.2.3. Knowledge as a path-dependent process

There is an old tradition in economics to compare the evolutionary processes in the economy with biological evolution. In all but the most extreme standpoints, similarities are seen as analogies rather than mutually transferable concepts. Alfred Marshall assumed that a mature economics science will have to look for analogies from biology instead of the physical sciences.¹⁰⁷ The decisive difference between economy and biology is that only human beings can make a decision to adapt. Only humans can make a conscious attempt to develop knowledge to promote survival. And only humans can identify the nature of a change and even anticipate an upcoming change by scientific logic or intuition and take appropriate measures to cope with the new circumstances. Knowledge is the principal difference between evolutionary processes in nature and in human created societies.¹⁰⁸

Those people making the decisions - be it an industry or a society or some other human-created entity - will form some sort of a group, have some sort of aggregate knowledge, some beliefs, and face some sorts of limitations due to technological development (at least in the short run) and facts of nature, such as the existence of raw materials. It is the action of such groups that impose motion (or momentum) in the path of development. This phenomenon was not unknown to the American institutionalist Thorstein Veblen in the closing years of the 19th century, who noting that economics showed strong traits of path dependence (although without using the concept), reaches the conclusion:

¹⁰⁷ Marshall (1898): *In this vital respect [the evolutionary processes] all sciences of life are akin to one another, and are unlike physical sciences. And therefore in the later stages of economics, when we are approaching nearly to the conditions of life, biological analogies are to be preferred to mechanical, other things being equal.* p. 43.

¹⁰⁸ A thorough discussion of the applicability (or rather non-applicability) of biological metaphors in economics is to be found in Freeman (1992) pp. 121-142.

“Under the stress of modern technological exigencies, men’s everyday habits of thought are falling into the lines that in the sciences constitute the evolutionary method; and knowledge which proceeds on a higher, more archaic plane is becoming alien and meaningless to them. The social and political sciences must follow the drift, for they are already caught in it.”¹⁰⁹

The issue of efficiency and evolution could be described in the following way: imagine three subsequent periods in time, called A, B and C. Certain structures might be efficient at A and C, but disastrously inefficient at B. When the system moves from A to C over B, the particular structures, so efficient at A will be lost at B and thus no longer exist at C. As long as we are dealing with human activity, such as a firm, what has been lost could in theory be reconstructed later. The accumulation of knowledge runs, perhaps surprisingly, contrary to this. If the time elapsed between A and C is long enough, new structures have developed in the meantime and have maybe gained enough accumulated knowledge to be viable enough to hinder the return of the lost structure.¹¹⁰ According to Richard Nelson, evolutionary processes may reach an equilibrium, but not in the same sense as in traditional economics.

“the equilibrium is strongly path dependent, and today’s “optimum” may be very local and likely poor stuff compared to what might have been.”¹¹¹

Hence there is, according to Geoffrey Hodgson a serious shortcoming in the theories which tend to end up with a “panglossian” view, i.e. that existing structures, created in an evolutionary process, are the most efficient ones for the sole reason that they have survived.¹¹²

In many respects technology *is* knowledge; without knowledge there would be no technology and knowledge is embedded in technology.¹¹³ On the other hand – and this is my purpose in addressing the topic of knowledge in a separate chapter – any further development of technology requires knowledge. Once technology is in place, it can to a certain extent be used

¹⁰⁹ Veblen (1898) p. 397.

¹¹⁰ There is a rather common misconception that biological evolution would ultimately lead to the “survival of the fittest”. This view has little credibility in biology. Instead those traits that best correspond with the challenges of the environment are strengthened, but at the same time the successful survival of a species is favoured by a large genetic pool, which supports the survival of not only “the fittest”. For a thorough analysis of modern evolutionary theory in biology, see Mayr (2002).

¹¹¹ Nelson (1995) p 58.

¹¹² Hodgson (1991).

¹¹³ For a discussion on this relationship, see Constant (2003).

by people without comprehensive knowledge of its principles.¹¹⁴ But if technology is to be developed further, knowledge becomes crucial. Such knowledge could, of course, be gained gradually by experience by previously ignorant people, but then again, they would have gained knowledge. Moreover, for technology to develop, the knowledge base has to be sufficiently broad. In principle this implies the existence of a professional community dedicated to the development of any particular strand of technology. In this work, I will repeatedly refer to what I call the Estonian oil shale community, which is the group of professionals of various disciplines engaged in oil shale technology. The combined actions of this group (including also sub-groups more or less opposing each other) are a key to understanding the processes the Estonian oil shale industry has undergone.

Knowledge, which has not always been separated from the concept of information, has been highlighted by Friedrich Hayek, who put focus on the disperse character of economic information¹¹⁵. Any attempts at detailed planning of the economy will encounter the insurmountable problem of gathering all the relevant information. This information exists, nevertheless, but is spread between the numerous agents of the economy. Because of this, decision-making has to be de-centralized in order to be efficient. All economy is about planning, but the question is how centralized this planning ought to be. Hayek thus distinguishes between scientific knowledge and *knowledge of the particular circumstances of time and place*.¹¹⁶ The former shows similarities with the concept codified knowledge, while the latter could be said to share certain attributes with tacit knowledge, a concept introduced by the philosopher Michael Polanyi.¹¹⁷ This “knowledge of the particular circumstances of time and place” is essentially the reason why central planning becomes inefficient. This knowledge can not easily be forwarded and it can not be presented statistically. Thus only those “on the spot”, possessing this knowledge, can take appropriate action when circumstances change.¹¹⁸

¹¹⁴ For example, I write this text on a computer, the actual functioning of which I only remotely understand. I am in no position whatsoever to develop this technology.

¹¹⁵ Hayek (1945).

¹¹⁶ Hayek (1945) p. 521.

¹¹⁷ Polanyi (1978/1958).

¹¹⁸ Hayek puts up a strong case against centrally planned economies with this reasoning. However, one of the aims with this work is to show that even a centrally planned economy had to give in to this challenge from reality. The changes in the Estonian oil shale industry between 1944 and 1991 give ample evidence of dynamics under the static surface.

Dominique Foray separates knowledge from information. While the latter is usually codified – or can be codified – the former stands for cognitive capability. The character of this type of knowledge is tacit. Approaching knowledge from this angle leads to complications for attempts at quantifying development. Thus, measurable indicators, such as levels of R&D, become only distant approximations of the processes under study. Knowledge is, by and large, heterogeneous, unobservable, there is no unequivocal link between input and output, and the total stock can not be measured.¹¹⁹ A related argument is put forward by Edward Constant. Technological evolution is based on recursive practices by engineers and scientists. Knowledge is embodied in numerous artefacts and practices, which in turn are used to further the increase of knowledge and more innovation. Thus what evolves in technological evolution is knowledge.¹²⁰ In traditional economics, technological knowledge is presented as a “book of blueprints”, which is directly accessible and more or less complete. This way of presenting knowledge obviously has its serious shortcomings, including the fact that it has little to do with actual observations. Producing a complete “book of blueprints”, including every detail that would have to be performed, would really be a daunting task. Neither is there any “chief engineer”, a single person possessing all the relevant knowledge.¹²¹

Gunnar Eliasson argues that knowledge is fundamentally what today’s economic processes are all about. The state or the government has lost its role as the key unit in understanding the economic processes. Knowledge is the input, while quality is the output. Neither can be properly measured.

“Our economic sensors will only be able to pick up a noisy reflection of the ongoing “hidden” production process, namely a positive return to these unmeasurable quantities, reflected in above-normal returns to measured capital in the capital market.”¹²²

The management of the process takes place in organizations, which in turn draw the outer boundaries for *the innovative, coordinating, filtering and knowledge transfer processes of the economy*.¹²³ Organizations thus become the memory of the economy, resulting in path dependence.

¹¹⁹ Foray (2004) pp. 9-10.

¹²⁰ Constant (2003) p. 224.

¹²¹ Nelson & Winter p. 60.

¹²² Eliasson (1990) pp. 16-7.

¹²³ Ibid. pp. 15-6.

A related argument has been presented by G.N. von Tunzelmann, according to whom firms are a sort of knowledge-processing units. They transform knowledge of technology (which they either develop themselves or obtain from exogenous sources) into knowledge of products and markets.¹²⁴ Disconnecting these two aspects of knowledge will produce inferior results.¹²⁵ According to von Tunzelmann, the basic weakness of the Soviet Union was its relatively poor performance in this transformation process, which followed from the incorrect assumption that technology and products are complementary. With focus put on mass-production, neither technology nor products were developed.¹²⁶ However, I will argue in this work that throughout the Soviet period, the Estonian oil shale industry tried to avoid ending up in such a situation, sometimes successfully.

Richard Nelson and Sidney Winter claim that knowledge resides in the firm as a whole. It is not the aggregate of competencies and capabilities of employees and equipment of the firm, but rather the entity composed of the various parts that form the firm.¹²⁷ Knowledge is subject to change, either intentionally or incidentally. Intentions can either be trivial and cheap or complicated and expensive, such as research. Incidents can on their side also be unwelcome, for example a break-down of machinery. Knowledge increases when employees learn by doing and decreases when skills are not kept up.¹²⁸ Knowledge diffusion between firms takes many shapes, but is certainly not a result of market pricing signals alone. Instead, personnel is exchanged, reports published, patent applications handed in to authorities, researchers meet, consultants gain broad experiences and firms are bought and sold. Knowledge can also be obtained when performing R&D under government contracts or from customer feedback.¹²⁹

What we will know in the future is to a large degree based on what we know today. The very character of knowledge is cumulative. True, knowledge may be lost, but the overall tendency is cumulative increase. Rosenberg describes this cumulative character of technological development:

¹²⁴ von Tunzelmann (1997).

¹²⁵ von Tunzelmann (2003) p. 187.

¹²⁶ Ibid. p 395 & 398.

¹²⁷ Nelson & Winter (1982). p. 63

¹²⁸ For a concretization of this reasoning, see the account of the Estonian engineer Juhan Tomberg quoted in chapter 6.1.1. Such learning by doing took place even during the Stalinist period of course.

¹²⁹ Nelson & Winter. p. 65

“There is always a huge overhang of technological inheritance which exercises a powerful influence upon present and future technological possibilities. Much technological progress at any given time, therefore, has to be understood as the attempt to extend and further exploit certain trajectories of improvement that are made possible by the existing stock of technological knowledge.”¹³⁰

This is what Rosenberg calls *soft determinism*, implying that history matters, that technology develops in a certain direction because of historical circumstances, often through a chain of small improvements on a particular technology. This is, of course, a derivative of Kenneth Arrow’s concept of learning by doing.

“Learning is the product of experience. Learning can only take place through the attempt to solve a problem and therefore only takes place during activity.”¹³¹

Arrow’s renowned phrase has been referred to in a variety of contexts. In this context, it is worth mentioning Nebojsa Nakicenovic’s modelling of new technology for the abatement of CO₂ emissions. Postponing investment in such technology because of high up-front costs will cause an overall loss over time compared to a scenario where investment is made following exogenous developments in R&D. Hence, learning by doing seems to have stronger positive effects than, say, waiting for publicly sponsored R&D to cause a decline in initial costs.¹³² It is no simple task to determine where the division line runs between deep understanding and learning by trial and error. Staffan Laestadius shows that even when a technology is well known (in his case paper production units) it is no straight-forward process to make it operational. The underlying reason is that technology is not only machinery as such, but a system, composed of several sub-systems. Thus engineers, technicians and operators have to develop a systems competence.¹³³

Knowledge should be treated as a *collective and path-dependent complex process*, according to Cristiano Antonelli, or in other words a response to previous views of knowledge as a public good or semi-private good. Because information is neither equally accessible for everyone nor wholly possible to codify (and thus have patent rights), the concept of knowledge has to be broadened. Following Antonelli, knowledge is a process of interaction,

¹³⁰ Rosenberg (1994) p. 16.

¹³¹ Arrow (1962).

¹³² Nakicenovic (2002).

¹³³ Laestadius (1998).

existing locally, but also reinforced externally. There is no possibility to concentrate knowledge to any single actor because of its fragmented and dispersed character. The change in the overall knowledge base takes place as agents possessing their various pieces of knowledge interact intentionally, or when market selection pulls knowledge development in a certain direction. The resulting process is path dependent, because the dynamic system (of knowledge) is constrained, i.e. the system has outer boundaries. Against this background the state (or “central authority” as described in the next chapter) has an important role as coordinator.¹³⁴

“The State can play a key role in the emergence of dynamic coordination among the variety of heterogeneous players involved in the generation of knowledge as a collective, complex and path dependent process. Specifically the State can specialize in the direct supply of knowledge, by means of University and Public research centers, only when it has high levels of fungibility, that is, knowledge with a wide scope of applications in a broad array of activities and high levels of incremental enrichment.”¹³⁵

Moreover, the role of the state is not limited to the supply of knowledge, but it can also communicate codified knowledge from science to enhance development of technological knowledge, primarily within firms. In addition to this the state can set up long-term goals on where to put emphasis on knowledge development.

Technology is not only path dependent as such, but it often also decides the direction of scientific knowledge creation. If the technological capabilities of a society enhance the use of any particular scientific knowledge, such knowledge is likely to be commercially exploited. In addition to technology, also organizational and marketing-related capabilities will have a heavy influence. Thus not only today’s technology as such or strictly economic calculations will direct the trajectory – or path – of tomorrow’s technology, but a combination of several factors. Dosi follows this train of thought by arguing that the direction of technological development can be laid down by the initial decisions where to look for new solutions. Thus path dependence is maintained by the bulk of knowledge – although not solely.¹³⁶ A question put by John Enos is whether innovation aims at substituting an abundant resource for a scarce

¹³⁴ Antonelli (1995).

¹³⁵ Antonelli (1995) p. 69.

¹³⁶ Dosi (1997) p. 1543.

one. If this is the case, for instance cheap capital for expensive labour, the direction of the path embarked upon could in retrospect be explained by shifts in relative factor prices.¹³⁷

In brief, knowledge makes the difference between evolution in nature and in human-created societies. If we wish to understand the evolutionary path of particular technologies, it is the topic of knowledge formation that has to be addressed. This approach limits the role of random developments, but does certainly not exclude them altogether.

3.2.4. The scope for remedies

As has been discussed so far, path dependent processes may lead to outcomes that are beyond our direct control. Sometimes these outcomes are quite unwelcome. Some crucial pieces of information may forever be obscure, of which perhaps the most important is the question of ex-ante knowledge of which systems are prone to non-ergodic processes. What are the conditions for the emergence of such processes? A minimal condition is the existence of two or more alternatives. Another is some sort of potential payback mechanism for choosing any particular option. A third condition, when it comes to human actors, is that there is no manifest striving in another direction: As long as one accepts the notion of human free will, no non-ergodic process can run contrary to collectively expressed (strong) preferences. The difficulty when analysing conditions for non-ergodic processes is that it can be difficult to establish whether or not they lie dormant in any given system before the process is set in motion. The purely theoretical model described previously suffers from the shortcoming that it can only occasionally be used to describe actual processes in society. In reality there will always be institutional constraints forcing the non-ergodic process in a certain direction.

Firms in certain branches have better chances of survival under changing circumstances than others due to their field of activity. Electricity is certainly more demanded under any institutional set-up than, say, video recorders. This feature of particular branches has been observed by the sociologist Langdon Winner, according to whom certain large-scale technologies are *inherently political*, i.e. their very structure requires certain institutional arrangements and they are therefore less prone to the forces of evolution.¹³⁸

¹³⁷ Enos (1962).

¹³⁸ Perhaps there exists an analogy for this in the realm of biology, but finding it would require effort not compatible with the intention of this work.

“...the initial choice about whether or not to adopt something is decisive in regard to its consequences. There are no alternative physical designs or arrangements that would make a significant difference; there are, furthermore, no genuine possibilities for creative intervention by different social systems – capitalist or socialist – that could change the intractability of the entity or significantly alter the quality of its political effects”¹³⁹

Limitations created by institutions can be grossly simplified to decisions made by a central authority. Such a point is raised by Robin Cowan.¹⁴⁰ Could non-ergodic processes be avoided by not allowing the market forces to have the final say, but instead allowing the government to pick the technology it deems more fit in the long run? However, part of the problem remains – the government or central authority may make the wrong choice, or in Cowan’s words:

”Suppose the bad technology is used, but that it produces good results. Not getting a bad reading, the central authority would be inclined to use it again. This can continue for many adoptions. But each time a technology is used it advances along its learning curve, so the expected value of its true benefits increases. If this technology continues to be used, it will eventually have advanced sufficiently along its learning curve that the other one, no matter how good, will have been left behind.”¹⁴¹

Cowan argues that when there is uncertainty about the merits of competing technologies, markets will avoid experimentation with the technology that is perceived inferior, thus creating a lock-in relatively quickly. A central authority can intervene and push for a certain outcome, but in the case of complex technical systems, where a long period of learning is inherent, those forces that strive towards a lock-in are further strengthened. Thus a central authority might become a part of the problem itself. Cowan continues:

“Finally, if it is important that the best technology be the one to which we lock in /.../ fiscal conservatism will have to be forsaken. In order to determine absolutely that one of the technologies is best, it would take an infinite expenditure, and an infinite amount of time. To be reasonably certain that we have the best technology will involve a very large expenditure. Any attempt to rationalise this expenditure will introduce a bias into the technology selection process/.../”¹⁴²

¹³⁹ Winner (1980) p. 134.

¹⁴⁰ Cowan (1991).

¹⁴¹ Ibid.

¹⁴² Ibid.

Thus, what actually is the better technology becomes more difficult to pinpoint. If a particular technology is not used, it is not possible to say anything about its qualities. On the other hand, Cowan claims, the technology from which there is more experience tends to be favoured instead of any new technology.¹⁴³ This technological conservatism can affect any central authority, which as a consequence is biased when choosing between two technologies, thus increasing the risk of being locked-in with an inferior technology. There probably exist central authorities which are more eager than others to implement radical new technologies, sometimes even at enormous cost. The underlying reasons for this might in turn be sought after in social values, ideologies, previous experiences etc. Two aspects should be taken into consideration. First, a central authority allowing costs for finding the best technology to increase without ceiling, or in Cowan's words to "forsake fiscal prudence", will under democratic conditions most likely lose its popular support, although this will be a function of the size of the resources used as well as general values in society. Second, presuming non-democratic conditions in a society would seemingly allow the central authority to act without having to react to popular opinion. However, even such an authority will face alternative costs restricting the scope for excessive costs within one sector. Theoretically, there is the possibility that the resources needed for any superior technology to gain the upper hand are of such a magnitude that the society simply lacks the means. It can even be speculated whether there are technologies that, possessing whatever superior qualities, are way beyond the financial (but not technological) resources of present-day mankind.

This reasoning is related to that put forward by Atkinson and Stiglitz, who address localized knowledge, i.e. circumstances when there are no large-scale spill-over effects from introducing a new particular technology to other related technologies. Under such circumstances the role of government would be to direct firms to pick a technology and support it in order to achieve long-term goals. The follow-up question is, of course, which technology? As soon as any particular technology is chosen as the target for government support, knowledge creation within that particular technology will increase and leave other technologies behind (still assuming the absence of significant spill-over effects). When technical knowledge is localized in this respect, the process of technological development becomes an important issue.¹⁴⁴

¹⁴³ Ibid.

¹⁴⁴ Atkinson & Stiglitz (1969).

Robin Cowan also points out that the magnitude of differences between technological options is a factor that has to be addressed. If one technology is obviously superior to some other technology, the risk of being locked-in to the inferior technology is minimal. If the difference is smaller, the risk increases. But obviously the drawback of ending up with the inferior technology in the latter case might be of less importance.¹⁴⁵ This reasoning is complicated by the fact that what might be perceived as a minor difference today may turn out to be a major difference in a few decades, when advance is made along the learning curve. And decades are, after all, the time span in which technological development can be evaluated.

The outcome of a path dependent process is often called lock-in, by which usually is meant a situation where the chosen path (or trajectory) is extremely difficult to alter. A lock-in is thus not to be confused with the concept of equilibrium, although both indicate an outcome. A lock-in remains a process, or more precisely the direction of a process – contrary to other possible directions. It is often assumed that the phenomenon of lock-in should be considered a negative outcome of a path dependent process, closely related to a lack of dynamism.¹⁴⁶ An example of this reasoning has been provided by Arthur:

“Increasing-returns mechanisms do not merely tilt competitive balances among nations; they can also cause economies – even such successful ones as those of the U.S. and Japan – to become locked into inferior paths of development. A technology that improves slowly at first but has enormous long-term potential could easily be shut out, locking an economy into a path that is both inferior and difficult to escape.”¹⁴⁷

Lock-ins may occur with respect to technological development, institutional arrangements, the creation of knowledge etc. Such lock-ins have their unique characteristics. This question can be approached from a perspective of proximity, by which is meant how closely the agents operate within one particular area, such as organizational structures, geographical closeness, institutional arrangements, social conditions and cognitive patterns. With this line of reasoning, lock-ins can be identified as involving too much proximity, i.e. the exchange of ideas is limited as a result of too closely knitted structures. If cognitive patterns are too similar

¹⁴⁵ Cowan (1991).

¹⁴⁶ This claim requires a comment. We can probably state that democracy and the market economy are “locked-in” in today’s Europe. At present there are no serious challenges to the path taken. Most people seem to have accepted this outcome without hesitation. This is not to say that the present arrangements in society will never be questioned, but for the time being there are no serious attempts to enter another path of development.

¹⁴⁷ Arthur (1990).

among those involved, new ideas will not emerge. If organizations are too closely intertwined, the result will be excess bureaucracy hampering innovation, while high social proximity might lead to a rather static society. Tightly held geographical proximity produces a degree of closeness to the outside world, while finally institutional proximity with respect to values and predictability in its extreme form also produces a one-dimensional society.¹⁴⁸

When a particular technology phases out competing technologies it becomes dominant. This does not, at least not *per se*, indicate that it is the superior technology that has gained the upper hand. Instead, this resulting *closure* is oftentimes the result of social processes, to a large extent non-technological. By closure is meant that the social groups for whom the issue is of relevance end up agreeing on having solved the technological problem. This approach is called the social construction of technology and is expressed in the following way by Trevor Pinch and Wiebe Bijker:

“Closure in technology involves the stabilization of an artifact and the “disappearance” of problems. To close a technological “controversy”, one need not to *solve* the problems in the common sense of that word. The key point is whether the relevant social groups *see* the problem as being solved.”¹⁴⁹

The concept of closure therefore carries “family resemblance” with path dependence and lock-in. To simplify, economists would prefer to speak about lock-in while sociologists, in particular, would favor closure. The difference might even be no bigger than a matter of perspective chosen and a question of which societal forces are ascribed the decisive impact on the developments.

In his article on the development of the QWERTY keyboards, Paul David identifies three features that were of fundamental importance for the ensuing lock-in, namely technical interrelatedness, economies of scale, and quasi-irreversibility. By technical interrelatedness is meant a situation when, for instance, an increasing number of specialists are trained to operate a particular technology because that technology is becoming increasingly dominant. Economies of scale, in turn, is another expression for the phenomenon illustrated earlier with Polya urns, i.e. that for each choice in favor of a particular technology, those making the next

¹⁴⁸ Boschma (2005).

¹⁴⁹ Pinch, T & Bijker W (1997).

choice are more likely to follow suit. With quasi-irreversibility is meant that while the technology itself could be modified (in a more optimal direction), the developments within other areas, such as operating skills, effectively prevent such change.¹⁵⁰

Lock-ins vary in strength. Breaking some of them comes with a huge cost while others require less.¹⁵¹ Bassanini and Dosi identify four factors which might break a lock-in. The first one is the emergence of a new technological paradigm, which also brings new actors, new knowledge and new forms of organization. Second, there will always be imperfection in the adaptation of agents to the social surroundings, which should also be seen as a process creating variation. Third, what defines the fitness of any technology, organizational routine and behavioral trait is a complex web, “a multiple landscape”. An increasing wedge between an aspect of fitness and the underlying “multiple landscape” may enhance new search and new solutions. Fourth, path dependencies can be challenged by new organizational forms that originate from the outside¹⁵²

Vernon Ruttan asks how firms escape lock-in and

“what happens when the scale economics resulting from an earlier change in technology have been exhausted and the industry enters a constant or decreasing returns rate?”¹⁵³

The direction of a technological trajectory, Ruttan argues, is a result of resource endowments and relative prices and to what degree technological change is a function of these. As a consequence, rise and decline in the history of industrialization can be seen as to some extent dependent on the initial conditions and those particular circumstances that initially prompted change.¹⁵⁴

The lock-in resulting from carbon-based energy-technological systems has been studied by Gregory Unruh and Javier Carrillo-Hermosilla¹⁵⁵ Escaping such lock-ins can be divided into three broad categories, namely discontinuity, continuity, and end-of-pipe approaches. The

¹⁵⁰ David (1985). See also Ruttan (2001) p. 110.

¹⁵¹ Cowan (1991).

¹⁵² Bassanini & Dosi (2000) p. 62.

¹⁵³ Ruttan (1997) p. 1523.

¹⁵⁴ Ruttan mentions Germany’s rise to power in the late 19th century due to the development of the chemical industry and coal-based technology. But starting in the 1920s the USA developed a petroleum-based industry which Germany had difficulties to emulate.

¹⁵⁵ Unruh (2000, 2002) Unruh & Carrillo-Hermosilla(2006).

first category includes all measures that would radically alter the present structure through the development of an alternative structure. The middle category implies development of present structures in an environmentally-friendly direction, while the latter category consists of measures which would leave the present structure intact, but otherwise reducing harmful externalities. Following this reasoning, promoting renewable energy technology would belong to the first category, carbon-dioxide capture and storage (CCS) would be an example of a measure from the middle category, while capturing carbon-dioxide from the air would allow for the continuation of the present carbon-based energy system without major changes. This technology has not been used, yet.¹⁵⁶ The reason for the lock-in into carbon is, according to Unruh, to be found in the structure of the techno-institutional complexes, or TICs, which are defined as not only technological structures, but:

“.../have to be seen as complex systems of technologies embedded in a powerful conditioning social context of public and private institutions. TIC develop through a path-dependent, co-evolutionary process involving positive feedbacks among technological infrastructures and the organizations that create, diffuse and employ them. Once locked-in, TIC are difficult to displace and can *lock-out* alternative technologies for extended periods, even when the alternatives demonstrate improvements upon the established TIC.”¹⁵⁷

Unruh notes that one reason for lock-ins is the institutional set-up, which was originally created to promote the expansion of the carbon-based TIC and occasionally even to discourage other developments. Moreover, governments oftentimes subsidize the carbon-based TICs, hence creating an additional obstacle for alternatives to become competitive. Also new entrants to the job market tend to favor persisting structures, thereby further strengthening the lock-in.¹⁵⁸ A change in, for instance, educational priorities might be a long-term solution to break with the present lock-in by causing a change in attitudes towards environmental hazards caused by the carbon lock-in.¹⁵⁹

What might have been an optimal choice within one context is not necessarily so in another, although the underlying cause has not changed (for example, electricity generation from a

¹⁵⁶ Unruh & Carrillo-Hermosilla (2006).

¹⁵⁷ Unruh (2000).

¹⁵⁸ *Ibid.*

¹⁵⁹ Unruh (2002).

vast, easily recoverable domestic resource). Geoffrey Hodgson states that inefficient structures exist and survive, while efficient structures might not come into being.¹⁶⁰

“In policy terms, although the existence of chreodic¹⁶¹-type development implies that small, marginal adjustments towards a more optimal path of development are generally ineffective, it does leave open the possibility of the planned transition from one chreodic path to another. Indeed, such a transition may be necessary if the chreodic path is approaching a ‘catastrophe’. A feasible transition can be instigated either at the early stage of development of a chreodic path, close to the point of bifurcation, or even later with a sufficiently large investment in resources.”¹⁶²

The actual events underlying the emergence of a certain path may today be perceived differently from when they took place, and thus with hindsight of their actual impact on today’s conditions, we might misjudge their importance on the technological development.

By claiming that history matters and that each outcome is therefore unique, it is implied that another outcome could have been possible had history looked different. But finding proof for this is far from simple. By saying this, we are approaching the controversial topic of counterfactual history, or in Bassanini’s and Dosi’s words:

“/.../the proposition that “history matters” intuitively goes together with some sort of thought experiment (or counterfactual) which can be rarely undertaken through an actual experiment (at least in the social and biological domains).”¹⁶³

However, the difficulty to stage an experiment with counterfactual history is not synonymous with such a task being impossible. In this work, with a minor and rare branch of technology being the subject, it is actually rather straightforward to find examples of developments where the development path has been different. For instance, despite several attempts, the oil shale industry never took off in the United States. Here one can argue that the difference between Estonia and the United States is too big for such a comparison to yield relevant insights. But the oil shale industry has existed elsewhere, too. I have chosen the example of Sweden to illustrate the possibility of a different development. In Sweden, the oil shale industry

¹⁶⁰ Hodgson (1993) p. 201.

¹⁶¹ Chreod – A relatively stable trajectory of development for a species, caused in part by the evolution of hierarchical control sequences in the genotype (Hodgson (1993) pp. 205-6).

¹⁶² Hodgson (1993) p 259.

¹⁶³ Bassanini & Dosi (2001) p. 43.

underwent some development phases similar to the oil shale industry in Estonia. Significant diffusion of technology between the two countries took place at an early stage, especially from Estonia to Sweden through Swedish investments in Estonia. There were, nonetheless, several profound differences, such as the Swedish oil shale being of lower energy value than the Estonian oil shale. Moreover the Swedish experiences during and after WWII were radically different from those of Estonia. These and other objections notwithstanding, the case of the Swedish oil shale industry can serve as an approximation of re-running history.

3.3. A summary of the theoretical argument

Path dependence is a concept which allows for a deeper understanding of particular evolutionary processes in society. The causes of path dependent processes are manifold, but can be roughly separated into two major categories, namely random developments and historical accumulation.

The former category might at a first glance look somewhat theoretical, because of its tendency to avoid elaborating with institutional constraints present in any real-world circumstances. Within given institutional frames, path dependent processes are nonetheless likely to occur, because short-term profits or advantages are often preferred to long-term benefits (and this is the case not only under free-market conditions). By introducing a term, “partially random developments”, I want to cover random processes within a certain institutional and cognitive framework, where there will always be some form of restrictions and biases. The category historical accumulation can be divided into at least technological, cognitive and institutional aspects. In the real world, these aspects are often intertwined. One particular aspect, it will be argued in this work, is that institutional change can cause tensions that actually enforce path dependent processes.

Another – rather simplified – approach would be to interpret partially random developments as the starting point for a path dependent-process, while accumulation would be the continuation of the same process, or a trajectory or a momentum. Even if most processes can not be assigned a particular initial moment, there are still occasions when small factors have a profound impact on the future direction of a major process. By taking into consideration institutional, technological and economic restrictions, it will be argued in this work that the sum of rather small initial advantages turned out to be crucial for the establishment of the

Estonian oil shale industry. Once in place, the accumulation of knowledge and existing technological artifacts together with the prevailing economic and political institutional set-up led to a path dependent process. This process was kept in motion due to the capacity of the actors to make significant adjustments to changing institutional surroundings. Without this capacity, it is not unlikely that the process would have come to an end. Thus it can be claimed that path dependence is an evolutionary trajectory, the direction and persistence of which is dependent on knowledge.

Furthermore, it will be argued that conflicting interests – both overt and tacit – have actually strengthened the path dependent process of the Estonian oil shale industry. The reason for this outcome is that conflicting aims have resulted in greater variety, which at a later stage has proven to be the basis for selection at the next stage of development. But strongly diverging views on the future of a technological system might also strengthen the lock-in. The less unanimity there is on the future path, the stronger the lock-in to the present path might become, because those forces aiming for a change might pull in mutually opposite directions.

4. Oil shale industries worldwide

Estonia is not the only country in the world with a history of oil shale utilization. Several attempts at creating such an industry have taken place worldwide in different periods. Most of these attempts have failed, usually for economic reasons. Therefore, in this chapter some of the most important attempts in this direction are described. Such an overview allows for drawing some conclusions as to what difficulties were overcome or avoided in the Estonian case. In brief, it can be claimed that energy-related production from oil shale often goes together with a policy of self-sufficiency in the energy sphere. Thus, the development of oil shale industries and a sense of need to secure national (energy) independence often correlate. It should be emphasized that the national security issue is not necessarily about what could be labeled “nationalism”, but rather a real or perceived threat to the well-being of the citizenry, either in times of crises or on a more general level.

Oil shale is usually considered one of three categories of non-conventional oil, the others being tar sands and heavy crude oil. The global reserves of oil shale are very large, although there is no agreement on the size of this resource. Relatively recent estimates (from the 1990's) vary between 482 and 920 gigatonnes of potential oil yield. These figures should be compared to the corresponding figures for conventional oil, which vary between 150 and 300 gigatonnes. Thus, even if we compare the lower figure for oil shale with the higher figure for conventional oil (482 versus 300 gigatonnes) it becomes clear that global reserves of oil shale are gigantic. If the corresponding figures for tar sands (115 gigatonnes) and heavy crude oil (110 gigatonnes) are added to the figure for oil shale, it should be beyond doubt that the world will not be running out of oil in the near future.¹⁶⁴ Oil extracted from non-conventional sources will, from the consumers' point of view, be the same as the dominant crude oil of today. The question is, however, whether the environmental impact from extracting such oil can be regarded as acceptable. In the UNDP's “World Energy Assessment”, Hans-Holger Rogner is skeptical about the future role of unconventional oil:

¹⁶⁴ World Energy Council Survey of Energy Resources 2001. See also Rogner (2000), Dyni (2003) and (2004).

“The ultimate resource base of unconventional oil is irrelevant to the 21st century’s energy supply. Occurrences of such oil that are already known and under exploitation can provide the global supply likely to be required in the 21st century. On the other hand, economic or environmental considerations – or both – could convert unconventional resources back to neutral stuff, as has occurred in recent decades with previously designated coal resources.”¹⁶⁵

The interest in oil shale is far from new. For decades oil shale has attracted the attention of those involved in the energy sector, but oil shale as a source of oil remains elusive and as a consequence the oil shale industry has not taken off on a larger scale. The history of modern oil shale production dates back to 1839, when commercial production of shale oil commenced in France. This industry lingered until WWII mainly due to government subsidies. A larger oil shale industry was developed in Scotland, but because of competition from crude oil, the industry gradually lost its importance. From the start, a total of 140 companies were active in the Scottish oil shale industry, but in 1919 only one remained as a result of a major merger into a subsidiary of Anglo-Iranian Oil Co. Twelve oil shale mines were still operated after WWII.¹⁶⁶

In the 1970’s, there was renewed interest in oil shale as a potential source for the production of, *inter alia*, motor fuel following repeated reports on the supposedly imminent end of conventional oil. But when new oil fields in both the North Sea and Mexico were developed, oil shale once again fell into the background. During the 1970s, attempts to produce shale oil for motor vehicles were conducted in such disparate countries as the USA, Syria, Romania, Morocco and Brazil. But with falling oil prices, these attempts were soon given up.¹⁶⁷

In 2002 world total output of shale oil is estimated at 578 thousand tonnes, which would be approximately 4.2 million barrels.¹⁶⁸ Oil shale is being produced on a commercial scale in three countries only, namely China, Brazil and Estonia. The use of oil shale might experience a renaissance in economically rapidly developing countries around the world when shale oil production becomes more competitive with higher oil prices on the global market. Countries depending on imported fuels, such as Jordan and Turkey, are increasingly interested in

¹⁶⁵ Rogner (2000) p. 143.

¹⁶⁶ Bell (1948) pp. 2-6.

¹⁶⁷ Kattai (2003b).

¹⁶⁸ Dyni (2004).

utilizing their oil shale reserves. New technology allows for cleaner and more economical utilization of oil shale both as a raw material in oil production or for electricity generation.¹⁶⁹

Table 4.1. Countries with the biggest oil shale reserves in the world.

Country	<i>Shale oil reserves, economically viable (million tonnes)</i>	<i>Yield (kg oil / tonne oil shale)</i>	<i>Estimated additional reserves (million tonnes oil)</i>
Australia	4,431	53	35,260
Brazil	11,734	70	9,646
Canada	2,192		
China	2,290		
Congo (Dem. Rep of)	14,310		
Estonia	2,494 (including 1,900 mln tonnes low calorific dichtsionema shale) 167 (kukersite)		
Jordan	4,000	100	20,000
Morocco	8,167 – 12,300	50-64	5,400
Russia	35,470		
United States	380, 566	57	62,000

Source: World Energy Council (2001) and Dyni (2003).

Giving exact figures for oil shale reserves can only be done with great caution. As there is only very limited commercial activity worldwide, the estimates of economically exploitable resources are highly uncertain. Table 4.1. should only be read as an approximation, or rather an illustration. It can, however, be seen from the table that the Estonian deposits utilized at present (the kukersite oil shale) are almost insignificant on a global scale. Despite this, in the year 2002, Estonia accounted for almost half of total global production of oil shale, with Brazil in second place and China third. In addition to the countries listed in table 4.1., a large number of other countries possess oil shale deposits, although smaller. Some of these countries have had an oil shale industry or have at some point seriously studied the possibility of utilizing their resource. Such countries are for example Sweden, Russia, Turkey, Israel,

¹⁶⁹ Hepbasli (2004).

Belarus, France, Turkmenistan, Uzbekistan, Egypt, Thailand, the United Kingdom, and the Ukraine.¹⁷⁰

4.1. USA

In the USA, with approximately two thirds of the world's total oil shale reserves, a number of small scale attempts at oil production from oil shale took place during the first half of the 20th century. But feasible oil shale production did not emerge. In 1964 an advisory board under the U.S. Secretary of the Interior was established with the task of identifying and evaluating major oil shale-related issues. Among the board's members was the renowned economist John Kenneth Galbraith, who probably thought of oil shale as a future large scale industry. Galbraith was concerned that federal land would be leased to private companies without genuine interest in developing oil shale technology, but which instead would look for windfall profits resulting from technological research done elsewhere. Calling for public sector spending on oil shale development, Galbraith compared the oil shale industry with the space, nuclear and defense industries.¹⁷¹

The reason for the oil shale industry remaining in its infancy is not solely the cost of shale oil compared with crude oil, as sometimes is claimed. As Metz pointed out already in the early 70's, shale oil should have been economically viable in the USA – at least compared to domestic crude.¹⁷² The main obstacles were to be found elsewhere. First, shale oil production requires large amounts of water – 3 barrels of water for each barrel of shale oil. The largest oil shale deposit in the USA, the Green River Formation, is located in a relatively dry part of the country in Colorado, Wyoming and Utah. Second, oil shale mining is a daunting task. In order to extract 1 million barrels of oil, a total of 1.5 million tons of oil shale has to be processed and then disposed of. A solution to some of the problems associated with oil shale mining would be an improved in situ technology.¹⁷³ A recent study refers to calculations from the late 70's, according to which commercial shale oil plants could feasibly operate at a level between 50,000 and 100,000 barrels of oil per day (this is to be compared with the previously mentioned world total output at present of 10,000 to 15,000 barrels a day), which would

¹⁷⁰ World Energy Council (2001).

¹⁷¹ Baker & Mulford (1966).

¹⁷² According to Metz' figures, the production costs of shale oil were \$5.5 per barrel in October 1973 while the price for crude oil was \$ 7.

¹⁷³ That is extracting oil directly from the ground by heating it.

require an annual minimum mining output of 25 million tons of oil shale. This has not been considered any major obstacle, the amount being only one third of the output of the largest coal mines.¹⁷⁴ On the other hand, a pilot project by the Union Oil Company¹⁷⁵ in the 1980s operated at only 50% of its design output of 9,000 barrels a day. Despite enjoying favorable tax conditions, this pilot project did not live up to the expectations and as a consequence, it was terminated in 1991. A full scale shale oil plant, producing a minimum of 50,000 barrels of shale oil a day, would need to have the capacity to process 1,500 tons of oil shale a day – a technological challenge still not resolved.¹⁷⁶ Another, significantly larger plant, never took off from the planning stage in the 1980's – the TOSCO II-plant, which was planned to produce 47,000 tons of shale oil a day.¹⁷⁷ Due to falling crude oil prices, the construction works on the plant were halted in May 1982.¹⁷⁸ There is no clear-cut price when oil shale becomes competitive with oil, but initial production costs for U.S. shale oil could be estimated to be in the span \$70-\$95 per barrel (in 2005 dollars). This figure would likely diminish radically with growing experience and developing technology. So far, any figures on the costs for large-scale shale oil production in the USA can only be estimates, for the simple reason that there has never been any large-scale oil shale industry in operation. Edward Merrow points out that the estimated costs for shale oil production more than quadrupled between 1971 and end-1974. The reason for this was partly a general increase in prices, but also greater awareness of the need for environmental protection as well as a better understanding of the total process in shale oil extraction.¹⁷⁹

Environmental issues are identified by Metz as the biggest obstacle to extensive oil shale utilization. Likely environmental damage would be alteration of the landscape, threats to various animal and plant species, higher salinity in nearby waters and the emission of sulphur dioxide and dust into the air.¹⁸⁰ On the other hand, Merrow unequivocally identifies costs of shale oil production as the main obstacle for full-scale commercial development of the industry.¹⁸¹ The energy scholar Vaclav Smil addresses the development in the United States towards the end of the 1970s:

¹⁷⁴ Bartis et al. (2005).

¹⁷⁵ The company was later renamed Unocal (Bartis et al. p. 13). Unocal, in turn, was merged with Chevron in August 2005 (see http://www.chevron.com/news/press/2005/2005-08-10_1.asp, accessed August 24, 2006).

¹⁷⁶ Bartis et al. (2005).

¹⁷⁷ The Colony Oil Shale Project (Bartis et al. (2005)).

¹⁷⁸ Bartis et al. (2005).

¹⁷⁹ Merrow (1978).

¹⁸⁰ Metz (1974).

¹⁸¹ Merrow (1978) p. vi.

“But I believe that one kind of government intervention – a targeted quest for massively expanded supply of a particular kind of energy – demands a great deal of scepticism and an extraordinarily careful scrutiny. These ‘solutions’ to perceived shortages of energy supply have been favored for decades by many interventionist advocates but looking back, there is a great deal to be thankful that so many of these proposals did not fly. To give just one notable example, during the late 1970s many experts favored the creation of a large-scale, government-subsidized oil shale industry and.../ massive public funding began to flow to create such an inefficient and environmentally objectionable entity.”¹⁸²

Ironically, Merrow’s report (published in September 1978) states that:

“If another oil embargo occurs or if world oil prices begin to climb rapidly because world production peaks sooner than expected, the perceived need to speed the introduction of domestic substitutes could quickly return.”¹⁸³

The Iranian revolution and the subsequent surge in oil prices was only months away.

The vast amount of oil in oil shale is, nevertheless, unlikely to lose its attraction in a world thirsting for oil, as the following recent comment illustrates:

“With oil prices at \$40 and declining crude oil production in most areas, some non-oil-company investors are taking another look at the huge volume of potentially recoverable hydrocarbons in vast oil shale deposits. These occur in several world locations, but US in particular.”¹⁸⁴

Estimates of the amount of recoverable oil in the Green River Formation varies between 500 billion and 1.8 trillion barrels. This could be compared to the known oil reserves of Saudi Arabia which do not exceed 300 billion barrels. With the present consumption rate in the USA of 20 million barrels a day, oil shale could meet the demand for 100 years.¹⁸⁵ At present, the Shell company is developing a so-called in situ conversion process (ICP) for extracting shale oil at Piceance basin in Colorado (a part of the above-mentioned Green River Formation). This method is basically the same as the Ljungström-method tried in Sweden in the 1940’s and 1950’s (to be described in chapter 9). The oil shale is heated in the ground

¹⁸² Smil (2005) p. 368.

¹⁸³ Merrow (1978) p. 1.

¹⁸⁴ Snyder (2004).

¹⁸⁵ Bartis et. al.(2005). See also Metz (1974).

instead of being mined. This is done by electric heaters dug into the ground. The heating process continues for two or three years, after which oil and gas is released from the shale. According to Shell, this method is more environmentally friendly than mining and retorting. Moreover, the ICP is supposed to produce twice as much oil as other methods. For every unit of energy used, the ICP produces 3 units.¹⁸⁶ Shell is also planning to construct a “freeze-wall” around the heated ground in order to separate the heated area from surrounding areas in the ground thus reducing the impact on the groundwater while keeping the released oil vapors within the heated area. What the consequences of the ICP process actually will be can not yet be established. There are still questions about mineral salts and metals from oil shale coming in touch with groundwater.¹⁸⁷ But it is clear that heating the oil shale in the ground would not leave scars in the landscape in the same way that open pit mining would do. These plans were repudiated straight away by James Udall and Steven Andrews, according to whom a successful operation in terms of achieving more than negligible production would require a huge investment in energy production. If the energy required produced in coal-fired power plants, emissions of greenhouse gases would have to be added to the total bill – “The world’s largest utility bill”:

“For a century, promoters have pitched oil shale as a path to riches and energy independence. A magic wand would indeed be nice, because the nation faces serious energy challenges. Because domestic oil production peaked 30 years ago, the need for energy efficiency, conservation, and renewable energy is both obvious and urgent. Instead, like an addict on a binge, we continue to pursue a policy of “strength through exhaustion.”/.../ Making intelligent choices about what energy paths to pursue is critical. In the 1970s, during the last energy panic, we failed this IQ test. Yes, there’s lots of low-grade oil shale in Colorado and Utah. But there’s also enough Helium 3 on the moon to power the world for thousands of years, and enough microscopic gold in the ocean to make everybody rich. It’s theoretically possible to microwave solar energy to Earth from the outer space, and to transmit wind energy from the Aleutians to Atlanta. Fusion has been around the corner for fifty years. Grandiose schemes to meet the world’s energy needs always find articulate proponents.”¹⁸⁸

¹⁸⁶ www.shell.com/static/us-en/downloads/shell_for_businesses/exploration_production/EP_Fact_Sheets4-1.pdf.

¹⁸⁷ Bartis et al. (2005).

¹⁸⁸ Udall & Andrews (2005).

4.1.1 The U.S - Estonian cooperation agreement

A potentially new chapter in the development of Estonian shale oil production was opened with the signing of an Estonian – US Joint Cooperation Agreement on oil shale research and utilization in February 2000¹⁸⁹. The agreement calls for cooperation on mutual experiences in the oil shale industry in order to reduce costs and enhance commercialization.¹⁹⁰ It is estimated that in the Green River Formation deposits alone in Colorado, Utah and Wyoming the amount of recoverable shale oil is 1,000 billion barrels, which equals the world reserves of conventional oil,¹⁹¹ but since 1991 there has been no large-scale activity for the extraction of shale oil.¹⁹² It can be assumed that the present US interest in the Estonian experiences stems from this combination of vast resources and lack of commercially feasible production processes. Estonia, on the contrary, has an industry in place and decades of experience. It is maybe too early to judge whether these experiences are relevant for any future global, large-scale shale oil industry.

The Joint Cooperation Agreement between Estonia and the USA also calls for cooperation in developing products for the chemical industry based on oil shale. Two existing product groups were identified as having further market potential – alkyl phenols and alkylresorcinols as well as epoxy resins (a kind of synthetic plastic). Moreover diesel fuel additives, biocides and light- and thermo stabilizers (additives in plastic and rubber) are identified as potential new products which require investments.¹⁹³ The Joint Cooperation Agreement resulted in the largest international investment in Estonian science at the time – with a U.S. investment of \$ 1 million and an Estonian contribution of EEK 5.8 million. Although this investment is rather low in absolute terms, it was a boost for Estonian oil shale research, which had reached a low point by that time. As of August 2006, a second agreement is under preparation.¹⁹⁴

¹⁸⁹ The USA is certainly not the first country to show interest in the Estonian experience. According to Ratnieks (1978), p. 162, in the beginning of the 1960s Brazil sought technical assistance from Estonia for developing the oil shale industry. In the 1970s Canadian power specialists are said to have studied the Estonian industry.

¹⁹⁰ Koel & Bunger (2005).

¹⁹¹ Ibid.

¹⁹² Dyni (2003).

¹⁹³ Koel & Bunger (2005).

¹⁹⁴ www.vkg.ee/index.php?op=printid=3645, webpage of Viru Keemia Grupp, accessed on August 29, 2006.

4.2. Canada

It is estimated that in Alberta in Canada there are some 2 trillion barrels of oil in the Athabasca oil sands deposit, making it the world's largest single oil deposit, counting for almost 15% of total world reserves. The oil sands consist of approximately 10 – 12 per cent of bitumen – from which oil is extracted - while the rest is mainly a mineral component. The production of oil from oil sands comprises roughly half of Canada's oil output.¹⁹⁵ In the late 1990's the annual output was 28 million barrels of oil. The production is based on the excavation of oil sand, but there is research done on heating the oil sands, thus liquidizing the oil. This method would allow ordinary oil field equipment to be used for pumping up the oil.¹⁹⁶ However, usually the oil sands are not considered to be included in the concept of oil shale.¹⁹⁷ Nevertheless, deposits of oil shale also exist in Canada, particularly in the eastern parts of the country, but at present there are no large-scale attempts at exploiting them.¹⁹⁸

4.3. China

Shale oil production in China is concentrated to Fushun, Liaoning province in the North-East, but there is also shale oil production at other sites, where oil shale is usually co-mined with coal. The oil shale industry in Fushun dates back to the 1920's. In 1929 a large shale oil factory started operations. On the eve of WWII, 150,000 tonnes of shale oil was produced annually.¹⁹⁹ The output reached a peak in 1959, when 780,000 tonnes of shale oil was produced. At present there are 80 retorts operating at Fushun producing annually 90,000 tonnes shale oil. Due to high demand and high prices on shale oil on the Chinese market, the capacity of the Fushun shale oil plant is planned to be increased by 100 per cent. In addition to this, a separate factory is being planned with a capacity for processing 5,000 tonnes oil

¹⁹⁵ "Alberta's Oil sands 2004", Alberta Department of Energy, updated December 2005. Accessed August 17, 2006 at www.energy.gov.ab.ca/oilsands. See also the homepages of Syncrude oil company, www.syncrude.ca, and Suncor Energy, www.suncor.com.

¹⁹⁶ George (1998). George mentions that the existence of oil sands was well-known to the indigenous population for centuries. The sticky bitumen found at the Athabasca river was suitable to cover holes in canoes. In this context it is interesting to note that oil shale in Estonia was also well-known to the local population long before the arrival of industrialization. In Estonia, oil shale was used by shepherds as a fuel for campfires.

¹⁹⁷ There is no mention of oil sands in Dyni's (2003) listing of world oil shales, neither is there any reference in Brendow (2003).

¹⁹⁸ Dyni (2003).

¹⁹⁹ Bell (1948).

shale a day.²⁰⁰ This figure should be compared with that presented by Bartis et al., who assess 1,500 tonnes a day as beyond present technological possibilities.²⁰¹

The development of the Fushun oil shale industry has not been straightforward. After its heydays in the 1950's, the oil shale industry began to decline in the 1960's and was finally shut down in the mid-1980's, only to be re-started in 1991, but this time with a thoroughly modern factory operated by the Fushun Mining Group. Technologically, the factory shows similarities with the Estonian Kiviter-technology.²⁰²

4.4. Australia

Australia has vast deposits of oil shale. Between 1865 and 1952 there was an oil shale industry operating in the country which processed a total of 4 million tons of oil shale. This industry was shut down because of the abundance of crude oil in Australia, making the country self-sufficient in oil.²⁰³ In the 1930s the Estonian engineering company *Franz Krull* (together with the German *Lurgi AG*) designed two tunnel ovens for the Australian shale oil producer Glen Davis, which during WWII produced 3 per cent of Australia's oil supply. The production ceased in 1952.²⁰⁴ But as demand for oil continuously exceeded supply, renewed attention was paid to oil shale in the 1970's and the 1980's. The desire for national self-reliance on oil was one of the core issues for oil shale being brought back as a potential source of oil.²⁰⁵ The known oil shale deposits of Australia contain 30 billion barrels of oil, of which 20 billion are located in Queensland. Exploiting these reserves would supply Australia with oil for 50 years.²⁰⁶ A major undertaking, the so called Stuart oil shale project (located near Gladstone, Queensland), was expected to result in a viable oil shale industry. For several years, there were great hopes for the Stuart project, which was supposed to produce 200,000 barrels of oil daily.²⁰⁷ The development of process technology was initially done in

²⁰⁰ Qiang, Wang, & Li (2003).

²⁰¹ Bartis et al. (2005) p. 13.

²⁰² Purga (2004).

²⁰³ Schmidt (2003).

²⁰⁴ "The Life of an Engineer. (In remembrance of Prof. Pyotr M. Sheloumov)" *Oil Shale* v. 14 n. 4, 1997.

²⁰⁵ Schmidt (2003).

²⁰⁶ Smith, S. (2002) "Focus on Australian Shale Oil" www.iea.org/textbase/work/2002/calgary/smithdoc.pdf accessed on August 28, 2006.

²⁰⁷ Some estimates would give a figure of one million barrels a day as the total production potential from Queensland oil shale. See "Strategic Significance of America's Oil Shale Resource. Volume II", Department of Energy, p. 10.

cooperation with the Canadian company *Suncor Energy Inc*, but in April 2001 *Southern Pacific Petroleum* purchased *Suncor's* interests.²⁰⁸

Nevertheless, the development of the Stuart project was postponed in 2003, when the oil shale developing company, *Southern Pacific Petroleum*, went bankrupt.²⁰⁹ The responsibility for the oil shale project was taken over by *Queensland Resources Council*, which still operates the pilot project known as Stuart, but has put further development on hold.²¹⁰

The Stuart project was based upon mining oil shale (in contrast to the in situ process). The technology chosen for the project was the Alberta Taciuk Processor (ATP), originally developed for processing the oil sands of Alberta, Canada. It is comprised of a retort, which is a 60 meter long horizontal device, self-sufficient in energy, but basically a rather simple construction. It requires little water for the process and it processes fine oil shale, not only lumps.²¹¹ The Stuart project was supposed to proceed in three steps in order to gradually develop technology and processing methods. Only the first stage was completed and the production capacity reached 4,500 barrels of oil a day.²¹² It was recognized that the emissions of greenhouse gases when processing oil shale would at least initially exceed the emissions from exploiting conventional oil, but according to Stuart Smith the emissions from the planned stage 3 of the Stuart project would be lower compared to scenario “business as usual”.²¹³ Stage 2 of the development of the Stuart project was supposed be a commercial plant, a scale-up of the pilot plant of Stage 1, able to produce 15,500 barrels per day of shale oil. Stage 3 would have been a full-scale commercial plant with 13 ATP modules and a production capacity of 157,000 barrels a day. The operating costs were calculated as \$7.50 to \$8.50 per barrel.²¹⁴

²⁰⁸ WEC Survey of Energy Resources 2001.

²⁰⁹ “Shale-oil dream ends in company collapse” by Brian Robins, *The Age*, December 3, 2003, at <http://www.theage.com.au>, accessed on February 21, 2007.

²¹⁰ Queensland Resources Council describes itself as a “not-for-profit company representing Queensland’s minerals and energy sector”, see www.qrc.org.au.

²¹¹ Smith (2002) and “Strategic Significance of America’s Oil Shale Resource. Volume II”.

²¹² Smith(2002).

²¹³ The reasoning in Smith (2002) is not particularly convincing. The method of reaching lower greenhouse gas emissions includes reforestation (named as “carbon sinks”), building a bio-ethanol plant operating alongside the Stuart project, and investing in cogeneration in order to reduce the amount of energy used per barrel of shale oil.

²¹⁴ “Strategic Significance of America’s Oil Shale Resource. Volume II”, p. 11.

4.5. Brazil

The oil shale deposits of Brazil are estimated to contain at least 2.6 billion barrels of oil, thus being one of the largest in the world. These deposits are located in two major areas, located in the Eastern and South-Eastern parts of the country. The first Brazilian attempts at utilizing oil shale were made at the Eastern Paraíba Valley area, where an experimental shale oil plant was founded before WWII. However, later focus was shifted to the South-Eastern Iratí formation.²¹⁵

In 1972 a pilot plant was made operational at São Mateus do Sul, while the first commercial plant in the area commenced its activity in 1981, and a second one in 1991. These two plants produce a total of 3,870 barrels of shale oil daily. In addition to this also fuel gas, liquefied shale gas and sulphur are produced. Total output of shale oil in 1999 was 195 thousand tons.²¹⁶ The technology used is the Petrosix Gas Combustion Retort, which is an 11 meters high vertical shaft making it the largest oil shale retort in the world. This technology is currently considered as being of interest to U.S. developers of oil shale.²¹⁷

4.6. Jordan

There are vast oil shale deposits in Jordan, the existence of which has been well known for millennia and used for lighting, but also in various forms of worship. In the last decade of the Ottoman Empire, Jordanian oil shale was used as a component in train fuel. Lacking other significant energy resources, Jordan has repeatedly paid attention to its oil shale deposits, but so far importing oil has been judged less expensive. However, the plans to exploit oil shale have never been rejected altogether, but rather postponed, in part in expectation of technological advances globally. Jordanian oil shale, with an average oil yield of 10 per cent, is supposed to be suitable both for shale oil production and for generating electrical power. Moreover, in Jordanian conditions, excess heat generated in the process could be used for thermal desalination of sea water. One of the main allurements for Jordan in exploiting its oil shale resources would be the enhanced national self-reliance in energy.²¹⁸

²¹⁵ Dyni (2003).

²¹⁶ World Energy Council (2001).

²¹⁷ "Strategic Significance of America's Oil Shale Resource. Volume II", p.13.

²¹⁸ Jaber, Probert & Badr (1997).

The Jordanian oil shale reserves would allow for a total oil extraction in excess of 5 billion tonnes. The oil shale is located close to the surface, and therefore it could be excavated in open pits. One particular obstacle is nevertheless the shortage of ground water needed throughout the process.²¹⁹ The mainly Saudi-Arabian investor group *International Corporation for Oil Shale Investments* has announced that it is prepared to invest ten billion dollars in creating a Jordanian oil shale industry. In cooperation with Tallinn Technical University (Estonia), a separate oil shale research unit is to be created at a new college in Amman.²²⁰

The Estonian monopoly electricity producer *Eesti Energia* announced in the autumn of 2006 that it is likely to get a concession from the Jordanian government for the production of shale oil and electricity from local oil shale. This operation is estimated by *Eesti Energia* to be less costly than shale oil production elsewhere, because the Jordanian deposits are located in the desert and thus little recultivation after the mining will be required. Jordan, having the fourth largest oil shale reserves in the world – 40 billion tonnes - has shown interest in Estonian know-how in oil shale. From the Estonian side, there is a corresponding interest in diffusing Estonian oil shale technology in the world.²²¹

4.7. Sweden

In the mid-20th century, Sweden developed an oil shale industry, in order to safeguard supply of fuels. The Swedish oil shale industry had many similarities with the Estonian oil shale industry. Especially technological diffusion took place between the countries. The rise and fall of the Swedish oil shale industry is analyzed in a later chapter in order to present the actual outcome of a different development path.

4.8. The failure of the oil shale industry to take off internationally

The international development of oil shale exploitation presented in this chapter can be summed up as a long development without significant success. Nowhere outside Estonia has

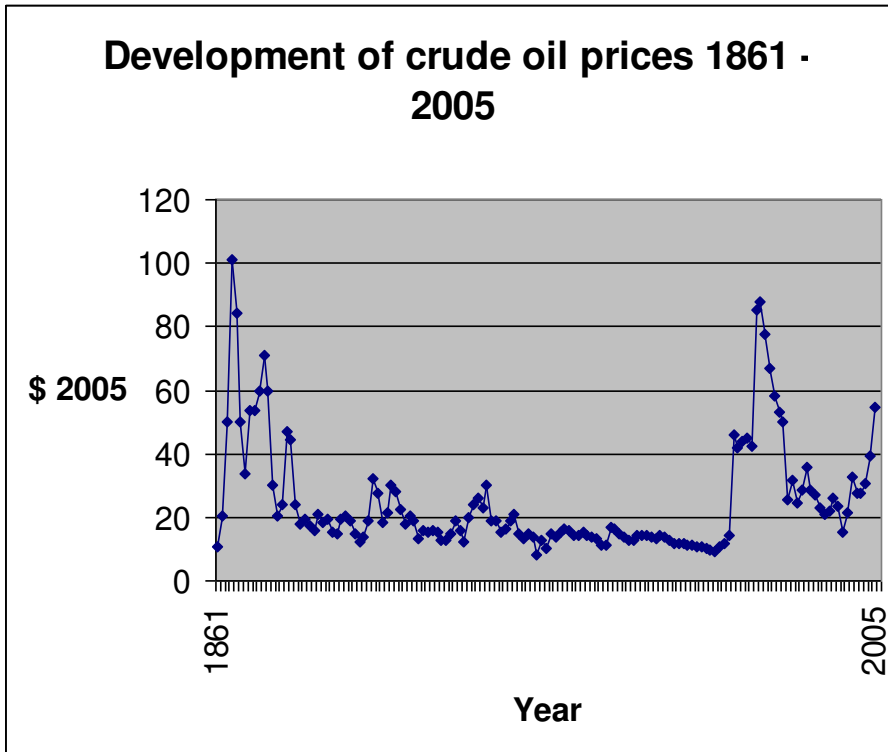
²¹⁹ Dyni (2003).

²²⁰ "Põlevkivist õli tootmise kunst äratub maailmas üha suuremat huvi" (*The art of shale oil production arouses ever bigger interest in the world*) by Erik Gamzejev, regional newspaper "Põhjarannik" (March 14, 2006), quoted on www.vkg.ee/index.php?op=print&id=3598, accessed on August 29, 2006.

²²¹ "Eesti Energia plaanib Jordaaniasse tehast" (*Eesti Energia plans a factory in Jordan*), by Andrus Karnau, Postimees, October 20, 2006. www.postimees.ee/20102006/esileht/majandus/.

oil shale become more than a marginal source of energy despite enormous reserves. This fact requires some comments. First, oil shale is very questionable from an environmental viewpoint. This fact alone is likely to slow down exploitation on a large scale. On the other hand, it should be kept in mind that environmental awareness is a relatively recent phenomenon and has not been at the core of societal discourse for more than a few decades. Clearly, environmental aspects cannot have had a decisive impact on development during earlier decades – at least not the same environmental concerns that are prevalent today.²²² Second, oil shale as a raw material for petroleum production has not been price competitive with conventional crude oil. The price for crude oil has actually varied enormously during the one and a half centuries commercial exploitation has taken place.

Figure 4.1. The development of oil prices 1861-2005 in \$ 2005.



Source: www.bp.com.

²²² For instance, deformation of landscape is a consequence that has been taken seriously for a long time.

Two facts can be derived from figure 4.1. First, the price for oil has been highly volatile both in the beginning of commercial oil extraction in the latter half of the 19th century until the end of WWI and in the period after the first oil crisis in 1974. Thus during both periods long-term planning has been virtually impossible. A long time horizon is a necessity if the enormous investments in infrastructure to be made that are required for a full-scale oil shale industry. Second, whenever oil prices have settled for a longer period of time, the price has been relatively low, as in the period from the early 1930s until the first oil crisis. From this it can be concluded that there has never been a period of any significant length of high *and* stable oil prices, which would be the most likely condition for an alternative to oil to become more widespread. Occasional price hikes for crude oil are not sufficient to motivate the establishment of a large-scale industry.

It can also be concluded from figure 4.1. that detailed planning for future development remains highly uncertain. Smil has demonstrated how forecasts on oil prices have failed repeatedly. Usually predictions on the future of oil prices are nothing more than guesswork or extrapolations. So far nobody has been able to anticipate the enormous swings in oil prices, which of course is only one way to say that the future is unpredictable.²²³

Because crude oil is a more convenient fuel than shale oil and because there is already a global infrastructure in place, it can be assumed that the volatile prices for crude oil have effectively prevented the emergence of oil shale as a competitor. This argument could even be taken as far as to suggest why present crude oil producers cannot afford to maintain a high oil price over a longer period of time. Were this to happen, oil shale (or some other competitor) would soon become a serious competitor. This reasoning is, of course, a development of the Schumpeterian notion of a monopolistic situation:

“It is hardly necessary to point out that competition of the kind we now have in mind acts not only when in being but also when it is merely an ever-present threat. It disciplines before it attacks.”²²⁴

The arguments in favor of oil shale production can roughly be summarized as security of supply and dwindling oil resources. Judging from the fact that not even the USA with its giant

²²³ Smil (2005) pp 121-180.

²²⁴ Schumpeter (1975) p. 85.

reserves and enormous consumption of energy has found it worth developing its oil shale industry indicates that the politics of global oil are not insecure enough to invest in domestic shale oil production.

If a shortage of crude oil gradually develops as a result of increased consumption worldwide parallel with the depletion of present oil fields, one might assume there would be a niche for oil shale, presupposing that the environmental hazards are addressed. Estimating when such a situation is to occur remains extremely difficult. Reported reserves should always be treated with some degree of reservation, as oil producing countries have few incentives to disclose their actual figures. This is particularly the case for members of the OPEC, whose production quotas are dependent on their reserves and they are therefore tempted to inflate their estimates. But adding to the difficulty of predicting remaining oil reserves is the uncertainty about the actual size of the reserves. Estimates are usually expressed in probabilities, which allow for a very broad actual fluctuation. Colin Campbell and Jean Laherrere put the beginning of the decline of crude oil production before the year 2010.²²⁵ This estimate is, however, vigorously contested by Vaclav Smil according to whom there is no conclusive evidence that a peak in oil production necessarily has to be imminent. Technical innovations will increase the exploitable ratio of oil in presently known oil fields, marginal oil fields will be exploited with increasing oil prices and non-conventional oil will become competitive.²²⁶

²²⁵ Campbell & Laherrere (1998).

²²⁶ Smil (2005) pp. 184-194.

5. The emergence of the Estonian oil shale industry

5.1. The beginning, 1916-1934

5.1.1 The emergence of oil shale as a fuel

The existence of oil shale in North-eastern Estonia was well-known to the local inhabitants for centuries, and oil shale as a “burning stone” was used for various forms of heating.²²⁷ This was nonetheless rather a regional curiosity than a harbinger of a future nation-wide energy source. It is easy to imagine the astonishment of the occasional traveler, who notices the local habit of burning stones instead of wood, but still Estonian oil shale could as well have remained a chapter in travel accounts, or a footnote in history books. True, geologists would probably have paid attention to this special substance, as they actually did, but even so oil shale could have ended up with only a brief mentioning in geological textbooks.

From time to time, the very existence of a useful raw material at a particular location is somewhat sloppily assumed to induce a wide-spread utilization. In the case of oil shale in Estonia, such an assumption would be totally incorrect. Instead, the emergence of the Estonian oil shale industry was triggered by historical developments, but also through active promotion by a group of people, who came to realize the potential of oil shale largely by coincidence. The existence of oil shale was of course a necessary prerequisite, but the development of Estonian oil shale could have stopped here, were it not for other developments, the most important of which was WWI.

The first time Estonian oil shale appears in a written document is in 1774, while the first scientific report on that oil shale was written by a certain academic J.G. Georgi from St. Petersburg in 1791. In 1839, another academic from St. Petersburg, G. Helmersen made an attempt to extract oil from oil shale. Towards the end of the 19th century Estonian oil shale was named kukersite, which is derived from the place name Kukruse in the oil shale region of

²²⁷ The Estonian word for oil shale is “põlevkivi”, literally meaning “burning stone”.

Estonia.²²⁸ Despite these surveys, the existence and character of the kukersite oil shale remained obscure for the educated public. At this time, Estonia was a part of the Russian empire and therefore the kukersite oil shale was mainly studied by scientists from the nearby Russian capital of St. Petersburg.

In 1910 a group of Russian engineers studied the possibilities of extracting oil from Estonian oil shale, but despite favorable experiments, no further steps were taken, with the exception of initial agreements with landowners to gain access to the resources. In 1916, however, imperial Russia saw oil shale as a solution to fuel shortages resulting from the ongoing war, especially as the deposits were located near the capital, Petrograd, where numerous industries were located.²²⁹ Foundations for a first open pit mine were laid in 1917, but as a result of the revolution in Russia, further development was soon aborted. Still in the summer of 1918, the local authorities in Petrograd viewed oil shale as a potentially important fuel for heating, as railway fuel, in cement production, and as illumination gas.²³⁰

After the first Russian revolution in March 1917, an Estonian technical society was formed in Petrograd. Among its members was the engineer Märt Raud, who came in contact with the Russian geologist Pogrebov while working at a geological library in Petrograd. Pogrebov had compiled the available information on geology in the region, which today is called the Baltic States. He told Raud about the existence of the oil shale in North-Eastern Estonia and that some small-scale mining had already commenced. Raud soon found out that there had been important research done on the Estonian oil shale in Russia. At this time, several individuals who were later to hold prominent positions in the Estonian Republic lived in the city, occasionally getting together to discuss the possible directions an independent Estonia could take after the war. In such circles the first ideas of an oil shale based energy system were gradually shaped.²³¹ The fact that the initial interest for oil shale as a national source of energy emerged among this group of people cannot be underestimated as an explanation for the further developments. In the late 19th century and early 20th century, St. Petersburg had become a multicultural metropolis with a vibrant intellectual life and therefore attracting

²²⁸ Today the village of Kukruse in the immediate vicinity of the town Kohtla-Järve harbors the oil shale museum, but no other oil shale-related activity takes place in the village.

²²⁹ Estonia was still at this time part of the Russian empire.

²³⁰ Raud (1925). During personal communication (October 30, 2007), Jaak Valge mentioned that the question of the first mentioning of the Estonian oil shale is somewhat obscure. It is possible that a certain August Wilhelm Hupel (1737-1819) wrote about the Estonian oil shale before anyone else.

²³¹ Riigi Põlevkivitööstus (1928) pp. 15-6.

people from all over the Russian empire, including minorities, such as Estonians.²³² Against this background it is no surprise that the first steps towards the Estonian oil shale industry were taken in this special milieu.

A publication dedicated to the 10th anniversary of the foundation of the Estonian oil shale industry in 1928 does not attempt to hide the role of Russian scientists:

“It should be particularly underlined that all research done in the Russian times and the materials and results based thereupon which were studied by the leaders of the Estonian oil shale industry played a fundamental role in the creation of the Estonian State Oil Shale Industry, providing it with directions but also supporting it in its struggle to exist.

The task of Estonia, but especially of the Estonian State Oil Shale Industry, is to implement on an industrial scale the development of the oil shale industry that was started by Russian scientists and engineers.”²³³

Had such a text been published during the Soviet years, it would almost certainly be dismissed as pro-Russian propaganda today. This text was, however, published in a time of increasing national sentiments in 1928 when there were no obvious reasons to please the Russians. Thus it should pose no difficulty to judge the contents as earnestly meant. The Russian interest was, as has been seen, twofold. First, there was the purely scientific interest, especially among geologists. Second, the prolonged and from a Russian point of view unsuccessful WWI led to increased interest in new sources of fuel. In this respect the Estonian oil shale was of particular interest, being located in the vicinity of imperial Russia’s capital St. Petersburg. One may thus safely claim that attention was paid to oil shale as a consequence of radically altered circumstances.

The oil shale territory (the county of Ida-Virumaa) was occupied by German troops in February 1918. Soon the Germans started excavations in the quarries originally started by the Russians, through a company named *Internationales Baukonsortium*, which never developed any large scale activity, but sent a trainload of oil shale to Germany to investigate the possibilities of producing lubricating oil. This episode might explain the rapid return of

²³² A history of Estonians in St. Petersburg before the Russian revolution can be found in Pullat (2004).

²³³ Riigi Põlevkivitööstus (1928) p. 16.

German interests in the Estonian oil shale industry in the 1920s.²³⁴ On November 29, 1918 the German employees left in fear of the advancing Bolsheviks, who took control of the area on December 7, 1918 and held it until January 16, 1919, when they were forced to leave by advancing Estonian troops. Initially the oil shale resources were intended to serve as a collateral for foreign loans by the interim Estonian government,²³⁵ but at a cabinet meeting on November 17, 1918, it was decided to further explore the little-known resources instead. This proposal was made by the previously-mentioned engineer Märt Raud (who also appears as a reference in this work). Raud was perhaps the most staunch supporter of government intervention in industry as a counterweight to the otherwise prevailing *laissez faire* ideology that had gained an upper hand after WWI. It was a direct result of his actions that the initial development of the oil shale industry was government-led.²³⁶

The existing open pits were subordinated by a government decree on November 24, 1918 to the *Estonian State Oil Shale Industry (Riigi Põlevkivitööstus)*, which was a department of the Ministry for Trade and Industry. Raud was appointed director of the department. This decree was later seen as the starting point for the Estonian oil shale industry.²³⁷ At this time it was still an open question whether *Internationales Baukonsortium* should be compensated for the equipment it had brought in, but with the departure of the Germans, the issue was *de facto* settled. Oil shale mining was resumed in May 1919 with 40 employees.²³⁸

In the last decades of the 19th century and the first decade and a half of the 20th century, Estonia had undergone a process of industrialization, although still remaining a predominantly agricultural society. Nevertheless, Estonia belonged to the most industrialized parts of the

²³⁴The short-lived German activity resulted also in a few scientific publications, which were, however, rather negative on the future possibilities of any oil shale industry. (*A/S Esimene Eesti Põlevkivitööstus endine Riigi Põlevkivitööstus*(1938)p. 13). On the other hand, this source claims (p. 49) that a trainload of oil shale was sent to Germany in 1920, in order to experiment with an oven (retort) constructed by *Julius Pintsch A.-G.* in Berlin, whose representative had visited Estonia in 1919. Whatever the details are, German industry was an integral part of the initial steps to develop Estonian oil shale.

²³⁵ It might be worth mentioning that in 1992, in the eve of the successful Estonian currency reform, the government-owned forests became the ultimate back-up for the new currency. Once again raw material was to be used as collateral for funding economic development. This time oil shale was not even considered, perhaps because there were doubts about its price. For further details on the currency reform of 1992, see Kelder ed. (1997).

²³⁶ Karma (1999) p. 14. During the depression in the early 1930s, Raud, disappointed with the functioning of capitalism, recommended government planning of the economy (Karma (1999) p. 113).

²³⁷ *A/S Esimene Eesti Põlevkivitööstus endine Riigi Põlevkivitööstus* (1938)p. 14. See also Martinson, H & Martinson, K. (1981).

²³⁸ *A/S Esimene Eesti Põlevkivitööstus endine Riigi Põlevkivitööstus* (1938)p. 14, see also Martinson (1987) p.130. The equipment used by the Germans was reported to be in a bad condition. (*Riigi Põlevkivitööstus* (1928) P. 12. Reprint of report by Märt Raud to the Ministry of Trade and Industry, dated November 22, 1918).

Russian empire, but compared to the rest of Europe at the time, Estonia would have qualified somewhere in the middle between the highly industrialized countries and those that had not experienced industrialization on any grand scale. One particular feature of the Estonian industrialization before WWI was the fact that industries in Estonia produced for the entire Russian market. This allowed for the emergence of large factories, such as the *Kreenholm* textile mill in Narva, which was one of the biggest in the world at that time.²³⁹ But at the same time, this heritage meant that Estonia had a dispersed industrial production, without internal cohesion.²⁴⁰ This particular situation called for a quick and reliable solution to the fuel situation in the wake of WWI.

Using today's vocabulary, we could describe the development as "picking the winner" or rather "creating a winner". Nevertheless, the choices made on oil shale utilization were not as much the result of informed assessment of all the available options, but instead quick, more or less improvised decisions made under remarkable uncertainty in a highly volatile political environment. The creation of the Estonian oil shale industry was also a result of coincidences, such as the meeting of Raud and Pogrebov and Raud's influential role in the government of the new Estonian Republic. Moreover, the geopolitical developments had a tremendous impact. The Russian experimentation with oil shale was a direct result of WWI, as was the German interest in the Estonian oil shale, which will be highlighted in the next chapter. Wars and political instability interrupt the normal flow of resources, triggering off the utilization of new ones. For a moment a shift in relative prices of resources had occurred in Estonia, which allowed for the rapid advance of oil shale.

5.1.2. Towards an oil industry

Despite these developments, oil shale did not dominate the Estonian energy agenda during the very first years of the Estonian Republic.²⁴¹ It was rather seen as a potential raw material for the chemical industry. The main reason for not using oil shale as a fuel was, in addition to its relatively unknown qualities, the recognized problem with its high ash content. This was a major problem when using oil shale directly as fuel, because ash tended to block any oven used. Another serious concern was the total lack of skilled miners in Estonia, because there

²³⁹ Valge (2006) pp. 39-45.

²⁴⁰ Valge (1995) p. 1715.

²⁴¹ Estonia declared independence on February 24, 1918 and signed a peace treaty with Russia on February 2, 1920 in Tartu.

had been no previous experience from any sort of mining.²⁴² But gradually the campaigns carried out by the *Estonian State Oil Shale Industry* started to bear fruit and a switch towards oil shale began.²⁴³

However, the lack of trained technical experts, big up-front investments and the poorly understood specific properties of oil shale made other sources for fuel look more plausible. Initially, oil shale was seen as a substitute for other fuels, especially coal, which had to be imported, because there are no coal deposits in Estonia. The abrupt stop of imports of coal caused by WWI and the consecutive wars in Eastern Europe²⁴⁴ forced Estonia to take action to develop a domestic source of energy.²⁴⁵ In 1921, after peace had been restored, wood (in various forms) stood for 90 per cent of the Estonian fuel supply.²⁴⁶ The supply chain of wood was soon riddled with corruption and thus rendered almost useless,²⁴⁷ which seemed to give peat as a fuel a jump start.²⁴⁸ For a short while, around 1920, peat seemed to be the fuel of the future. After times of peace had set in during the first years of the 1920's, imports of coal were resumed and peat lost its attraction.²⁴⁹ In 1922 the government-owned *State Peat Industry (Riigi Turbatööstus)* was founded. This sector never succeeded in attracting private investment (contrary to the oil shale industry, see below) and only one large private enterprise emerged, even this with poor profitability.²⁵⁰ It should, nevertheless, be pointed out that Estonia remained a significant producer of peat. Total production of peat in Estonia in 1934 was 79,000 tonnes, which could be compared to Sweden's 30,000 tonnes or to the 25,000 tonnes of the only slightly bigger Latvia.²⁵¹

²⁴² Luts (1939) p. 110.

²⁴³ Martinson (1987) p. 131.

²⁴⁴ In Estonia WWI was followed by a war against Russian Bolshevik troops as well as German troops that had remained as a result of German victory in the East, but defeat in the overall war. There was also a similar war in neighbouring Latvia. A formal peace treaty was signed only in 1920.

²⁴⁵ Mägi (2004) pp. 72-3.

²⁴⁶ Mägi (2004) p. 72.

²⁴⁷ Karma (1999) p.36.

²⁴⁸ Mägi (2004) p. 73.

²⁴⁹ Mägi p. 73. The use of peat jumped several hundreds per cent between 1920 and 1922, but this was soon followed by a decline until 1923, when a new jump occurred. This was again followed by a decline and by 1926 the use was back at the level of 1921. The use of coal increased dramatically from 1921 to 1923, but declined thereafter, at a slower rate, though. Wood dropped throughout this period, from having been dominant to a level equalling that of coal, but still many times higher than peat. Throughout this period only oil shale steadily increased, becoming the most used fuel in 1924. Source: Riigi Põlevkivitööstus (1928)p. 107 based on material from the Estonian statistics office.

²⁵⁰ Karma (1999) p. 38.

²⁵¹ Luts (1937).

Oil shale as a solid fuel was used either as fuel by big industries or, to a much smaller extent, produce electricity. It should be stressed that in the early 1920s a national electric grid for Estonia was still way off in the future. Gradually it was realized that beside using unprocessed oil shale as a fuel similar to coal, also shale oil (i.e. the processed oil product) and numerous other substances valuable for the chemical industry could be extracted from oil shale. This development meant that Estonian industry could take a long step ahead in processing techniques, but at the same time the lack of domestic capital was a potential obstacle. The chaotic times in the aftermath of the Russian revolution had left several big Estonian industries in desperate need of capital after losing their positions in the Russian markets, which they had been an integrated part of. On the other hand, Estonian industry before WWI was mainly built around textile and metal production on a scale that now turned out to be superfluous. In this situation, the Estonian government took steps in directing industrial development while the Estonian central bank became the main provider of credit. The amount of credit provided and guaranteed by the central bank was not sufficient, though. The understanding of these domestic limitations together with the wish to develop a strong Estonian industry led to an increasing acceptance of foreign investment, especially in heavy industry. Domestic investment remained smaller than foreign investment throughout the period of independence, although the Estonian share gradually increased. In 1936 the share of Estonian capital in heavy industry was 39 per cent, and in 1938 Estonian capital made up a total of 44 per cent of the capital invested in all heavy and medium-sized industry, including that entirely owned by the public sector.²⁵² This decided the further development of the oil shale industry, too, where the Estonian government and Estonian private capital together with foreign capital coexisted in a rather fruitful way, as will be shown below.

Oil shale as a fuel replacing coal was first exploited on a larger scale in the cement factory at Kunda. Between 1920 and 1924, the cement industry consumed 60 per cent of oil shale mined in Estonia.²⁵³ It is noteworthy that oil shale is still today the fuel used at the factory and the company now plans to mine oil shale at a location closer to the factory, where it is estimated the deposits last for several decades.²⁵⁴ Soon other industries followed suit. In 1923 a pulp factory in Tallinn, *Põhja paberi- ja puupapivabrik*, opened its own oil shale mine while a newly-built electrical power station in Tallinn used oil shale to heat its boilers. But the

²⁵² Pullerits et al. (1939) pp. 72-80.

²⁵³ Martinson (1987) p.131.

²⁵⁴ http://www.knc.ee/index.php?lang=est&main_id=4&id=25 (accessed on January 17, 2006). Kunda Nordic Cement is today part of Heidelberg Cement Group of Germany.

shareholders' union of the pulp factory remained skeptical towards the development of oil shale as a big industry in its own right:

“A large-scale oil shale industry needs thousands of workers, who, however, cannot be found in Estonia. For this reason, the labor force should be imported from abroad, otherwise it will not be possible to create a big industry of oil and oil shale. These questions are likely to become accentuated when suitable ovens for the oilstone industry have been invented and the latter develops into a big industry.”²⁵⁵

The attitude towards oil shale was certainly not one of rejection in government circles, although some hesitation can be sensed in the early years of oil shale development. Maybe the oil shale enthusiasts' visions were simply too good to be true? Extracts from the minutes from a meeting between ministries in February 1923 reflect this mood:

“...Mr Raud, who states that the development and the perspectives of the oil shale industry are very hopeful. Oil shale is much cheaper than peat. Many factories have made trials in order to introduce oil shale as a fuel and gained good results. /.../ The most important quality of oil shale is that it is possible to extract oil from it as well, and for this reason a bigger oil factory is being built at Kohtla with a power station...

...Mr Kark and Mr. Jalajas [*from the ministries of trade and industry, and roads, respectively- my addition*] hesitate to put too much hope on the future of oil shale, because there has not yet been any general demand.

...on the question put forward by director Lukk, Mr. Raud informs that no definite contracts with users have yet been made.

...Mr Vuh [*expert-my addition*] thinks that the State Oil Shale Industry should be made similar to private enterprises, with information on incomes and expenses. A real industry develops naturally through competition”²⁵⁶

Nevertheless, by 1924 oil shale had been established as a fuel among others.²⁵⁷ While oil shale accounted for a mere 3 per cent of heavy industry fuel in 1920, the corresponding figure for 1928 was 44 per cent. In the meantime peat and wood dropped from 88 per cent to 22 per cent, while the remaining share was mainly imported coal.²⁵⁸ This rapid shift from one fuel to another was rather paradoxical, because at the time there was no universally accepted

²⁵⁵ ERA 2491-1-41 p 106, Põhja Paberi ja Puupapi Vabrikute A/Ü Kaubandus-Tööstusministeeriumile, Herra Ingenier A. Lukk. 12.7.1923.

²⁵⁶ ERA 2491-1-41 p. 111. Protokoll ministeeriumite vahelisele erikomisjoni istangul 9.2.1923.

²⁵⁷ Martinson (1987) p. 131.

²⁵⁸ Mägi (2004) p. 77 and Riigi Põlevkivitööstus (1928) p. 107.

technology for using the new fuel. The point made here is that this radical shift took place more or less simultaneously with the emergence of untested technology. A major shift in energy sources usually emerges over time, while technology is going through a phase of trial-and-error before its full-scale utilization. But this was not so in the Estonia of the 1920s. Trials at various factories in 1922 and 1923 showed that costs could be reduced by as much as 50 per cent when substituting oil shale for peat or wood. The results from different branches of industry all pointed in the same direction. There were strong indicators of an enormous cost saving potential by switching to oil shale, but at the same time there was no clear-cut technological option to reach this end.²⁵⁹ For example, in 1923, the local German-language newspaper “Revaler Bote” reports that in the winter of 1921-22 a certain engineer, A. Männiksaar, experimented with using different fuels in one and the same boiler coming up with the result that achieving the same heating value was most expensive when peat was used as fuel, while wood was cheaper, but oil shale was the least expensive option.²⁶⁰ But because there was no universally accepted technology at the time, choosing oil shale was more or less a jump into the unknown, which naturally gave rise to occasional concerns, especially in heavy industry. When the paper mill *Põhja paberi-ja puupappivabrik*, which even had its own oil shale mining operations, in 1923 dared to doubt the pace at which oil shale-related technology was developing and instead suggested to the Ministry of Trade and Industry that it should be allowed to import coal from Britain,²⁶¹ Märt Raud, (director of the *State Oil Shale Industry*) contacted the ministry and declared in a rather irritated tone that:

“...shale oil is a local fuel, standing above any competition, because oil shale is the cheapest fuel, it can always be supplied in any amount demanded, its qualities and fuel value are assured and guaranteed, there are appropriate and well-adapted boilers found for its utilization, therefore the taking of oil shale into use as a fuel for the companies of our industry is increasing every day, as the ministry well knows...”²⁶²

The documents don't disclose whether the factory was allowed to import British coal on that occasion, but in the end Estonian industry switched to oil shale and imports of coal constantly decreased after 1924.²⁶³

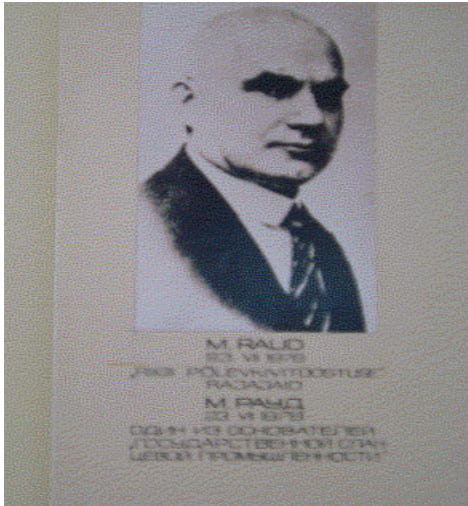
²⁵⁹ Riigi Põlevkivitööstus (1928) p. 106.

²⁶⁰ ERA 2491-1-41 p 113 l. Beilage des Revaler Boten 5.2.1923 “Zur Frage der einheimischen Brennstoffe” Ingenieur N. Wiegand.

²⁶¹ ERA 2491-1-41 p. 104 (dated 12.7.1923).

²⁶² ERA 2491-1-41 p. 99-100 (dated 22.9.1923).

²⁶³ Pihlamägi (2004) p. 216.



Märt Raud (photograph by the author from the collection of the Oil Shale Museum).

The switch to oil shale was accommodated by the introduction of import tariffs on coal in 1921. In 1924 the import tariff on coal was increased from 2 per cent to 2.9 per cent, but this did not significantly alter the consumption pattern.²⁶⁴ Thereafter the tariff was stabilized at approximately 3 per cent of the total price for coal throughout the 1920s. A fall in the world market price for coal in the same period caused the tariffs to reach 4.7 per cent by 1929, because the tariffs were fixed in currency terms, not as a percentage of price. The tariffs were, however, not directed towards coal in particular, but they were a part of a more comprehensive tariff package. Could the introduction of tariffs be said to have altered the economy in favor of oil shale instead of coal? Trials with locomotives in 1923 and 1924 gave the result that oil shale would be 24 per cent cheaper than coal. Following the Estonian economic historian Jaak Valge, one can assume that a removal of the tariffs levied on coal would not have altered the overall advantage of oil shale, even when allowing for the fact that the *Estonian State Oil Shale Industry* played an important role in the assessment of various fuels while at the same time having the outright task to promote the use of oil shale.²⁶⁵ Furthermore, there is little evidence that supporting oil shale would have gained unequivocal support from the government in the first crucial years of the existence of the oil shale

²⁶⁴ Valge (1995) p. 1722. According to figures presented by Valge (1995) imports of coal went down from 98 thousand tonnes in 1924 to 89 thousand tonnes two years later, while oil shale output increased from 228 thousand tonnes in 1924 to 390 thousand tonnes in 1926. Thus, the decline in coal is insignificant in comparison with the increase in oil shale.

²⁶⁵ Valge (1995) p. 1722.

industry. On the contrary, evidence points in another direction, namely that the all-encompassing task was to guarantee stable conditions for all Estonian industry, which suffered from little horizontal integration as a result of its earlier dependence on the entire Russian market. Oil shale emerged as a solution, although initially perhaps a temporary one, for this purpose, not for its own sake. Only later did the oil shale industry become the showpiece of Estonian industry.



A horse pulling oil shale in a mine, probably in the early 1920s. (Photograph by the author from the collections of the Oil Shale Museum).

In 1923 the government launched a competition to find the best technology for burning oil shale. Both domestic and foreign competitors were invited. Danish engineers had developed an oil shale oven at the *Port-Kunda* factory, which was Danish-owned, while British-designed technology was used at the paper mill *Põhja paberi-ja puupappivabrik*, partly owned by British capital. The competition resulted in a draw, after which the government gave up all further attempts at influencing the development of the most suitable technology for burning oil shale. Instead it was up to the individual users to develop their own methods.²⁶⁶ From this point onwards, the government would follow a policy of involvement in the sector through its own company, but without attempting to influence the overall choice of technology, thus

²⁶⁶ Riigi Põlevkivitööstus (1928) p. 106 see also Mägi (2004) pp. 75-6.

limiting its role to its own company. This particular episode can be singled out as the watershed when the government gave up its attempts at controlling the entire oil shale sector.

A particular problem remained, namely that oil shale comes in three sizes – chunks, nodules (of the size of a nut) and fine-grained. The chunks could easily be used as such, especially as locomotive fuel instead of coal, while the latter two categories required special equipment, which was gradually developed in Estonia. In 1939, Märt Raud could claim that basically all the problems with using oil shale directly as a fuel had been solved. This statement was supported by the fact that virtually all bigger industries had switched to oil shale.²⁶⁷

The transition to oil shale was supported by the government-ordered shift to oil shale in the railroad system, where oil shale replaced coal as the fuel for the railways by 1925.²⁶⁸ Initially there were serious doubts whether the locomotives could be reconstructed to use oil shale, and therefore this process did encounter resistance. It was, for instance, feared that oil shale would make it difficult for trains to run on schedule. By the spring of 1925 all locomotives were powered by oil shale.²⁶⁹ In 1927 the railways consumed roughly one fourth of all oil shale produced.²⁷⁰ It naturally had a significant impact on the profitability of the oil shale industry when this important sector of modern society (in the 1920s) made the transition to oil shale, and it can be asked whether this was the final push in the direction of an oil shale-based energy system. Even if there was no staunch resistance in industry circles to oil shale, the government still had to create demand for it in order to allow for a production big enough to alleviate industrial concerns. By focusing on the railways, the government caused increased demand for oil shale allowing the new-born oil shale industry to develop in terms of both technology and economy.

In less than a decade, Estonia had thus managed to develop a strong domestic contender to imported fuels, mainly coal. On the other hand, the supply of coal was severely hampered by the post- WWI disarray on the European coal market, causing concerns in any coal-importing country.²⁷¹ In a time of nation states jealously guarding their balance of payments,

²⁶⁷ Raud (1939).

²⁶⁸ Estonia was particularly interested in exporting oil shale for the Soviet railways. See Loit (1994) p. 325

²⁶⁹ Raud, M. (1925) pp. 16-7. There were, according to Raud, a total of 65 locomotives in use, all of which had to be reconstructed in order to be oil shale compatible.

²⁷⁰ Riigi Põlevkivitööstus (1928) p. 110 and my own calculations.

²⁷¹ For an analysis of the bleak outlook for the European coal production in the wake of WWI, see Keynes (2004/1920).

successfully harnessing a national energy resource was nothing short of success. In an amazingly short time span a major switch in the energy system had taken place in Estonia. This rapid development should moreover be contrasted against the backdrop of an almost total lack of previous experience and capital. In these formative years of the oil shale industry, tariffs on imported coal remained low and were hardly crucial for the success of oil shale.

At this time, electricity was not yet being produced by burning oil shale, but instead from peat at steam power stations and small-scale hydro plants. The electricity grid was still underdeveloped and highly localized. Per capita electricity consumption remained much lower than in neighboring Scandinavia throughout the entire first period of Estonian independence.²⁷² In these early years oil shale was only slightly processed. Oil shale went directly from mines to the boilers of factories and locomotives. In the following years, the processing of oil shale would become the focal issue for the oil shale industry, which at the same time meant that a new technology had to be developed. But by the mid-1920s one can safely claim that Estonia had grown accustomed to the idea of using oil shale as fuel. Resistance faded away with improving technology and the industrial users, trouble-ridden after the collapse of the vast Russian market, saw oil shale as a method to reduce costs.

This rapid diffusion of the previously unknown oil shale seems to indicate that after the government had taken the initiative to create both supply and demand and had participated in a few attempts at promoting oil shale, there was little that could stop the emergence of oil shale as a fuel. Among the underlying reasons one can of course mention the relatively high energy value of Estonian oil shale (kukersite), but the up-front costs tied to a rapid switch could still have delayed the process. Suitable ovens for burning oil shale were relatively quickly developed by the Estonian engineering companies *Ilmarine* and *Fraz Krull*.²⁷³

In the story of the emergence of the Estonian oil shale industry, the government played a role similar to what Robin Cowan calls a central authority favoring a particular technology in a situation of a choice (see chapter 3.2.4.).²⁷⁴ The technology chosen by the government will develop along its learning curve, even if it might be inferior to its alternatives, and as time goes by become seemingly superior. The Estonian government, though increasingly in favor

²⁷² Mägi (2004) p. 81.

²⁷³ Mägi (2004) p. 75.

²⁷⁴ Cowan (1991).

of oil shale, never actually tried to squeeze out other sources, at least not by other means than by creating an example to follow. Oil shale was a truly radical solution, but the factors that made such radicalism possible are to be found in the dramatically changed environment and perhaps not so much in technological breakthroughs. A major shift in the institutional structure had taken place and, following Douglass North or John Campbell, positions were renegotiated between the parties concerned.²⁷⁵ In the particular case of Estonia, an entirely new party emerged and won.

Equally important for the emergence of an oil shale-based energy system was the fact there was no real resistance. As a consequence of Estonia no longer being a part of Russia, there were no interests of Russian coal producers to consider. The lack of a domestic fuel-producing industry also meant that there were no particular, strong interest groups within Estonia who would have objected to the introduction of oil shale. There was hesitation, though, but little outright resistance. Such a clean table before settling for a future energy system must be extremely rare. Instead there was a short period at a crossroads, when several alternatives lay open. In most respects oil shale was the most radical choice and maybe this was the ultimate reason why it gained the upper hand in the ensuing competition. As a result of a fortunate twist in world history, Estonia had won independence and perhaps the most appropriate way to manifest this extraordinary event was to go for the most radical choice of technological solution. In the end, the sense that the impossible had suddenly become possible could be seen as the final factor that triggered off the rapid victory of oil shale. Recalling Arthur's example with two competing technologies²⁷⁶ and Arthur, Ermoliev and Kaniovski's reasoning about the poly urns,²⁷⁷ it can be said that Estonia in the early 1920s came to be the stage for a competition between technologies, in which actually no one seemingly had an initial advantage. But soon the development tilted over in favor of oil shale. This outcome was probably not inevitable, but with hindsight it becomes reasonable to claim that oil shale was the best fit with the prevailing paradigm of the independent nation state. In addition to this, oil shale had active promoters, whose actions had a crucial role in tilting the system in their favor.

²⁷⁵ North (1990) and Campbell (1997).

²⁷⁶ Arthur (1989) and (1990).

²⁷⁷ Arthur, Ermoliev & Kaniovski (1987).

In the social sciences, it has become common to deny particular individuals the crucial role in broad societal developments. This has been observed by Paul Hirsch and James Gillespie, according to whom:

“/.../ the path dependence literature does not focus enough on the role of individual actors. This is ironic given the tendency of path dependence to “romance” small events and thereby ignore or deny larger social and institutional contexts.”²⁷⁸

In the case of the early developments of the Estonian oil shale industry it would nonetheless be incorrect to play down the role of Märt Raud, who, according to all accounts, was a key individual in constructing the industry. However, Raud was not an entrepreneur in the traditional meaning of the word, but instead a sort of “administrative entrepreneur”, probably driven by a sense of commitment to the young Estonian state. It can definitely be asked whether the oil shale industry would have come into existence without him, or at least, whether it would have gained its momentum. This particular case shows that occasionally individuals can have a decisive impact on development. Earlier, it was mentioned that there has been some discussion on whether Thomas Hughes in his studies of large technical systems (LTS) puts too much emphasis on individuals, system builders.²⁷⁹ Whether the Estonian oil shale industry in the 1920s would qualify for being defined as an LTS, in the sense described earlier, can be questioned. It was merely a big industry emerging. But with hindsight, applying this perspective should cause little hesitation to call Raud an individual system builder. By recalling the example put forward by Arthur, Ermoliev and Kaniovski on the poly urns, where a small initial lead might tilt the entire system in a particular direction, it is possible to treat the presence of a single enthusiastic individual as that particular random occurrence that creates the initial lead.²⁸⁰

5.1.3. Processing

The processing of oil shale was still in its infancy in the early 1920s. By processing is meant that oil and other chemical substances are extracted from the oil shale instead of simply burning it, i.e. an upgrading process. This was a way to increase the value added, but also to broaden demand for oil shale. Some early attempts were made by various firms in Tallinn, but

²⁷⁸ Hirsch & Gillespie (2000) p. 82.

²⁷⁹ See also for instance Joerges (1988) p. 12.

²⁸⁰ This reasoning was suggested by Staffan Laestadius (April 11, 2007)

those attempts were “haphazard and lacked coherence”.²⁸¹ Moreover, there was still no universally accepted retort technology and each industrial site had to develop its own technology.²⁸² This problem became clear in 1920, when the newly-created army tried to extract oil by using two upright retorts – initially a Scottish technology – but had to give up when the retorts were blocked with ash and tar.²⁸³

The crucial problem that had to be overcome was the fact that (Estonian) oil shale turns into asphalt when its temperature stays between 300°C and 400°C. The failure of the first attempts was that oil shale close to the heated walls of the ovens was transformed to asphalt, while oil shale in the middle of the oven stayed too cool.²⁸⁴ Another problem was the earlier mentioned issue of size. As oil shale comes in three sizes – chunks, nodules and fine-grained – the choice of technology also reflects upon what varieties of the raw material can be used. In particular, some technologies did not allow for the use of fine-grained oil shale. The efficient use of these various sizes called for variety in technology.²⁸⁵

As has been mentioned before, the Estonian state played an important role in promoting the use of oil shale, but it never went as far as trying to take control of the sector. Instead, one may identify an attempt at breaking new ground for the private sector to follow. Such was also the initial development in processing oil shale, as will be described below. Of course one can ask whether the government actually perceived the situation in these terms or whether it was rather indifferent to private sector activity, but whatever its intentions were, this was the result. But at the same time the government wanted to remain an important actor for a number of reasons. The main reason for this was a wish to reduce dependence on imported energy, to develop a new product group for exports, and to create new jobs by introducing new technology.²⁸⁶ The ensuing development was rapid. For a few years it seemed as if a virtual oil bonanza would take place in Estonia. Total production of crude oil increased 15-fold in the decade from 1925 to 1934, from 3118 tonnes to 47,000 tonnes.²⁸⁷ This figure was tripled by

²⁸¹ Martinson (1987) p. 132.

²⁸² In 1921 the Estonian Ministry for Trade and Industry arranged a competition for developing suitable retorts for a number of purposes, but the results were disappointing. In particular the problem with ash was not solved in any contribution. (Mägi 2004 p. 75).

²⁸³ A/S Esimene... (1938) p. 50.

²⁸⁴ Luts (1939) p. 59.

²⁸⁵ Raud (1939).

²⁸⁶ Loit (1994).

²⁸⁷ Kalviste (1936).

1938.²⁸⁸ Also production of gasoline increased from zero to 6,000 tonnes in 1934.²⁸⁹ Despite this rapid growth, the total amounts of oil extracted remained rather modest and would only meet the Estonian domestic demand at the time, where consumption per capita was clearly lower than in Sweden or Finland. But it was expected to rise,²⁹⁰ and with growing experience and developed technology, it was hardly the case that foreign companies participated only to satisfy Estonian demand. Instead, as will be shown below, Estonia became a sort of testing ground for new technologies.

The depression in the early 1930s did not hit the oil shale industry particularly hard. Despite the fact that production ceased (temporarily, as it would turn out) at the Swedish-owned *Estländska Oljeskifferkonsortiet*, most companies remained in business. The introduction of dramatically higher tariffs on imports of fuels contributed to create a protected market.²⁹¹

In the end, the stable demand from the railway system and the successful attempts at exporting oil paid off. Gasoline was exported to Czechoslovakia, while impregnation oil found buyers in several countries. The experiences from the depression years made the oil shale industry more aware of the need to diversify its production to be able to cope with sudden price fluctuations and the need to increase the value added in the oil products, for which a niche in the world market was easier to find. At this time it was also recognized that one competitive disadvantage for the Estonian oil shale industry was its small size, which increased average costs of production.²⁹² But the increased processing was also stimulated by the distortion caused by the introduction of tariffs on imported oil. Between 1932 and 1933 imports of oil all but ceased, thus giving domestic shale oil a significant advantage. The all-important railway system also switched from oil shale to shale oil in the 1930s.²⁹³

The biggest actor in oil shale processing was the previously mentioned *Estonian State Oil Shale Industry (Riigi Põlevkivitööstus)*, which in October 1936 was restructured as the government-owned joint stock company *First Estonian Oil Shale Industry Ltd. (AS Esimene Eesti Põlevkivitööstus)*. Oil production started with an experimental factory in August 1921 at

²⁸⁸ Raud (1939).

²⁸⁹ Kalviste (1936).

²⁹⁰ Merits (1935).

²⁹¹ Valge (1995) The drastic tariff hikes can be illustrated with the following figures: In 1929, 4.9 per cent of the cost of imported coal in Estonia was due to tariffs, while the corresponding figure for 1932 was in the range 22 per cent to 85 per cent (depending on various tariff reduction arrangements). p. 1723.

²⁹² Merits (1935).

²⁹³ Valge (1995) p. 1725.

the Kohtla mine.²⁹⁴ The factory had been designed by the German engineering company *Julius Pintsch A.-G.* Such an experimental factory was needed because:

“.../the Estonian oil shale was a previously unknown substance in the world’s industry and because of this, the appropriate methods and means for its processing had still not been found/.../”²⁹⁵

This first factory had the capacity to process 7 – 8 tonnes of oil shale daily, extracting 18 – 20 per cent shale oil.²⁹⁶ By the end of 1925 this factory had produced 1,100 tonnes of shale oil, which found several uses. It was used as lubricating oil (particularly by the railways), but it was also refined to produce motor vehicle fuel (gasoline and fuel oil) and a substance called gudron (a distillation rest) used in asphalt works. In addition to this, also various lacquers were produced. These results were considered promising and in January 1925 a much bigger factory started its production at Kohtla - also constructed by *Julius Pintsch A.-G.* This new factory had six retorts (or ovens) and had a daily processing capacity of 200 tonnes of oil shale.²⁹⁷

In March 1936 a second oil factory was opened and in 1938 a third one. The retorts used at these factories were modifications of the original construction. After gaining experience of the process, the local engineers improved the technology, which was then built by local Estonian companies *Riigi Sadamatehas*, *Franz Krull* and *Ilmarine*.²⁹⁸

The second factory produced 20,000 tonnes of oil annually and for the third 40,000 tonnes. In addition to these factories, a bitumen factory was opened in 1927, a petroleum factory in 1931 and a gas-petroleum factory 1936. The combined capacity of these three factories thus rose oil output sevenfold in less than a decade. This development was made possible by an increasing demand after the crisis in the early 1930s, but also as a result of active measures to create both a domestic and foreign market.²⁹⁹ In February 1939, the *First Estonian Oil Shale Industry*

²⁹⁴ According to Raud (1939), this experimental factory had its origins in an experimental factory run by Julius Pintsch AG at Fürstenwalde in Germany.

²⁹⁵ Raud (1925) p. 10.

²⁹⁶ Earlier attempts had resulted in an oil capture between 9 and 11 per cent in Scotland and between 6 and 8 per cent in France, while German attempts with brown coal produced only between 4 and 7 per cent oil. (Raud (1925) p. 11).

²⁹⁷ Raud (1925) p. 11.

²⁹⁸ Raud (1939).

²⁹⁹ A/S Esimene (1938) pp. 51-3.

presented plans to construct a fourth factory with an annual production capacity of 50,000 tonnes of crude oil.³⁰⁰



The factory at Kohtla-Järve in the 1930s. Photograph by the author from the collections of the Oil Shale Museum.

Already in the mid-1920s the *Estonian State Oil Shale Industry* underwent some changes towards a market-oriented firm. In 1927 it was obliged to pay state and municipal taxes on the same basis as privately owned firms while its employees were no longer considered state officials. The corporate leadership was also made more business like, with an appointed CEO instead of a commission of state officials. When the *Estonian State Oil Shale Industry* became a joint-stock company in October 1936, the Estonian government retained a 95 per cent stake in the company.³⁰¹

By September 1938, *First Estonian Oil Shale Industry* employed 2,600 persons, provided housing for 3,000 persons and “bread” for approximately 6,000 persons. In 1933 the number of employees was as low as 930,³⁰² down from 1,400 in 1928.³⁰³ The total number of

³⁰⁰ Karma (1999) p. 142.

³⁰¹ A/S Esimene...(1938).pp. 17-8.

³⁰² A/S Esimene...(1938) p.15 & 89.

³⁰³ Riigi Põlevkivitööstus (1928).

employees in both state-owned and private oil shale enterprises reached about 3,500 persons in 1936.³⁰⁴ According to another source the total number of employees reached 6,000 in the late 1930s.³⁰⁵

5.1.4. Private investment

Private enterprises in the Estonian oil shale industry were not wholeheartedly welcomed by the Estonian government, especially not foreign enterprises. In the end, however, a sort of uneasy coexistence developed between the government, its oil shale enterprise and foreign actors. There were repeated calls on the Estonian political scene to ensure that ultimate control over the oil shale production remained in Estonian hands. The opposite strand saw foreign investment as a sort of soft security policy. The more foreigners were involved in Estonia, the better the protection from possible Soviet aggression.³⁰⁶ In the end, it was the economy that decided the development. Estonia, with relatively little domestic capital, simply had to accept foreign private involvement in order to develop the oil shale industry.³⁰⁷ But it should also be added that the Estonian government had given up all attempts at controlling the technological development, but instead allowed competition for developing the most suitable technologies. This would have been impossible under strict government control. In the end, the government ended up being a sort of swing producer (to use a modern term) by retaining the capacity to control prices. The price for oil shale remained remarkably stable for most of the 1920s, with price changes never exceeding 10 per cent.³⁰⁸

Concessions to utilize oil shale were granted to private, including foreign, capital in the beginning of the 1920s, but despite significant interest, relatively few holders of concessions eventually started production. The reasons for this include general uncertainty about Soviet plans for the future of the Baltic states, but also the unclear legal framework in Estonia on the exploration of natural resources and the possibility of landowners to oppose exploration by a

³⁰⁴ Luts (1937).

³⁰⁵ Pullerits et al. (1939) p. 81.

³⁰⁶ Loit (1994) pp. 336–40.

³⁰⁷ Loit (1994) pp. 336–40. A detailed analysis of the Estonian state involvement in the economy between 1919 and 1939 is presented by Karma (1995).

³⁰⁸ Oil shale was sold in three categories, which complicates direct price comparisons with other fuels. The price difference between the cheapest and the most expensive sort of oil shale exceeded 100 per cent. (Riigi Põlevkivitööstus (1928) p. 110).

concession holder.³⁰⁹ Of 30 concessions granted, only a few turned operational.³¹⁰ Initially, the system with concessions was developed by the Union of Estonian Industrialists,³¹¹ which was concerned that the *Estonian State Oil Shale Industry* would not be capable of supplying oil shale as fuel for the industry, or that it would pursue a price policy not in accordance with the interests of the industry. These concerns never materialized, but as a result two industrial enterprises otherwise not engaged in oil shale commenced their own mining activity, while other investments were related to shale oil production.³¹²

The number of concessions granted reflects a significant foreign interest in Estonian oil shale. The Swedish-Estonian historian Aleksander Loit distinguishes between three types of interest. First there were purely commercial interests. Second, there were political concerns on the international level that adversary nations would get the upper hand in the utilization of Estonian oil shale, especially in the 1930s. Third, technology choices and innovations in Estonia created curiosity in international oil companies.³¹³

In 1922 *Eesti Kiviõli (Estländische Steinöl)*, where the majority stake was held by the Baltic-German bank *G Scheel & Co*, started mining and experimental processing at Kiviõli.³¹⁴ The capital actually originated from *Bankhaus Mendelsohn & Co*. in Germany, while *G Scheel & Co*, which was perceived as pursuing a policy of promoting German interests in Estonia, became the logical domestic counterpart. This investment was particularly noteworthy, because the relations between Estonia and Germany in the 1920s were rather strained after the Estonian government had confiscated land from manors previously owned by the Baltic German nobility. It is likely that the fuel shortage in Germany following WW I became the

³⁰⁹ Loit (1994) pp. 323 – 4. Luts (1939) p. 107 claims that the system was rather favourable for the concession holders, who only had to compensate the land owners for the land itself, but not for resources found underground. There was however a tax of 15 Estonian senti on each ton of excavated oil shale. Valge (1995) claims that negotiations between the Estonian government and foreign concession applicants were actually difficult and lengthy. p. 1718.

³¹⁰ Figures vary on the actual number of concessions. According to Loit (1994) there were 30 concessions granted already by 1923, while Kattai (2003) mentions 20 concessions by 1933. As of August 1938 there were 12 concession holders: H.Prensky, A/S Port Kunda, Wanamõisa Oilfields Ltd, A/S Kütte-Jõud, Eesti Kiviõli A/Ü, G.Oliver & H.M. Ommaney, The Consolidated Gold Fields Ltd, The New Consolidated Gold Fields Ltd, A/S Esimene Eesti Põlevkivitööstus, A/S Eestimaa Õlikonsortium, J. Aarmann & K. Zeren, Knut Malm. The last one was located East of the Narva river, an area which today belongs to the Russian Federation. Of the concession holders, Eesti Kiviõli held 3 different concessions. Source: A/S Esimene Eesti Põlevkivitööstus (1938).

³¹¹ Eesti Vabrikantide Ühing, in Estonian.

³¹² Raud (1939).

³¹³ Loit (1994) p. 325.

³¹⁴ According to Valge (1995), the archives of *Eesti Kiviõli* have been lost. p. 1938.

impetus for investing in Estonia, while the Estonian government, short of funds for industrial development, preferred German investment to no investment at all.³¹⁵

The potential of the investment in *Eesti Kiviõli* was initially perceived as very promising by *Bankhaus Mendelssohn & Co* because of the opportunity to develop new technology for producing shale oil. However, the hopes of fat profits soon turned out to be premature. The exploration of new oil deposits in North America in 1929 caused the price of crude oil to fall in the world market, which badly hit *Eesti Kiviõli*, specialized in shale oil (and not raw oil shale). In addition to this, the Estonian devaluation of 1933 made things even worse, because of the amount of liabilities in foreign currencies. At this point *Bankhaus Mendelssohn & Co* refused to provide more funding.³¹⁶ But at this time political developments in Germany entirely changed the picture (on which more in chapter 5.2. below). In brief, the German navy became the principal buyer with an enormous appetite for oil.

The technological development of *Eesti Kiviõli* had nevertheless a profound impact on the development of the oil shale industry in Estonia. In 1929 two tunnel ovens started production, which already in 1931 made *Eesti Kiviõli* the biggest private producer of shale oil.³¹⁷ *Eesti Kiviõli* sold this technology also to Australian producers.³¹⁸ The tunnel ovens, constructed by the Estonian-based engineering company *Franz Krull*, were basically similar to those of *Estländska Oljeskifferkonsortiet* described below.³¹⁹ *Eesti Kiviõli* built a new factory in 1932 and yet another in 1938.³²⁰ In 1939, the capital stock of *Eesti Kiviõli* comprised 38 per cent of the total in the oil shale industry in Estonia, leaving all other companies far behind (for the sake of comparison, the state-owned *Esimene Eesti Põlevkivitööstus* was second with approximately 25 per cent, being of roughly the same size as *Estländska Oljeskifferkonsortiet*)³²¹ In spite of these developments, *Eesti Kiviõli* still did not become a particularly profitable enterprise. In 1938, the Estonian government not only increased the tax on mining concessions, but also required companies to build housing for the employees, schools and even cinemas.³²²

³¹⁵ Rasch (1986).

³¹⁶ Rasch (1986).

³¹⁷ See appendix II.

³¹⁸ Luts (1939) p. 108. See also A/S *Esimene...*(1938).

³¹⁹ Luts (1939) p. 74.

³²⁰ Raud (1939).

³²¹ Loit (1994) p. 327.

³²² A/S *Esimene...*(1938).



The oil shale factory at Sillamäe in the 1930s. (Photograph by the author from a picture in the Oil Shale Museum).

In 1922 the Union of Estonian industrialists founded *Eesti Kütte-Jõud*, as a result of concerns that *Riigi Põlevkivitööstus* would not be able to keep its promises to deliver oil shale to factories, or that it would use its dominant position to increase prices. *Eesti Kütte-Jõud* was solely mining oil shale for fuel. This was actually the first private enterprise in the oil shale industry.³²³ It was soon purchased by the paper and pulp factory *Põhja Puupapivabrik*, which opened an open oil shale mine at Vanamõisa, but continued mining oil shale only as fuel for its factory in Tallinn. In due time, the mine was bought by *Estonian Oil Development Syndicate Ltd*, with a somewhat unclear owner structure.³²⁴ Later *Vanamõisa Oilfields Ltd*, founded by British capital, took over.³²⁵ This company ran two retorts, producing 540 tonnes of shale oil from 4769 tonnes of oil shale between 1924 and 1931.³²⁶ It also had an experimental factory (close to Kiviõli) producing shale oil by heating oil shale on two moving lattices, one upper and one lower. Gases from burning oil shale on the lattice below freed oil gases in the bitumen on the lattice above, which then were collected. The organic material left on the upper lattice after this process fell down to the lower, where it was burnt to free the oil gases from new, incoming oil shale. This process was seriously hampered by tar

³²³ Riigi Põlevkivitööstus (1928) p. 112.

³²⁴ Luts (1939) p. 108.

³²⁵ According to Valge (1995), *Estonian Oil Development Ltd* was restructured into *Vanamõisa Oilfields*. p. 1935

³²⁶ Orviku (1933). According to Martinson (1987) the activity was shut down in 1930. According to Luts (1939, p.108) production was shut down because of lack of funding, but he does not mention when.

that stuck to the lattices, impeding their movement.³²⁷ Consequently, *Vanamõisa Oilfields* was the only firm to fail totally in the Estonian oil shale processing industry.³²⁸

Despite these developments, the main task of *Eesti Kütte-Jõud* remained producing oil shale for *Põhja Puupapivabrik* while excess production was sold to electrical power plants in Tallinn and Püssi as well as to some liquor distilleries and dairies. In 1940 the total number of employees was around 250.³²⁹

The Danish-owned *Port-Kunda* at Ubjä (in the county of Lääne-Virumaa) has already been mentioned before. This investment was rather small, 0.67 million Estonian kroon or 2.5 % of total investment in the Estonian oil shale industry.³³⁰ The company used oil shale for burning cement, which was its main production.³³¹ The cement factory at Kunda has remained in business until today and the oil shale mine was to be reopened in 2006.³³²

Estländska Oljeskifferkonsortiet (*Eestimaa Õlikonsortsium* in Estonian), founded in 1926, was owned by Swedish and Norwegian interests under the name of *Emissionsinstitutet* – consisting of *Investor*, *Emissionsinstitutet*, and *Norsk Hydro* – but in practice run by the Swedish banker Marcus Wallenberg,³³³ whose long-term ambition was to develop a monopoly in the Estonian oil shale industry. In brief, due to the weakness of Estonia, both in economic and population terms, an opportunity seemed to emerge for Wallenberg to gain monopoly in oil shale, backed by the financial resources and technological strength of the consortium. In the end, the Estonian government finally turned down Wallenberg's ambitions in March 1933, to a large degree as a result of the activities of Märt Raud, who among other things was concerned about possible price hikes on the domestic market were a foreign-controlled monopoly to emerge.³³⁴ One may ask whether the five-year break in the production of *Estländska oljeskifferkonsortiet* between 1930 and 1935 was only a reaction to decreased demand during the depression or whether the Estonian resistance to his monopoly plans

³²⁷ Luts (1939).

³²⁸ Valge (1995) p. 1935. See also Appendix II.

³²⁹ Kuhi (1999) pp. 17-8.

³³⁰ Loit (1994) p. 327.

³³¹ Luts (1939) p. 109.

³³² www.knc.ee, accessed on July 29, 2005.

³³³ Loit (1994) p. 332.

³³⁴ Karma (1999) p. 141.

played a role in postponing the restart of production.³³⁵ This picture is complicated by the fact that in 1931 the private companies had agreed upon a price cartel on the Estonian market for both gasoline and petroleum, which was broken by the *State Oil Shale Industry* which started selling at a lower price, but also by the government subsidizing imported fuels. Probably such a market did not appear as profitable enough for the Swedish banker.³³⁶ The total Swedish investment was 6.5 million kroon, equalling 24 per cent of total foreign investment in the oil shale industry in 1939.³³⁷

Estländska oljeskifferkonsortiet built a factory in what is now the town of Sillamäe. Initially it did not have any mining operations of its own, but purchased oil shale from the *State Oil Shale Industry*.³³⁸ The factory, with tunnel ovens, produced almost exclusively gasoline, which was supposed to be as good as any other gasoline in the world.³³⁹ Oil shale was initially crushed and made into nodules, which then were loaded on train-like small wagons, which went through the oven, 20 at a time, heated by gases pouring in at a temperature of 500°C. The oil gases freed from the oil shale were then suctioned into a cooler and oil separators. This method allowed also for the extraction of 76 octane gasoline, 13 per cent of the weight of the oil shale put into the process. The factory could process 300 tonnes of oil shale, producing 40 tonnes of gasoline daily.³⁴⁰

The Great Depression hit *Estländska oljeskifferkonsortiet* hard. Plans to integrate its activities with the international giant *Anglo-Persian Oil Company* came to nought. In addition to this the Estonian government refused to grant the company any of the privileges it sought, such as government-guaranteed purchases, a price reduction on government-produced oil shale (which was used in the factory, because *Estländska oljeskifferkonsortiet* did not have any mining operations of its own at that time). As a result, production was halted in 1930 and started anew only in 1936. In the meantime the consortium was reorganized into *Baltic Oil*

³³⁵ Wallenberg had been turned down by the Estonian authorities once before, in 1924, when he aspired to become the representative of the League of Nations for negotiating a loan from its Financial Committee to Estonia. The reason for the opposition from the Estonian government is somewhat unclear, but Wallenberg was assumed to have too close ties with Baltic German capital (Karma (1999) p. 71). Moreover, it should be mentioned that the Swedish “match king” Ivar Kreuger had gained a de facto monopoly on the Estonian market for matches in 1928. The events that soon followed caused concerns over similar monopolization tendencies. (Karma (1999) pp. 85-6).

³³⁶ Karma (1999) pp. 140-1.

³³⁷ Kattai (2003) p. 42, Loit (1994) p. 324 & 327 Martinson & Martinson (1981) p. 15.

³³⁸ Loit (1994) p. 333.

³³⁹ Loit (1994) p. 333.

³⁴⁰ Orviku (1933).

Company Ltd (chaired by Axel Axelsson Johnson) and new capital was added and the factory at Sillamäe re-equipped. The company now also had its own oil shale mine. Production soon picked up and increased by a factor of ten in only four years. However, by then market shares had been lost to competitors and equipment had remained idle for years.³⁴¹ The increased production was, in the end, largely a result of exports to Germany – a development discussed at length below. This consortium made a modest profit before WWII, but when the consortium was liquidated after WWII, it had been a significant loss to the Swedish banker Marcus Wallenberg, who initially had judged an engagement in Estonian oil-shale “very promising”.³⁴² In May 1941 Sweden signed an agreement with the Soviet Union, which occupied Estonia in 1940, concerning compensation for lost investment,³⁴³ followed by a Soviet one-time payment of two million Swedish crowns in 1947. This sum could be juxtaposed with the total loss of the company of 5 million crowns.³⁴⁴ The long-term director of the Sillamäe factory, the Estonian-Swede Mathias Westerblom was arrested by the Soviets during the mass deportations of Estonians in June 1941 and died in a Soviet prison camp in 1942.³⁴⁵

The British-owned *New Consolidated Gold Fields Ltd* started its Estonian activities in 1928 at Kohtla-Nõmme (1.5 million Estonian kroon or 5.5 % of the total investment in the Estonian oil shale industry)³⁴⁶ At the factory at Kohtla-Nõmme a rotating Davidson’s retort was used. This technology basically constructed for processing smaller pieces of oil shale also allowed for the heating of small crumbs, which had posed a challenge. Oil shale was heated in a rotating drum-like pipe, 22m in length and 1.6 m in diameter. Inside the drum a “knife-like” mechanism cleaned the walls from tar, allowing for longer uninterrupted use. But despite this, the retort had to be shut down every two or three months for cleaning. Oil shale which had emitted its oil gases dropped down from the retort and was re-used as fuel (because it still contained organic matter). No additional fuel was needed in the process. The problem with this technology was that the total amount being processed was limited, approximately 20 tonnes daily, which made it rather uneconomical.³⁴⁷ Initially, *New Consolidated Gold Fields*

³⁴¹ Loit (1994) pp. 333-4 & 347.

³⁴² Gärdlund pp. 538-9.

³⁴³ Norman (1988).

³⁴⁴ Loit (1994) p. 335.

³⁴⁵ E-mail correspondence with professor Göran Hoppe, February 24, 2006, chairman of “Svenska Odlingens Vänner” – an Estonian-Swedish cultural organization.

³⁴⁶ Loit (1994) p. 335.

³⁴⁷ Luts (1939) pp. 75-6.

Ltd bought the oil shale it needed from *Riigi Põlevkivitööstus*, but from 1937 it also operated its own mine.³⁴⁸

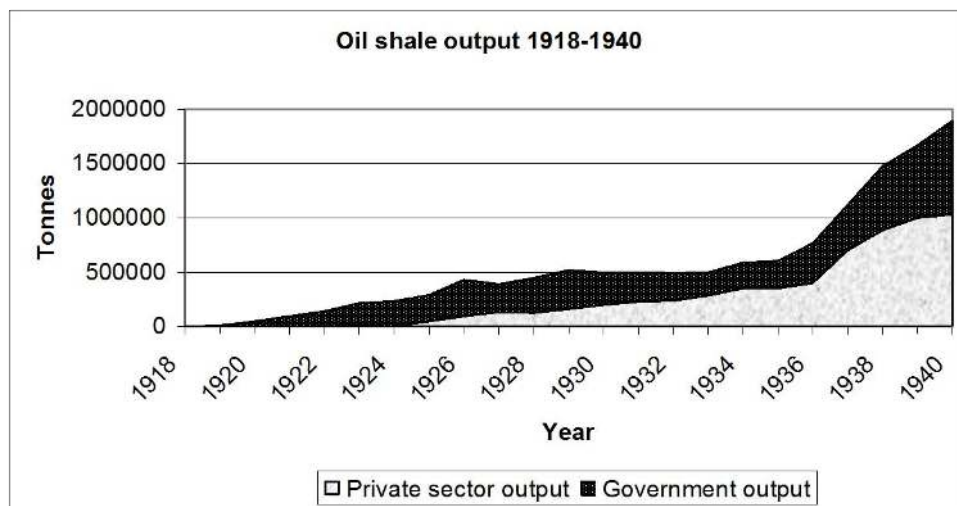
5.1.5. Production and sales

All companies active in shale oil production also had their own mining enterprise, at least at some point. Oil shale could of course be traded between the companies. Initially the development of the oil shale industry was hampered by the complete lack of mining experience in Estonia. In the 1920s, the nascent oil shale industry found it difficult to find employees, and occasionally prisoners were brought to work, which only made matters only worse, because of their limited motivation to contribute to production. During the years of crisis in the early 1930s, the oil shale industry received employees through government job programs for the unemployed. As a consequence of these measures, the oil shale industry got the nickname “Estonia’s Siberia” – an extremely ironic phrase with hindsight. When exports of oil picked up after the depression, the oil shale industry became a more attractive employer, with rising wages. The Government added to this by cutting import duties on goods used for investment in the oil shale industry, while allowing for tax breaks for new investments.³⁴⁹ The number of active mines varied somewhat over the years, but by 1937 there were in total eight mines in operation, both government-owned and private.

³⁴⁸ Valge (1995) p. 1935.

³⁴⁹ Luts (1939) pp. 110 –1. Raud (1939) mentions briefly that the increase in salaries in the oil shale industry in the late 1930s was so rapid that an imbalance with the rest of the labor market occurred, resulting in demands for higher wages elsewhere.

Figure 5.1. Oil shale output 1918-1937



Source: *A/S Esimene...* (1938), *Loit* (1994), *ERA 2491-1-84* p. 24, *ERA 2491-1-70* p. 3, 27-28, own calculations.

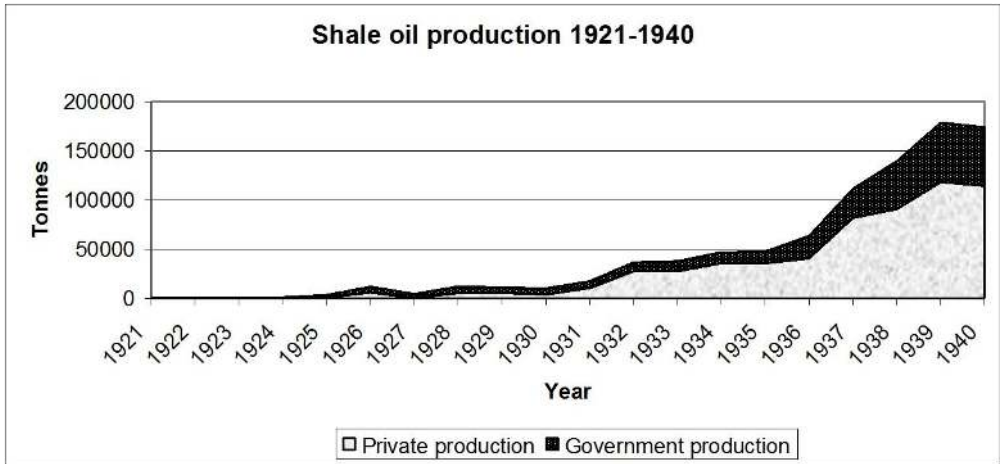
From figure 5.1., it should in particular be observed that during the depression in the beginning of the 1930s, oil shale output remained more or less constant. In Estonia, like in the rest of the world, these years saw a dramatic decrease in overall industrial production, and it could have been expected that also the oil shale industry would also have been affected. However, due to raised import tariffs on especially coal, the position of oil shale remained unchallenged. The price for coal in Tallinn went up almost 20 per cent between 1929 and 1932.³⁵⁰ The Estonian economic historian Jaak Valge has observed that oil shale could compete with imported coal only through government intervention during these years. On the other hand, it should be remembered that the introduction of tariffs was a global phenomenon during the crisis.³⁵¹ In August 1934 a bilateral agreement between Estonia and Great Britain allowed for imports of British coal with lower tariffs, which doubled the imports of coal within three years, but coal was no longer in a position to challenge oil shale.³⁵² It should be added that especially *A/S Esimene Eesti Põlevkivitööstus* supplied private enterprises with oil shale for the production of shale oil, particularly until they opened their own mines. The total amount of oil shale traded for this purpose varied over the years, between 5,333 tonnes in 1931 (the lowest figure) to 60,031 tonnes in 1936 (the highest figure).

³⁵⁰ Valge (1995) p. 1723.

³⁵¹ *Ibid* p. 1723.

³⁵² Valge (1995) p. 1734 and p. 1946.

Figure 5.2. Shale oil production 1921-1940



Source: *A/S Esimene...*(1938), *Loit* (1994) , *ERA 2491-1-84* p. 24, *ERA 2491-1-70* p. 34, *ERA 2491-1-81* p. 76, own calculations.

These new entrants increased production capacity significantly. Their emergence in the market also reduced the relative role of the *Estonian State Oil Shale Industry*, which in 1927 produced 99 per cent of all shale oil but a little more than 20 per cent in the 1930s, except for the year 1936, when the new, third, shale oil factory became operational, causing a hike in output. Thus, by the end of the 1920s it had become clear that the shale oil industry was no longer government-led. In particular the new plant of *Eesti Kiviõli* that was made operational in 1932 significantly increased total production, by at least 100 per cent. The price for Estonian shale oil fell to less than one third between 1929 and 1934, which was perceived not as a threat, but a possibility to become competitive on the international market. On the other hand, a significant increase in shale oil exports between 1933 and 1934 (from 6,000 tonnes to almost 14,000 tonnes) was partly a result of selling out the backlog caused by excess production that had occurred during the years of the Great Depression. However, any figure for exports is likely to be a lower-end estimate, for the reason that shale oil was also used in other export products. These products were not always classified as oil shale-related.³⁵³

Before the late 1930s, exports started to expand, although on a modest scale. Between 1927, when exports began, and 1934 a 15-fold increase of shale oil exports was registered (in tonnes). The share of exports reached 30 per cent of total production. This rapid increase in exports was a result of decreasing production costs due to technological improvements and

³⁵³ Kalviste (1936).

large-scale production,³⁵⁴ but to perhaps an even higher degree due to the tariffs imposed on imported fuels, including coal and petrol. This made not only domestic shale oil but also gasoline competitive.³⁵⁵ From figure 5.2. above, a hike in private sector production of shale oil can clearly be identified during the years of crisis. In June 1933, Estonia made a major devaluation of the *kroon*, which lost some 35 per cent of its external value. One explicit aim was to follow the development of the Swedish *krona*, which had been detached from the gold standard earlier.³⁵⁶ Exports of shale oil and gasoline picked up immediately and doubled between 1933 and 1934, albeit the total figures remained rather low – total exports were 13,800 tonnes and 2,000 tonnes, respectively.³⁵⁷ The increase in exports was mainly a result of clearing trade between Estonia and Latvia (and to a smaller extent Czechoslovakia). Estonian-produced gasoline was not competitive on the international markets due to its production costs. Actually, the price of Estonian-produced gasoline went up by 75 per cent in the period 1929 -1934.³⁵⁸ Between 1932 and 1934 domestic production of gasoline corresponded to over 70 per cent of domestic demand.³⁵⁹ Production of gasoline reached 5,900 tonnes in 1934, up from 690 tonnes in 1929. Supported by export subsidies and bilateral trade agreements the value of gasoline exports was roughly the same as the value of shale oil exports until 1936, when the dramatic increase in shale oil exports to Germany left total gasoline exports far behind.³⁶⁰ However, by July 1939, Estonian-produced gasoline could meet the entire domestic demand and was perceived as being of no lower quality than other sorts of gasoline.³⁶¹

5.1.6. Establishing oil shale research

Systematic research on oil shale in Estonia dates back to 1921, when a laboratory was founded at Kohtla-Järve in connection with the first experimental oil shale factory. Initially, the task of the laboratory was to make current analyses on oil shale samples. Later the activity was expanded to also include analyses of products, such as oil, gasoline, bitumen etc. In

³⁵⁴ One is tempted to add "learning by doing", but this is not mentioned in the context by Kalviste (1936).

³⁵⁵ Valge (1995) p. 1725.

³⁵⁶ Karma (1999) p. 118.

³⁵⁷ Estonian Economic Year-Book for 1934 p. 33.

³⁵⁸ Kalviste (1936). Gasoline cracking had to be conducted as a separate process from the shale oil produced by the Estonian State Oil Shale Company, while it could be obtained by distillation of the shale oil from the major private enterprises. Thus prices for Estonian-produced gasoline are average prices.

³⁵⁹ Valge (1995), p. 1727.

³⁶⁰ Valge (1995) p. 1930. Measured in tones, the figures will of course be entirely different, because shale oil is much heavier than gasoline.

³⁶¹ ERA 2491-1-70 p. 30. Description in German by M. Raud.

addition to these tasks, the laboratory, led by Karl Luts (who appears as a reference in this work), increasingly started what today would be called research and development. Oil shale products were to be streamlined with demand, new production processes to be developed, and entirely new products created. Furthermore, the laboratory was also engaged in basic research on oil shale and its derivatives. Dozens of articles on the topic were published not only in Estonian, but also in English, Russian and German. The laboratory also received oil shale samples for analysis from Bulgaria and Yugoslavia.³⁶²

In 1925 the chemist Paul Kogerman managed to raise funds from state and private enterprises for the establishment of a laboratory on oil shale in collaboration with Tartu University. The main sponsor was the British-owned oil shale producer *New Consolidated Gold Fields Ltd*, which had developed an experimental oil shale processing unit at Kohtla-Nõmme in 1928³⁶³. The laboratory was allegedly the first in the world in this field. From 1930 onwards the laboratory published a periodical under the name “Bulletin”³⁶⁴. One major impact of the laboratory was to switch the focus of the oil shale industry towards the production of liquid fuel instead of low-quality raw oil shale³⁶⁵. During the 1920s the main product of the oil shale industry was only slightly processed oil shale. This type of shale can be used as fuel in a number of ways, but because of its bulkiness,³⁶⁶ transportation costs reduce the export potential³⁶⁷. It is obvious that a higher degree of the value added would increase the export potential and also develop know-how within Estonia.

In the late 1930s there were far-reaching plans to coordinate research activity through a council of oil industry. The private companies rejected the idea, which therefore never materialized. This development, in turn, raised the question whether the government had gone too far in granting concessions to private investment.³⁶⁸

³⁶² A/S Esimene...(1938) pp. 79-80.

³⁶³ Clearly there is some confusion about when this factory was actually taken into use. Obviously there was an experimental device – a rotating retort – taken into use in 1928 by New Consolidated Gold Fields (see Martinson & Martinson p. 15). In 1931 the same company established a regular factory.

³⁶⁴ Martinson, H. & Martinson, K. (1981) pp. 20-1. One may ask how big a role did the fact play that Kogerman finished his M.Sc. at the University of London in 1921 (with the thesis “The Chemical Composition of the Middle-Ordovician Oil-bearing Mineral –Kukersite”) and seems to have been fluent in English. See Martinson & Martinson p. 17.

³⁶⁵ Mägi (2004) p. 77.

³⁶⁶ A reason for this is the high proportion of ash in oil shale.

³⁶⁷ Loit (1994) p. 325.

³⁶⁸ Karma (1999) p. 143.

5.1.7. Comments

By the end of the 1930s, the technology for extracting oil from oil shale had undergone a significant development in Estonia. Attempts at importing technology in the early 1920s had not been particularly successful, mainly because of the special properties of the Estonian kukersite oil shale. Instead, rapid technological development took place in Estonia with the ultimate goal of creating a profitable production from a previously little-known raw material. The development between 1920 and 1940 was nothing short of a success, despite occasional setbacks. Using the terminology of evolutionary economics, it could be said that variety was created. Without it, development might have stagnated. Variety in production technologies allows for the development of several alternatives, some of which might prevail in the end. If there exist only one or two modes of production, the risk of failure for the entire industry will increase.³⁶⁹

The government refrained from taking total control, but insisted on staying in business as a competitor. Estonia had emerged as the scene of technological development within this particular sector and the oil shale industry had become the leading industrial sector in Estonia beside the textile industry.³⁷⁰ Two decades of trial and error, constant learning and incremental innovation had finally yielded what looked like a vibrant technology for the future. In 1936, the future undoubtedly looked bright. In the plans of the Estonian Ministry of Economic Affairs, production of shale oil would increase tenfold in the coming 10 years. The problems anticipated largely concerned housing for the new employees in the region and the problem of producing gasoline for motor vehicles at a level exceeding domestic demand with a factor of four. This gasoline could not be exported without subsidies, because contrary to shale oil, the price of Estonian-produced gasoline exceeded three times the world market price. Exports to Latvia and Finland were made possible by bilateral agreements.³⁷¹ Finding the appropriate technology to optimize the output relation between shale oil and gasoline became an important task for the companies in the oil shale branch.³⁷² Control of the domestic

³⁶⁹ Fagerberg (1995) p. 151.

³⁷⁰ Pullerits et al. (1939) p. 81.

³⁷¹ As a cooperation between *Eesti Kiviõli* and *New Consolidated Gold Fields Ltd*, a joint venture with some Finnish firms was founded under the name *Trustivapaa Bensini*, which set up some 100 petrol stations in Finland. The operations grew significantly and by 1940 it was estimated that sales in the Finnish market would exceed the entire Estonian market for gasoline. Valge (1995) p. 1932. The ownership of this distribution chain was somehow transferred to the Soviet Union during WWII (probably simply grabbed) and it continued to exist in Finland until at least 2005 under the name *Teboil* or *TB*. Having grown up in Finland, I am well aware of the many political connotations that were connected with the act of filling your car at these stations.

³⁷² Luts (1937).

market for gasoline was secured by import tariffs throughout the 1930s, leading to higher prices for gasoline in Estonia compared to neighboring countries. This hampered the introduction of gasoline-driven equipment.³⁷³

Nevertheless, in less than two decades, Estonia had embarked on a path not ventured on before anywhere else in the world and had shown that this radical creation of an entirely new energy system was not only possible, but perhaps also successful. All the major obstacles seemed to have been overcome: where there had been no skills in mining, an ever-growing cadre of skilled miners appeared, technology that did not exist before had been invented and even the potential for increased efficiency seemed enormous as substances left over from the core production could be utilized in chemical production. And what was most promising, there were supposed to be oil shale reserves for the next 3 – 4 thousand years.³⁷⁴ In a world of competing nation states, each left to its own devices for survival, Estonia seemed to have struck gold.

5.1.8. Digression 1: A contemporary observer

The reserved attitude towards foreign engagement in an industry that gradually became perceived as a cornerstone of the Estonian nation state is well reflected in articles from the late 1930s by the Estonian journalist Osvald Tooming, who toured the newly industrialized district of Ida-Virumaa. The moderately nationalistic descriptions (for being the 1930s) are still of significant interest. Tooming describes a competition between two towns to become the “capital” of the oil shale region – Kohtla-Järve, dominated by the *First Estonian Oil Shale Industry* and Kiviõli, where German investment was prevalent. In Kiviõli the working population is, Tooming claims, becoming decadent, mainly because of the excessive consumption of alcohol, while in Kohtla-Järve he observes a different behavior:

“There were 10,000 people coming together for the song festival. Many were tourists and others driven by curiosity, but the lion’s share of the giant crowd still consisted of local inhabitants. Miners, from both under the ground and from above, men, stained by the gases of the oil factories and workers having gone through the purgatory of the tar factory. While passing by I overheard how they contemplated in one choir: “Tonight there will be a big party at Järve. With fireworks. It would be great. I’d love to stay, but I can’t.” ”Why?”

³⁷³ The price for gasoline in Estonia was some 20 per cent higher than in Scandinavia. Valge (1995) p. 1727.

³⁷⁴ Luts (1939) p. 115.

another enquired. “You never know if you will return in one piece. Once I was in Kiviõli at a dance party. My God, what a hurly-burly. It can’t be better here. Go wrestling with the drunks.” But they took the risk and stayed. Already in daytime they couldn’t have been more astonished about people being – sober. Also the locals.”³⁷⁵

The picture from the town of Kiviõli is bleaker. The journalist enquiring for an address is met only by replies in Russian and German, because half of the population is claimed to be foreign. There was allegedly a local proverb, according to which:

“Five words in Russian means you get taken up from working underground to the oil factory, ten words of German makes you a foreman”³⁷⁶

In this description, Estonians were on the lowest step on the social ladder, next the Russians, while the Germans were at the top. One can argue about the correctness of this view in the Estonia of the 1930s, but nonetheless, it is probably an accurate account of sentiments, if not facts. Estonia was ruled by Russia and a German-speaking nobility for centuries and therefore a certain aversion and inferiority complex had developed among Estonians towards these groups. In Kiviõli, Tooming describes ever-present drunkenness, poverty, dirt and wide differences between classes in Kiviõli, while the overwhelmingly Estonian Kohtla-Järve is, despite poverty, characterized by responsibility, modesty and low class barriers.

“They [*the workers*] are proud because the directors and chiefs all live in this same place, in the middle of the industrial centre. And not as in Kiviõli, on the other side of the railway in another world. This deepens the self-confidence of the men and enhances the commitment to work. “I have already worked in many mines”, said another man, “In Ubja and Kiviõli./.../ For instance Ubja. The boss of the mine did not speak a word of Estonian, and the same with technicians and other big guys, the foremen only when they really must, although they don’t want to talk to you in Estonian./.../. Here it’s a totally different story! Bump into the chief director himself, at least you can be sure that you can talk to him like a man. Without an interpreter, directly man to man”³⁷⁷

³⁷⁵ Tooming, O & Tooming, P (1993) p. 51, reprint from “Virumaa Teataja” 10 August 1938 “Põlevkivi pealinnas”.

³⁷⁶ Tooming, O. & Tooming, P. (1993) p. 60, reprint from “Vaba Maa”, 8 September 1937 “Tänavapilte Kiviõlist”.

³⁷⁷ Ibid. p. 52.

Although there is good reason not to draw too far-reaching conclusions from accounts like this, they still carry a picture of how the situation was perceived by many people in Estonia. Recently freed from German and Russian rulers, a wide-spread resentment was still in the air, which was certainly not cured by the influx of German capital. In another article, Tooming describes the poor conditions of Polish immigrants in the region. There is no similar negative attitude towards them to be found in his description, but instead he shows understanding for their homesickness.³⁷⁸

It is interesting to notice that later the official Soviet view of the developments actually toyed with some of these national characteristics, but mixed them in another way. In an account published in the Soviet era, the author E. Smider insinuates that the population of Kiviõli was actually Russian from the beginning, which then welcomed the Estonian workers. With joint efforts, the Russian and Estonian workers managed to start an educational society which got hold of books from the Soviet Union. Thus the Estonian workers started reading works by Russian authors like Sholohov and Leonov. According to this account, those in power did not approve of this, but preferred seeing the workers drinking alcohol in illegal bars. Smider continues:

“In 1936 the workers of Estonian and Russian nationality easily found a common language on the basis of class. Now a wedge was to be driven between them by means of the Polish-Catholics. The Poles arrived after the strike of 1936. 370 unhappy, hungry families. Official propaganda announced that there was a shortage of labor in Estonia and therefore more had to be brought in from Poland. But already in February 1933 there were 26,851 officially registered unemployed. In all the big industries there were approximately 25,000 employed at this time. In other words, for every second worker there was no work, and even a part of the 25,000 worked 3 – 4 days a week. And suddenly a labor shortage.”³⁷⁹

The nationality issue in the region has been sensitive throughout the 20th century (as will be seen throughout this work). The region has probably never been entirely monolingual, but each institutional set-up has exaggerated the role of some particular nationality while downplaying others. Therefore it can be said without hesitation that this particular issue can be seen both as a formal and informal institution having a major impact on developments, or

³⁷⁸ Tooming, O. & Tooming, P. (1993), reprint from “Vaba Maa”, September 14, 1937. “Poolakad igatsevad koju. Pildikesi Kiviõli “poola linnaosast”.

³⁷⁹ Smider (1972) p. 64.

the attitudes towards it. In the 1930s, the undertone was that the region should be monolingually Estonian and therefore others were to some extent foreign elements. There is, however, no evidence of the Estonian government having taken major concrete steps towards the Estonification of the oil shale industry. According to the Estonian historian Jaak Valge, one contributing factor was that the Estonian government of the 1930s held “an agrarian worldview”, and therefore it effectively acted against the migration of Estonians from the countryside to urbanized areas, the oil shale district included.³⁸⁰ In particular, foreign experts employed in the industry faced no difficulties in obtaining working permits, though the requirements on foreign manual labor were tightened. Especially regarding *Estländska Oljeskifferkonsoriet*, in 1936 it was demanded that the language of internal communication be switched from German (!) to Estonian.³⁸¹

Later, the policy of the Soviet Union required the creation of another picture, as can be seen above. Now the small Polish immigrant group was described as a tool for increased Catholic(!) influence, which for one or the other reason would have suited the interests of those in power. Moreover, Smider makes a leap in his reasoning when comparing unemployment statistics from 1933, i.e. the depression, with the situation in 1936.

One particular issue is worth paying attention to; in the account of Tooming, Estonian workers in foreign (non-Estonian) businesses fell prey to excessive alcohol consumption. In the later account by Smider, the same phenomenon was supposed to have been caused by the capitalist masters. Even without any detailed information on this issue, one can conclude that alcohol consumption has obviously been a major problem among the employees throughout the existence of the oil shale industry.³⁸²

5.2. Germany becomes the principal buyer

Soon after the Nazi takeover and the ensuing rearmament in Germany, the production of shale oil in Estonia came into the spotlight. The existence of high-calorific fuel in Estonia combined with the fact that a producer based on German capital operated in the country proved too

³⁸⁰ Valge, personal communication, October 30, 2007.

³⁸¹ Valge (1995) p. 1732.

³⁸² Even today cheap alcohol is abundant in the region. Manytimes the problem is attributed to the long Soviet rule.

much of an opportunity to be overlooked for the Germans with experience from the fuel crisis of WWI. However, the issue was delicate. Too obvious an interest, the Germans feared, would result in the Estonian government nationalizing *Eesti Kiviõli*. The relations between the two countries were far from unproblematic.³⁸³

Nevertheless, in the end the German offers of investment were too attractive to cause a counter reaction from the Estonian government. *Eesti Kiviõli* feared a shortage of qualified labor, were it to expand its operations in accordance with the German needs. It decided to move quickly and succeeded in reassuring the Estonian government of its business-focused goals when a contract was signed with Germany in October 1935.³⁸⁴ *Eesti Kiviõli* agreed to export annually 35,000 tonnes of shale oil to Germany. Behind this deal was, however, the German *Reichkriegsministerium* (Ministry of War) together with the company *I.G. Farben*,³⁸⁵ which would gain a sinister reputation during WWII. The agreement gave *Eesti Kiviõli* access to credit from Germany, which allowed it to build the new factories in order to expand production.³⁸⁶

The competitors faced the dilemma of following suit or being shut out from the rapidly expanding German demand. This caused the *First Estonian Oil Shale Industry* to sign a similar agreement in April 1937, with guaranteed exports to Germany of 45,000 tonnes of shale oil a year. This amount was supposed to be increased to 70,000 tonnes after the agreement was re-negotiated, but the Soviet occupation of Estonia in 1940 effectively put an end to this process.³⁸⁷ According to the agreement all new equipment for the production was supposed to be bought from Germany. In July 1938 *Estländska Oljeskifferkonsortiet* followed suit and signed a similar agreement with the German navy, and would now produce 9,500 tonnes of shale oil annually for Germany.³⁸⁸ These agreements caused widespread concern abroad. Already in 1935 the Estonian government tried to convince Britain that British capital had been invited to make similar agreements through *New Consolidated Gold Fields*, but the offers had been turned down. British investors, with access to some of the world's largest oil

³⁸³ Rasch (1986).

³⁸⁴ Rasch (1986). Already in 1932 a clearing agreement was signed between Estonia and Germany, which opened the German market for Estonian oil products, but the unstable German mark made fulfilling the agreement a loss for Estonia. Source: Valge (1995), p. 1726.

³⁸⁵ Ilmjärv p. 214.

³⁸⁶ Rasch (1986).

³⁸⁷ ERA 2491-1-62 pp. 6-7, pp. 77-80.

³⁸⁸ Ilmjärv (2004) pp. 214-8.

fields at that time, saw little potential in Estonia, leaving the Germans without competition.³⁸⁹ In addition to this, it was claimed by the Estonian government that the deals were business-like, giving Germany no control of the industry. On the other hand, it was not particularly stressed that the German counterpart was the military.³⁹⁰ Nonetheless, the economic relations between Estonia and Germany seem fairly reasonable from a trading point of view. Estonia could supply Germany's rearming navy with oil, which it could have had difficulties in obtaining from elsewhere. In exchange, Estonia received investment and export earnings. As has been shown, the German involvement in the development of Estonian oil shale dates further back than the period of German re-armament in the late 1930s.³⁹¹ Consequently, it can safely be claimed that the German interest rather was renewed than new at that time. The Estonian historian Magnus Ilmjärv claims that the consequence of the large exports to Germany was that the oil shale industry became too specialized in shale oil and did not develop other strains of the industry, such as gas, chemical products, binding agents etc.³⁹² Moreover:

“/.../ bringing in the foreign investors for providing necessary funds for improvements was not wrong. But in the case of German capital, Estonia was dealing with a state – and investors – which were hostile to its independence. On the other hand, Estonian shale oil and its products were extremely important to Germany's war economy”,³⁹³

Aleksander Loit paints a slightly different picture. The Estonian government was seriously concerned by the increasing German involvement and tried to counterbalance it by efforts to sell shale oil to the British navy. Moreover, when the Germans in 1935 wanted to buy the production of the British-owned *New Consolidated Gold Fields*, the Estonian government was fully in favor, because that would make the British responsible for German rearmament, too.³⁹⁴ In brief, the development in the late 1930s was characterized by a monopsony situation, with one buyer, but several sellers. In particular, it was the German navy that was in need of a stable supply of fuel and the Estonian shale oil met the quality requirements of the

³⁸⁹ In 1934 Great Britain tried to persuade Estonia to import British coal, an offer which Estonia turned down referring to the need of the oil shale industry to have a domestic market. This unsuccessful attempt at a bilateral trade agreement might have had an impact on later British attitudes towards Estonian shale oil. Source: Pihlamägi (1999b).

³⁹⁰ Ilmjärv (2004) p. 217.

³⁹¹ As has been shown earlier, German technology was employed from the very start of the industry and German-related investments stemmed from the early 1920s.

³⁹² Ilmjärv (2004) p. 218.

³⁹³ Ibid. p. 216.

³⁹⁴ Loit (1994) p. 340.

navy well.³⁹⁵ In this context it can be pointed out that it was a well-known fact that shale oil matched naval demands, and for instance in Sweden shale oil was known as “naval oil” (*marinolja*).³⁹⁶ The German demand is clearly reflected in export figures to Germany for shale oil of the *First Estonian Oil Shale Industry*, which jumped from almost zero to 987 tonnes in 1936 and 17,000 tonnes one year later or 74 % of the total exports of the *First Estonian Oil Shale Industry*. Exports to Latvia, the once largest foreign market for shale oil (38 per cent of exports in 1935 and 39 per cent in 1936) dropped to a mere 6.6 per cent in 1937.

Table 5.1. Production and exports of shale oil 1927-1937.

Year	Total production, in tonnes	Total exports, in tonnes	Exports' share of total, %	Increase of exports, year-on year, %	Exports to Germany, tonnes	Exports to Germany, share of total production, %
1927	4,291	877	20	-		
1928	11,866	2,517	21	187		
1929	10,776	1,866	17	-35		
1930	10,066	1,365	14	-27		
1931	17,149	2,354	14	72		
1932	36,595	3,475	10	48		
1933	37,617	6,180	16	78		
1934	46,876	13,879	30	125		
1935	47,272	14,827	31	7	8122	17
1936	63,392	11,520	18	-22	2,852	5
1937	111,721	53,885	48	368	44,983	40
1938	139,631	62,408	45	16	54,270	39
1939	178,889	103,252	58	65	87,002	49
1940	174,130					

Source: *A/S Esimene...*(1938), *Ilmjärv* (2004), *Valge* (1995), own calculations.

³⁹⁵ Hayes (1995) p. 263.

³⁹⁶ For further details, see chapter 9.

In 1939, almost half of all shale oil produced went to Germany and it is fair to state that the Estonian oil shale industry had become dependent on Germany and that the increased production capacity in Estonia was made possible by German war preparations.³⁹⁷ German total demand for oil at this time reached 7 million tonnes annually, while its domestic production reached only 625, 000 tonnes.³⁹⁸ The resulting strong increase in demand for shale oil made the investments in the new factories at Kiviõli in 1936 and 1938 and at Kohtla-Järve in 1940 possible. Moreover, it was the increased demand caused by German war preparations that allowed the Estonian state-owned oil shale industry to switch from excavation and sale of oil shale to a processed end product.³⁹⁹ It is worth noting that the role of German interests is conspicuously absent in the book published by the *First Estonian Oil Shale Industry* on the occasion of its 20th anniversary in 1938.⁴⁰⁰ On the other hand, Germany was an important market for various Estonian exports throughout the 1920s and 1930s.⁴⁰¹

5.2.1. Comments

The Estonian oil shale industry ended up in a rather awkward situation in becoming an important supplier of fuel to the German navy. One important reason for it ending up in this situation was definitely the small size of the Estonian domestic market, which precluded the rejection of such an important purchaser. However, it has been shown that there existed a market for exports already before the soaring German demand. Moreover, the biggest foreign actor in the Estonian oil shale industry was *Eesti Kiviõli*, with strong German ties, but this company had started its activities in Estonia already in the 1920s, long before the German connection became troublesome. Thus, the German interest in Estonian oil shale was a result of Germany largely lacking domestic fuels, together with German technological specialization in chemistry and related fields.⁴⁰² The role of the Estonian shale oil for Germany is briefly commented upon by the then commander of the German navy, Erich Raeder, according to whom the agreement with *Eesti Kiviõli* made it possible to purchase significant amounts of

³⁹⁷ For details on political and military relations between Estonia and Germany, see Ilmjärv (2004) p. 222 ff. For the purpose of this work it suffices to state that in the mid-1930s, Estonia tried to maintain a façade of neutrality, but was in reality entangled in a German drive for influence.

³⁹⁸ Raud(1939).

³⁹⁹ Martinson (1987) p. 132.

⁴⁰⁰ A/S Esimene... (1938). It is, however, clearly mentioned in the statistical appendices.

⁴⁰¹ The share of exports to Germany of total exports of goods increased from 34 per cent in 1931 to 36 per cent in 1939. Corresponding figures for other countries were: Great Britain 37 per cent and 26 per cent, respectively, Sweden 4 per cent and 7 per cent, Finland 3 per cent and 6 per cent and Soviet Union approximately 5 per cent both in 1931 and 1939. (Source: Pihlamägi (2004) p. 222.

⁴⁰² The emergence of a strong chemical industry in Germany and its importance for creating substitutes for raw materials has been researched extensively. For an overview, see Porter (1990) p. 371.

high quality Estonian oil, which was cheaper than domestic German synthetic oil. This agreement was the first of its kind with a foreign country. Raeder makes no further mention of the Estonian oil, which might indicate that, after all, it was not of crucial importance for the overall German aims.⁴⁰³ There are also indications that by 1938, oil from the world market had become increasingly accessible for Germany at prices below Estonian shale oil, which led to a declining interest from the side of the German navy. Furthermore, in 1938 the principal investor in *Eesti Kiviõli, Bankhaus Mendelssohn & Co* was liquidated for being “non-aryan”. The assets were transferred through a chain of transactions via the Netherlands to Sweden. Despite this, *Eesti Kiviõli* continued its operations as a separate company until the Soviet nationalization in 1940.⁴⁰⁴

By the late 1930s, Estonia had witnessed the emergence of a new industry that was well suited for the prevailing ideology of far-reaching national self-sufficiency, especially in such a sensitive area as energy.⁴⁰⁵ By allowing foreign actors but remaining a key producer, the Estonian government can be said to have tried to keep the best of two worlds – and not without success. However, any small state with a unique resource will have to accept that bigger nations will throw more than an occasional glance at what is unfolding. It should not come as a surprise that today the United States have shown remarkable interest in Estonian experiences (without otherwise comparing the USA with Germany of the 1930s). But having said this, it still looks unlikely that the destiny of Estonia would radically have been different in WWII and afterwards without the oil shale industry.

The issue of exporting shale oil in large quantities to Germany seems to be haunting today’s Estonian historians. The historian Jaak Valge claims that there were alternatives to exporting to Germany, namely by responding to the increased domestic demand and by focusing on exports to Finland, Sweden, Norway, Latvia and Lithuania, even though the terms for such exports would initially have been somewhat worse. In the last years of the 1930s trade between Estonia and Germany had shifted in an unfavorable direction for Estonia and soon Estonia was tied up by increasing German demands and for instance pressured to abstain from

⁴⁰³ Raeder (1957) p. 61.

⁴⁰⁴ Rasch (1986).

⁴⁰⁵ The by far three most important Estonian exports to Germany in 1939, measured by value, were butter, animals and shale oil, in that order. (Pihlamägi (2004) p. 245).

all export reductions of particular goods.⁴⁰⁶ Under these circumstances a unilateral cut of the exports of shale oil to Germany would probably have come with a significant political cost.

In his analysis of the foreign policy of the Baltic States until 1940, the Estonian historian Magnus Ilmjärv identifies the authoritarian regime of Estonia in the 1930s as the main domestic culprit for the disaster during WWII. Among the shortcomings of that regime was, *inter alia*, the close cooperation with Nazi-Germany by exporting products important, or even crucial, for German rearmament, which successively stripped Estonia of the tools to pursue an independent foreign policy.⁴⁰⁷ Such an analysis is at least partially correct, but only with hindsight. From the oil shale industry's point of view in the late 1930s the issue looked different. In a newspaper interview in the late 1930s, Raud expresses his views on the dominant role of Germany in the following way:

“This is natural, because Germany is one of the great powers closest to us, which needs oil for its many industries. As this new oil shale market allows for relatively fast growth for the oil shale industry now and even faster amortization, then why not use the business boom and why shouldn't we create assets in our national economy in the shape of new factories, whose work is safeguarded by agreements. Even in the case of breaches of these agreements by force majeure, the losses would not be of a threatening character, because new investments are made from collected strength, from reserves piled. Moreover, the German market is not the only market for Estonian oil, but at the moment it is one of the biggest markets”⁴⁰⁸

There is some evidence that the Estonian government was concerned about the situation and initially took measures to broaden the export market. When these measures rendered no result, the only remaining option would have been to cease or strongly limit exports altogether, regardless of the consequences. Such a measure would certainly not have been left unanswered by the Germany of the late 1930s. Perhaps the only sustainable solution would have been for other countries to import Estonian shale oil, thus leaving Germany without. In a

⁴⁰⁶ Valge (1995) p. 1940. Because the trade was conducted through a clearing account, Estonian imports from Germany had to match its exports. However, Estonia encountered difficulties in finding proper goods for imports. In the end, the Estonian surplus was used as a compensation for property left in Estonia by the Baltic Germans, who were compelled to leave the country in 1940 (by the Germans, not the Estonians). Source: Valge (1995), p. 1739.

⁴⁰⁷ Ilmjärv (2004).

⁴⁰⁸ ERA 2491-1-61 p. 365. The origin of this article is obscure, because the version to be found in the Estonian State Archive does not disclose neither the name of the newspaper nor the date. Only the article itself is to be found among files left by Märt Raud himself. However, as this clearly is a newspaper article from the late 1930s, it is still worth quoting.

world without free trade, there was no way for Estonian oil shale products to prove their qualities in the market place. When governments made purchases based on political preferences in the first place, the result was that a small nation simply had to adapt to such an environment, and this also applies to the industry too. The Estonian oil shale industry was in no position to shape or even influence the environment. For the oil shale industry at the time, the only option left was to adapt.⁴⁰⁹

In order to further broaden the picture, it should be mentioned that Estonia in the 1930s was a predominantly agricultural economy, with butter, meat, wood, pulp and textiles as primary export products. But in the late 1930s, the share of shale oil and gasoline rapidly increased and amounted to 8.5 per cent of total exports in 1939.⁴¹⁰ The newly developed skills to produce oil and oil-related products must have had a significant impact on the nation's self-perception. It would therefore have been extremely unlikely that there would have been any understanding for giving up what had become a source of national pride. In the aftermath of the Great Depression, the following statement was to be read in the Estonian Economic Year-Book for 1934:

“The economic troubles of the last years also exerted a marked influence on industrial production and its marketable share in the national exports. Thus, the proportion of the products of large-scale (employing over 20 hands) industry fell away from 37%, or roughly one-third, in 1928 to approximately 18-20% in 1932”⁴¹¹

As has been noted before, the depression years had caused alarm in the oil shale industry. One of the lessons learned was that the size of the industry was of crucial importance in order to keep unit costs down. The increased foreign, i.e. German, demand in the second half of the 1930s made an upsizing of the industry possible.

In 1934 the conservative government of Estonia carried out a coup d'état and the parliament was dissolved. Officially the reason was to abort a far-right takeover, of which there were reasonable fears. In the end, however, this coup also negatively affected democratically

⁴⁰⁹ A justified question is whether Estonia actively fostered ties with Germany in the second half of the 1930s. There is little evidence for a particular pro-German stance, but instead an attempt to appease all regional great powers at the time, i.e. Germany, the Soviet Union and Great Britain. The latter was even perceived as the ultimate guarantor of Estonian independence (Hiden & Salmon (1991:p. 73)). See also Misiunas & Taagepera (1993: pp. 8-14) and Fitzmaurice (1992: pp.106-9). For an account in Swedish, see Isberg (1988, chapter 7).

⁴¹⁰ Pihlamägi (2004) p. 202.

⁴¹¹ Estonian Economic Year-Book for 1934, p. 73.

oriented political movements. The old-new government could best be described as authoritarian, but not totalitarian.⁴¹² There are nevertheless few indications that this development would have had any deeper impact on the oil shale industry. In this respect the domestic institutional framework remained basically stable. But on the international scene the situation had changed radically after the Nazis had come to power in Germany. Thus, it is reasonable to ask whether an institutional change actually took place at this time, not so much domestically, but internationally, to which the Estonian oil shale industry had to react in one way or the other. The oil shale industry seemingly did not alter its direction, but an observer in later times might claim that actually there occurred a lock-in into selling shale oil to Germany. Could this lock-in have been broken by any means available under the new institutional set-up of international politics? As has been mentioned, there were some concerns in Estonia about the development, but in the end continuing along the path was deemed a superior choice, or at least this was the outcome. This situation can be contrasted with the arguments presented by Liebowitz and Margolis on the plausibility of what they call third degree path dependence, i.e. that an inferior technology (or other solution) is chosen instead of a superior one, despite the existence of accurate knowledge.⁴¹³ Of course, in the latter half of the 1930s no-one could tell the future (as it is still today), but the concerns about becoming dependent on German purchases were nevertheless real. Would there have been any realistic alternative to the path taken? The most obvious one would have been to broaden sales to other countries, which was actually attempted, but unsuccessfully. Another potential solution could have been that the government unilaterally limited sales to Germany, thereby risking stirring up wrath from both German and domestic Estonian interests (from capital and labor in unison). A similar outcome could have been reached through a government-ordered shift in production away from shale oil. Such a possibility was limited by the fact that the government ever since the early 1920s had given up any attempts of total control of the sector. Therefore the most likely explanation remains that despite concerns about having entered a dangerous path, hopes were put to a benign future development. Therefore it might be concluded that hopes of a better outcome or environment in the future are one important reason why certain paths are stuck to. Unexpected events may change the course of history and therefore sticking to a troublesome path is not entirely pointless, even if developments look threatening at some point. This reasoning could be illustrated with a modified version of

⁴¹² Fitzmaurice (1992) calls the Estonian and Latvian and Lithuanian governments “*relatively mild rightist dictatorships*” p. 36. For a thorough analysis of the political developments, see Isberg (1988).

⁴¹³ Liebowitz & Margolis (1995).

Arthur's example of lock-in to an inferior solution because of bigger present gains in favor of bigger future gains and Liebowitz' and Margolis' criticism thereof. The gains for the Estonian oil shale industry (and consequently for the whole country) in the late 1930s were real, while the threats of a poor outcome contained at least some hypothetical elements. To some extent the dangers lurking behind the growing dependence on Germany were understood in Estonia (although nobody at that time could possibly fully predict the mayhem the German leadership would cause and its consequences), but they were downplayed and embedded in wishful thinking. This is definitely true for the oil shale industry, where increased export earnings allowed for the expansion of production. As the future can never be entirely predicted, there exists always some hope of a sudden turn for the better for those that have embarked on a dangerous path. In this respect it does not suffice to claim that it was the very existence of the oil shale industry that forced Estonia to continue advancing along such a path. Until the mid-1930s, the oil shale industry had not been dependent on exports to Germany. Therefore, the Estonian oil shale industry stood at a crossroads in the mid-1930s – either to remain a domestic supplier or to make an attempt to grow. The concerns about the role of Germany were, however, not of a pecuniary character, which, from the oil shale industry's point of view made them less relevant. This situation, as presented here, corresponds with my earlier reasoning on why fossil fuels firmly remain in place despite serious environmental concerns. The bottom line here is that a potentially inferior path will prevail over a potentially superior one if the former but not the latter includes a pecuniary pay-off in the short-run. But, once again, in reality judging which path is which is never as simple as in theoretical models.

Finally, as a concrete example of hopes for a benign outcome, it is appropriate to close this chapter on the pre-war development by quoting the Estonian chemist Leonard Tiganik's foreword to the Estonian translation of the Dutch author L. Nauwelaerts' book "Petroleum".

"In the pages of Estonian newspapers we often read notes from "our oilfields"; by this is meant our oil shale industry. Does it play any role in the world's oil fields? In 1939, we produced some 200,000 tonnes of oil, at the same time the rest of the world produced some 1,000 times more. Thus our share would be only 0.1%. But for us this is a great deal. If the annual oil production of Estonia was divided equally between all Estonians and the production of the rest of the world between all 2,000 million non-Estonians, each Estonian would have twice as much oil as the rest. In the coming years, our oil production is planned to be increased to half a million tonnes. How much richer we are than others! We do not have to worry about the future, unlike elsewhere in the oil industry. Here, oil shale can be

found in a territory of 3,000 square kilometers. From one surface square kilometer, 1.5 – 2 tonnes of oil shale can be extracted; thus 5 billion tonnes of oil shale lie under the surface of Virumaa. Present methods allow for extracting 20% of oil from oil shale. As a consequence, we have a reserve of 1 billion tonnes of oil, which is so “conserved” that it will not flow anywhere and cannot disappear. We don’t have to worry for a couple of millennia.

A lot of coal and oil is burned upon the altar of the god of war. We are not concerned by this crisis thanks to oil shale.”⁴¹⁴

These lines were written in February 1940. Less than half a year later disaster was to strike, head-on and in full force.

5.3. Disaster 1940-1944

On August 23, 1939 Nazi-Germany and the Soviet Union agreed in the Molotov-Ribbentrop pact on mutual non-aggression. According to an additional protocol, which was kept secret at the time, Eastern Europe was to be divided between them. Estonia, which had declared neutrality, was included in the booty of the Soviet Union (together with Latvia and Finland, among other countries).⁴¹⁵ The first Soviet occupation 1940-41 and the subsequent Nazi occupation 1941-44 will both be treated in this chapter since both only created havoc in the oil shale industry.

In the autumn of 1939, the German minority in the Baltic States was “called home to Germany” by the German government⁴¹⁶. The fact that many Germans heeded the call left a significant share of Estonian industry without owners and managers, including *Eesti Kiviõli*, which after an attempt by the previous German owners to sell the shares to Swedish interests, was put under direct government control in May 1940⁴¹⁷.

On September 28, 1939, Estonia was forced to give up chunks of its territory as military bases for Soviet troops, numbering 25,000. Estonia was still formally neutral, but had decreasing

⁴¹⁴ Nauwelaerts, L. (1940) p. 10, [foreword by L. Tiganik].

⁴¹⁵ The fact that Germany accepted that Estonia would belong to the Soviet sphere indicates that in the end the Estonian shale oil did not play such a crucial role for the German military.

⁴¹⁶ The reasons and consequences for this exodus go far beyond the scope of this work, but basically the Nazi-German government, after having divided Eastern Europe with the Soviet Union, called for an evacuation of ethnic Germans from areas that were supposed to come under Soviet rule.

⁴¹⁷ Pihlamägi (1999a) p. 125.

room to maneuver. The Estonian government curtailed some civic rights in order to reduce the risk of actions that could have been interpreted as provocations by the Soviet Union. This was not enough for the Soviets, who constantly made more demands on Estonia, and soon increased the number of troops in the military bases.⁴¹⁸

During the spring of 1940, the Soviet Union started making preparations for occupying the whole country, and on June 17 the Soviet troops marched into the rest of Estonia, taking control of the whole country and soon also even replacing the government. On the same day also Latvia was occupied as well. Armed resistance was judged hopeless after Lithuania, further to the south, had been occupied by the Soviet Union two days earlier.⁴¹⁹ Soon the fake parliament created by the occupying forces in Estonia turned to the Soviet Union with the rather unique request that Estonia would cease to exist as an independent country and become incorporated into the Soviet Union. This “request” was granted by the Soviet leadership on August 6, 1940.⁴²⁰ There is no room in this work to go into details of these developments. It should suffice to state that Estonia had fallen prey to one of the predators of European politics of the late 1930s and early 1940s. The chain of events that started with the Soviet military bases in the autumn of 1939 would lead to enormous population losses in Estonia and the country would remain occupied until August 1991. It should therefore be stressed that many Estonians perceive 1991 as the year WWII ended.

These events were also reflected in the oil shale industry. On December 28, 1940 the entire oil shale industry, both government-owned and private, was subordinated to a government body named the Mining Office (*Mäetööstuskontor*). All sales of oil shale other than through this office were prohibited.⁴²¹ In most cases, the operating leadership of the Estonian industry was allowed to remain in place for the time being, although without the power to make decisions. Technical staff, however, could continue their work more or less as usual. But with the new order, the self-regulatory mechanisms of the economy ceased to function, almost immediately causing a shortage of labor in all Estonian industries. The reason behind this was that the

⁴¹⁸ “Valge Raamat” pp. 10-1. For instance Soviet airplanes used these bases in Estonia for bombing raids against Finnish cities during the Soviet attack on that country 1939-1940, in violation of promises made to Estonia on the use of the bases.

⁴¹⁹ Misiunas & Taagepera (1993) pp. 15-22.

⁴²⁰ Misiunas & Taagepera (1993) p. 29.

⁴²¹ ERA 2491-1-82 p. 20. It might be worth quoting the wording of a letter sent by *Esimene Eesti Põlevkivitööstus* to *I.G. Farben* “Da die entscheidene behördliche Instanz für unsere wichtigere Exportangelegenheiten nunmehr in Moskau ist, hat sich die Regelung von schwebenden Fragen leider etwas verzögert. Wir hoffen aber auf eine sehr baldige Ordnung der Angelegenheit” ERA 2491-1-62 p. 93.

Estonian communists neither understood how the economy had functioned before, nor how the Soviet economy actually functioned, beyond the phrases.⁴²²

The German takeover of Estonia from the Soviets in the autumn of 1941 led to the widespread destruction of the oil shale industry by the retreating Soviet forces. The new masters basically left the Soviet order in place, replacing the Soviet structure of *The General Directorate of Mining and Fuel Industry of the Peoples' Commissariat for Light Industry* with a company named *Baltische Öl GmbH – Berlin*, which was to make all important decisions, leaving no control of the oil shale industry to the local German-installed governing structures of Estonia.⁴²³ This company was subordinated to *Kontinentale Oel* in Berlin, which in turn was influenced by *IG Farben*, i.e. the very same company that stood behind the agreements with Estonia in 1935 concerning delivery of shale oil. The only aim of *I.G. Farben* was to increase the oil yield, without otherwise getting involved in daily management.⁴²⁴

Märt Raud, who had been dismissed by the Soviets (but who so far had survived physically), tried unsuccessfully to convince the Germans to hand over the everyday management of those parts that previously formed the *First Estonian Oil Shale Industry* to the local Estonian authorities under a company that was supposed to be called *Estnischer Brennschiefer und Brennschieferöle GmbH Tallinn*. This company would then supply the German army with fuel on the same basis as *Baltische Öl GmbH – Berlin*. This arrangement would have left the local Estonian governing structures with more resources for the overall development of the Estonian industry.⁴²⁵

Information on the role of the oil shale industry during the German occupation beginning in the autumn of 1941, is rather unclear. German statistics from that period (1942) disclose that what could be classified as exports from Estonia to Germany mainly consisted of wood, while charcoal was imported (44,000 tonnes). Such information should only be used with great scepticism, because German statistics from that time do not actually mention “imports” and “exports” but rather “shipments to and from Germany”. It is, nevertheless, worthwhile mentioning that the unit used in German statistics was “wood equivalent”. Thus Estonian industry used an equivalent of 1,349,669 cubic meters of wood, of which oil shale accounted

⁴²² Pihlamägi (2005).

⁴²³ Letter from Märt Raud to Director Raadik, May 27, 1942. ERA 2491-1-84 pp. 60-1.

⁴²⁴ Hayes (1995) p. 263.

⁴²⁵ Letter from Märt Raud to Director Raadik, May 27, 1942. ERA 2491-1-84 pp. 60-1.

for the equivalent of 592,102 cubic meters of wood, or 44 per cent of total, leaving both wood (326,108m³) and peat (252,311m³) behind.⁴²⁶

With the advance of Soviet troops into Estonia in the early autumn of 1944, several Estonian oil shale specialists were evacuated together with the German army, most of them obviously voluntarily. Germany, now with a desperate shortage of fuel, found the knowledge and skills of the Estonian engineers valuable when attempting to start processing low-calorific oil shale in Rottweil-Billingen, in South-Western Germany. The production started in March 1945 and was finally shut down in 1949 as unprofitable.⁴²⁷

Even if one should avoid putting too much emphasis on the importance of the Estonian oil shale industry as an attractor of occupying forces, it certainly played some role. The Soviet Union probably perceived the delivery of shale oil to the German navy in the 1930s as a threat, and, from their point of view, a political statement. Even if this aspect probably was of less importance for the overall Soviet goals in the Baltic region, it at least opened the eyes of the Soviet leadership that there existed a developed energy industry in the vicinity of St. Petersburg, which otherwise lacked nearby energy sources.⁴²⁸ On the other hand, it is noteworthy that the German company *I.G. Farben* – the previous business partner – showed up as the new master during the German occupation of Estonia.

⁴²⁶ Statistischer Jahresbericht für den Generalbezirk Estland 1942.

⁴²⁷ Kogerman, A.(1997).

⁴²⁸ In the references used for this work, there is no mentioning of serious Soviet interest in the Estonian oil shale industry before 1944.

6. The Soviet Years

The Soviet period in Estonia spans over four, almost five, decades. During this time several periods can be identified with varying politics, also with respect to the oil shale industry. Therefore it is only with some hesitation that this era is covered in one chapter. However, during this period Estonia was never free to make its own decisions on major issues, which motivates treating the Soviet period as a continuum. In this chapter, five aspects will be identified, which are not necessarily chronological, because some developments took place simultaneously, but which represent different approaches or policies prevailing within the Soviet system; 1) the Stalin years, 2) the attempt to develop a significant chemical industry during the relatively mild late 1950s and early 1960s, 3) the increased use of oil shale for electricity generation, 4) the striving for at least limited scientific and technological freedom in Estonia between 1955 and 1975, and finally 5) stagnation, which set in gradually after the mid-1960s.

In this period two main developments can be identified. On the one hand, there were the Soviet efforts to harness the oil shale industry for immediate needs of energy, and on the other hand, attempts by the Estonian oil shale community to develop the industry in a knowledge-intensive direction. Although these interests occasionally coincided, the tension thus created contributed to the creation of new technological variety and thereby enhanced the capability of the industry to survive.

6.1. Reconstruction under Stalin 1944-1953

According to Soviet sources, the war had caused a 90 per cent decline in the production of fuels and a 40 per cent decline in electric energy in Estonia. The total number of industrial workers in Estonia had declined to 46,000 at the end of 1944, down from 89,000 in April 1941.⁴²⁹ In particular, the county of Ida-Virumaa had lost more than 40 per cent of its population as a direct consequence of the war.⁴³⁰ Moreover, the retreating Germans destroyed some major oil shale mines as well as the factories at Kohtla-Järve, Kiviõli and Sillamäe.

⁴²⁹ Eesti NSV Ajalugu (1971).

⁴³⁰ Vseiov (2002) p. 96.

Whatever the accuracy of the figures listed above, it should be stressed that the Soviets probably created equally as much havoc on the oil shale industry as the Germans, but in a Soviet account there was no room for such objections whatsoever. But regardless of the causes, the fact remains that the oil shale industry was in disarray in the immediate aftermath of the German withdrawal.

When restarting the oil shale industry after the war, a period beginning in the autumn of 1944 in Estonia's case, the most urgent task was to generate electricity in order to restart the industry. This was done by using diesel generators left in more or less good shape by the Germans. In addition to this, a movable train-based power station produced by the company *Westinghouse* was brought to Kiviõli in the end of 1944.⁴³¹ In June 1945 the Central Committee of the Estonian Communist Party decided to reconstruct and restart the retorts at Kiviõli and Kohtla. The extra labor force required was to be recruited from Communist youth and prisoners of war.⁴³² This reconstruction was given high priority, which is indicated by the fact that the order of the Communist Party explicitly mentions that it was forbidden for any other organ of the state, including organs of the Communist Party itself, to remove any material from the gas and oil factories.⁴³³ In 1945, the first of the four tunnel ovens was taken into use and towards the end of the 1940s all four tunnel ovens were operational (two in Kiviõli and two in Kohtla-Nõmme, previously belonging to *New Consolidated Goldfields Ltd.*⁴³⁴) The petroleum extracted from oil shale in these ovens was of lower quality than what could be procured from elsewhere in the Soviet Union, but other petroleum became available in larger quantities only later when reconstruction after the war accelerated. The 66 octane petroleum produced in Estonia was mainly used as truck fuel.⁴³⁵

But most attention was paid to the production of household gas for the city of Leningrad from Estonian (and partially nearby Russian) oil shale. The importance of this step to the Soviet authorities should not be underestimated. In a law on restoring and developing the national economy of the Soviet Union with respect to the five-year plan 1946-1950, the gasification of

⁴³¹ Õpik (1999).

⁴³² According to Mertelsmann (2007) approximately 80 per cent of the labor force in the oil shale industry consisted of prisoners of war in the spring of 1946. If this figure is accurate, it mirrors either enormous population losses or use of what was perceived as cheap labor, or both. On the other hand, only a very small percentage of the prisoners of war were in such a physical condition that they could be assigned heavy work.

⁴³³ ERA R-1825-1-7 Decision of the Council of the Peoples' Commissars of the Estonian SSR and the Central Committee of the Estonian Communist (Bolshevik) Party no 606, June 27, 1945.

⁴³⁴ Õpik (1999).

⁴³⁵ Ivar Rooks, personal communication, October 13, 2005.

Estonian oil shale is explicitly mentioned. More specifically, it is mentioned that the output of Estonian oil shale mines will reach 9.4 million tons (and 3 million tons in Russia) for the production of oil shale gas.⁴³⁶ From one point of view, this measure can be seen as fairly rational because of the enormous devastation caused by the war, especially in the Leningrad area, where there are few natural energy resources. The rationale for utilizing Estonian oil shale gas becomes more or less obvious when taking into consideration that such a measure would release significant transport capacity in the Leningrad region, which otherwise would be used for transport of solid fuels, mainly wood, into the city. Also liquid fuels, which were short in supply, could thus be redirected to other purposes. Moreover, supplying the city with fuel had until then required the labor of an estimated 10,000 hands, which could now be assigned other tasks. In addition to this, general access to a fast and reliable energy resource would shorten the time needed to prepare food, thus allowing for higher female participation in labor. In brief, significant efficiency gains were expected to be made from utilizing Estonian gas, while at the same time the rebuilt shale oil industry would supply the Soviet navy with liquid fuel.⁴³⁷ By 1954, some 2.5 million people enjoyed heating from oil shale gas, which was estimated to be four or five times cheaper than other heating.⁴³⁸

From a technological perspective it was a unique development to produce household gas from oil shale. Actually, this was the first time in the world that synthetic gas was produced using oil shale as raw material.⁴³⁹ The technology to produce gas from oil shale was known already before WWII in Estonia, but considered unprofitable in comparison to the extraction of gas from coal.⁴⁴⁰ The reason for this was that semi-coke stemming from the gasification of coal could be sold as a product in its own right, while no such profitable externality emerged from the gasification of oil shale.⁴⁴¹ After WWII the prevailing ideology did not acknowledge the Estonian roots of this technology, but claimed instead that it stemmed from Russia, where the gasification of oil shale was reported to have taken place in the 1930s.⁴⁴² There is probably no reason to doubt the accuracy of the claims that a similar technology was used in the 1930s in

⁴³⁶ The law was published in the economic periodical *Plaanimajandus* ("Planned Economy") Nr. 2 1946. See pp. 97-8 for Estonia.

⁴³⁷ Kurtsavov (1945).

⁴³⁸ Kuznetsov, D. (1956). In this source it is not disclosed where the gas was consumed, but it was probably mainly in Leningrad.

⁴³⁹ Yefimov, Rooks, Rootalu (1994). See also Kattai (2003a).

⁴⁴⁰ Paul Kogerman mentions (in a letter from 1947) that gasification of oil shale had been conducted as early as 1921 at Kohtla-Järve in cooperation with Julius Pintsch AG. Source: Helle Martinson's papers, no 9743.

⁴⁴¹ Luts (1939) p. 105.

⁴⁴² G. Klevakin in *Rahva Hääl* 11.5.1946.

the Soviet Union, but for one reason or the other it did not take off.⁴⁴³ Only with the incorporation of the Estonian oil shale industry, did gasification become possible. One reason could be that size mattered. The deposits in Estonia are bigger than those on the Russian side of the border, which could have made gas production a more competitive option (and with traditional economic calculations sidestepped). But another explanation would be that Estonian technological know-how was a prerequisite for successful production.

This development should, nevertheless, be judged as an almost clear-cut case of colonial economy, because it was characterized by tapping into the energy resources of a subdued country.⁴⁴⁴ In return for its energy, Estonia was to receive only the investments needed to build the system.⁴⁴⁵ The later renowned expert on oil shale-based electricity generation, Ilmar Õpik, recalls being in Moscow in 1945 at a night-time meeting, when the invited Estonian oil shale specialists were informed of a decision by Stalin that the city of Leningrad was to be provided with household gas from Estonian oil shale.⁴⁴⁶ This decision had been taken by the Soviet State Defense Committee in June 1945 and was then to be implemented by the central committee of the Estonian Communist Party. It should be stressed that even the language of the implementation decision, technically made by the local Estonian Communist Party, was Russian and it is clearly stated in the Estonian version that it is a translation.⁴⁴⁷ This fact, however minor it might look at first glance, strengthens the perception that the aim was to harness this natural resource of Estonia for the purposes of Russia. This did not seem to bother the Soviet apparatus at the time, which rather openly announced its aims in the Estonian-language Communist Party daily *Rahva Hääli*:

“The development of the oil shale industry which will be carried out on the basis of the government decision is a grandiose enterprise, which is aimed at developing the industry of the Estonian SSR and will fundamentally change the face of our republic”⁴⁴⁸

⁴⁴³ Officially the results were described as a gigantic success, but no explanation is given as to why no further development took place. See footnote above.

⁴⁴⁴ See also chapter 6.3.2.

⁴⁴⁵ Veimer (1946) p. 544.

⁴⁴⁶ Õpik (1999). Õpik writes that he cannot remember the exact date when this happened. (This is precisely one of the problems with recently published unedited Estonian memoirs. On the other hand, for obvious reasons there is some urgency in publishing).

⁴⁴⁷ ERA R-1825-1-7. It should be mentioned that according to the introductory note of ERA R-1825-1-3, the decision to create a Ministry for oil shale and chemical industry was made on May 10, 1943, that is while Estonia was still under German occupation. See also “Leningradi gasifitseerimine Eesti põlevkivi basil” (*Gasification of Leningrad on the basis on Estonian oil shale*), by A. Nugis, *Rahva Hääli* 24.7.1945.

⁴⁴⁸ A. Nugis, *Rahva Hääli* 24.7.1945.

Numerous Estonians participated in the construction of the new gas network. Õpik makes no secret that he and numerous fellow Estonians lived a rather comfortable life in Leningrad in the summer of 1944 (only months after the supply lines to the city had been reopened after the extreme circumstances of the German blockade) eating at restaurants and even going out yachting. Waiting for the Soviet army to invade Estonia, Õpik and other engineers made plans for the reconstruction of the oil shale industry.⁴⁴⁹ Whatever the circumstances were, it can be assumed that at the time numerous Estonian engineers participated wholeheartedly in the rebuilding and restructuring of the oil shale industry, though it was for Soviet purposes.⁴⁵⁰ For many engineers, the personal interest in developing the oil shale industry probably had priority over political considerations. In this respect, there is no essential difference to engineers in other times and other societies who compromise with possible moral sentiments in favor of being able to carry on with technically challenging tasks.⁴⁵¹

But occasionally the Soviet rulers went quite far in their attempts to rebuild the engineering and scientific capacity of the oil shale industry. Early in 1946, the leading oil shale chemist Paul Kogerman was released from GULAG prison system and already in May 1946 he participated in rather high-level consultations in Moscow on the reconstruction of the oil shale industry. These consultations were followed in June by the decision to integrate the oil shale industries of Estonia and the Leningrad district.⁴⁵² As a consequence, the Kohtla-Järve oil factories, the German war-time oil factory and power plant at Ahtme as well as some mines and quarries were to be subordinated to all-Soviet structures (and not local Estonian ones) These structures were obviously *Glavgaztopprom* and *Glavslanets*, i.e. the all-union central directorate for gas and heating industry and the peoples' commissariat for coal industry.⁴⁵³ The Kiviõli and Kohtla-Nõmme factories and a few mines remained under the control of the Estonian people's commissariat (a government department) for oil shale and chemical industry.⁴⁵⁴

The Russian element is conspicuous in all newspaper reports from the time. The Estonian readers are informed through the newspapers by a certain A. Kuznetsov, secretary of

⁴⁴⁹ Õpik (2000) p. 36.

⁴⁵⁰ Mertelsmann (2007) also arrives at this conclusion: "*Although the majority of the leading cadre was Russian-speaking, the role of experienced Estonian experts should not be underestimated. The course was set by Moscow, but local bodies still had a certain right to participate*" p. 57.

⁴⁵¹ See for example Hughes (1969).

⁴⁵² Kaasik (2004).

⁴⁵³ Õpik (1999) is not entirely clear on this point, but mentions these organs in the context.

⁴⁵⁴ *Ibid.* p 41.

Leningrad district, without any additional references. Moreover, most persons referred to in this context are Russian, such as Petrov, Sobolev, Tshukanov, Glebov.⁴⁵⁵ In 1946, the newspaper proclaims without hesitation that Estonia's big treasure will now become gas for Leningrad and adds that the small communities of Kohtla-Järve and Ahtme will become big industrial cities by the end of the current five-year-plan.⁴⁵⁶ That the most important role of the Estonian oil shale industry is to provide Leningrad with household gas is similarly overt in a couple of articles published in the daily *Rahva Hääl* in 1947. In an article under the headline *Gas to the city of Lenin*, the newspaper describes how the women of Leningrad will enjoy a more convenient life by 1950 thanks to Estonian gas, when consumption per capita there will reach the level of other big cities in the world.⁴⁵⁷ Less than two months later an article with exactly the same headline informs that three factories, two of which will be located in Estonia, will start producing household gas by 1947 which supposedly meant that:

“All this is available to the simplest, the lowest paid people. Such a civilization – achievements made available to the broad masses - is possible only with Soviet power, where the prime goal of each enterprise is not only making profit, but the wish to increase the well-being of the working population”⁴⁵⁸

Thus it can be claimed that the Soviet Union never even tried to hide the colonial logic of its intentions, and its aims were only slightly disguised in Soviet jargon. One could of course argue that the years immediately following the Soviet victory in WWII saw a surge in Russian nationalism, which was gradually muted as time went by. Nevertheless, the role of the Estonian oil shale was to supply Leningrad with household gas without any particular mention of compensation. In his contribution to the Estonian national assessment of damage created by the occupations,⁴⁵⁹ the economist Kalev Kukk, is straightforward about the ultimate aim of the Soviet policy:

“The goal of turning Estonia into a hinterland of Leningrad in an economic sense (of course also in a political), was then the most relevant reason why Estonia attracted particular attention from the central power. In the first place, this was manifested by the forced

⁴⁵⁵ *Rahva Hääl* 31.7.1946.

⁴⁵⁶ *Rahva Hääl* 11.5. 1946.

⁴⁵⁷ *Rahva Hääl* 25.1.1947.

⁴⁵⁸ *Rahva Hääl* 18.3.1947.

⁴⁵⁹ The Estonian State Commission for Research on the Policy of Repression of the Occupations was created by the Estonian Parliament in 1992. Its aim is to document and assess losses and damage inflicted upon Estonia by the Soviet Union and Nazi-Germany. See “Valge Raamat”(2005).

exploitation of the local oil shale deposits for supplying the inhabitants of Leningrad with oil shale gas and its industry and transportation with liquid fuel produced from oil shale.⁴⁶⁰

But as has been pointed out above, an important element of this policy was the existence of Estonian know-how on oil shale. Otherwise it would perhaps have failed.

Starting from November 1948 household gas from oil shale was delivered to Leningrad in a 200 km long pipeline. The gas was pumped by American-built compressors produced by the company *Clark*.⁴⁶¹ Despite the fact that the uniqueness of the compressors was mentioned in the press, their origin was not disclosed in public.⁴⁶² From 1953 gas was also delivered to Tallinn in a 150 km long pipeline.⁴⁶³ The pipeline to Tallinn was smaller and used below transmission capacity, because the supplies to Leningrad left little excess gas.⁴⁶⁴ At the same time there were plans to enlarge the gas supply to the cities of Tartu (in Estonia), Riga (in Latvia) and Pskov (in Russia),⁴⁶⁵ but these plans were never realized. Oil shale gas was a convenient solution for the city, which until then had been heated with coke (and wood) causing severe smoke pollution. This network of pipelines carrying oil shale gas was planned to later merge with a supply network of natural gas.⁴⁶⁶ In the late 1950s and early 1960s, the city of Leningrad started to receive natural gas from elsewhere and the demand for oil shale gas declined. Production was kept up, however, by increasing demand within Estonia, although the future for gas production looked bleak already then.⁴⁶⁷ Still, the five-year-plan for the period 1956-1960 included the construction of a fourth gas production unit, which

⁴⁶⁰ Kukk (2005) p. 159.

⁴⁶¹ The origin of these compressors is obscure. After all, in 1947-48 the cold war was already a fact, and thus it is less likely that any transaction of this kind would have taken place between the USA and the Soviet Union. If they were shipped to the Soviet Union during the war or immediately afterwards, the question remains what they were initially intended for. For further details on this assumption, see footnote below.

⁴⁶² Rooks (2004) pp. 27- 9. According to Rooks (p. 35) altogether 9 compressors were planned to be taken into use, but only 8 were actually installed, because one was sent to Leningrad to be dismantled in order to get an in-depth picture of American engineering. On the fundament already in place for the 9th compressor, a statue of Joseph Stalin was erected instead. Later, employees gathered at the statue to play domino, for which the statue for some reason was well suited. The statue was finally removed in 1961. The problem with the statue is noticed in a report by representatives from Svenska Skifferolje AB, the Swedish shale oil company (SSAB) in 1956, according to which the possibilities to increase gas capacity to maintain a stable pressure were hampered by the fact that the statue was standing on the only reserve fundament.(Arkivcentrum Örebro D2:139 p. 17).

⁴⁶³ Tarmisto, rd. (1959) p. 85. See also Rooks (2004) p. 40. In 1919 – 1921 gas produced from oil shale was used by Tallinn gas factory as a mode of illumination. (Martinson (1987) p. 131).

⁴⁶⁴ Kaelas (1958) p. 61.

⁴⁶⁵ Report by representatives of Svenska Skifferolje AB 1956 (Arkivcentrum Örebro D2:139 p. 4).

⁴⁶⁶ Arkivcentrum Örebro D2:139 p. 21.

⁴⁶⁷ Rooks (2004) p. 52 & 64. On this point Järvesoo's account differs from Misiunas & Taagepera's (see footnote below). While the former claims that the gas supply for Leningrad continued more or less unchanged in the 1970s (p.164), the latter claim it was phased out around 1968.

would lead to an increase of gas production by 70 per cent.⁴⁶⁸ The production of gas from oil shale was gradually reduced from 1970 onwards, but it was eventually phased out only in 1987.⁴⁶⁹

Initially, the output of oil shale gas rapidly increased. While total production reached 173 million cubic meters in 1950, the corresponding figure for 1960 was 433 cubic meters.⁴⁷⁰ By 1965 the figure was 510 cubic meters,⁴⁷¹ an increase of 300 per cent since 1950. Meanwhile, oil production in the Soviet Union increased from 38 million tonnes in 1950 to 148 million tonnes in 1960, or 390 per cent.⁴⁷² The cost for producing oil shale gas was 5 – 7 times higher than the cost for oil or natural gas. Thus the prospects for the continued production of household gas from oil shale were looking ever more unlikely.⁴⁷³

Production of oil shale increased rapidly after the war. In 1945 the total excavation of oil shale was down to 861 thousand tonnes, in 1950 the figure was up at 3,543 thousand tonnes, and in 1965, 16,500 thousand tonnes. Compared with figures from 1940, the increase was 870 per cent, and compared with 1945 the increase was almost 20-fold.⁴⁷⁴ In 1939, the corresponding figure was 1,660 thousand tonnes.⁴⁷⁵ In 1958, the oil shale processing industry (including gasification) consumed 38 per cent of the total oil shale produced, while district electricity plants consumed 19 per cent. The remaining share was used directly as fuel in boiler houses and industry. In 1965, the share of oil shale produced that was used for electricity power generation had increased to 44 per cent, while the use of oil shale directly as a fuel had decreased to less than 20 per cent.⁴⁷⁶

In the immediate post WWII-period an additional shale oil factory was built at Kohtla-Järve, with an annual capacity of 70,000 tonnes of shale oil. This increased total annual capacity to 253 thousand tonnes shale oil by 1956, according to Swedish estimates. In addition to this, 45

⁴⁶⁸ Kaelas (1958) p. 61.

⁴⁶⁹ Yefimov, Rooks & Rootalu (1994).

⁴⁷⁰ Figures from Aarna (1965) p. 9. One might question the reliability of these statistical figures in the same way one would question other Soviet statistics. But as the point is to show a relative shift, there is no specific reason to distrust the trend shown.

⁴⁷¹ Tarmisto (1959) p. 85.

⁴⁷² Aarna (1965).

⁴⁷³ Aarna (1965).

⁴⁷⁴ Tarmisto ed. (1959) p. 81.

⁴⁷⁵ See appendix I. If the figures from the Soviet time are correct, the increase was 10-fold between 1939 and 1965.

⁴⁷⁶ Tarmisto ed. (1959) p. 82.

thousand tonnes gasoline were produced.⁴⁷⁷ These figures, if correct, point at a dramatic increase in production since the pre WWII-period. As can be seen from appendix II, total Estonian production reached little more than 179 thousand tonnes in 1939. The Swedish report provides no figures for the production at Kiviõli.⁴⁷⁸

In brief, the period after WWII was characterized by a rapid build-up of the destroyed capacity, but also further expansion. Especially the oil shale industry received much attention from the power structures, while other Estonian industries remained without particular attention.⁴⁷⁹ On the basis of this reasoning it looks obvious that the development of the oil shale industry had been cut loose from the development of the rest of Estonia. Due to the particular circumstances, the Estonian oil shale industry had surpassed the society that once created it and it had become something of a foreign element in its original surroundings.

6.1.1. Digression 2: More oil shale!

The period starting from the Soviet re-occupation of Estonia in the autumn of 1944 until the years following the death of dictator Joseph Stalin were characterized by severe oppression in all spheres of Estonian society. Massive deportations of people from Estonia took place in June 1941 during the first Soviet occupation and in March 1949, but the repression was constant even in other times. The Soviet repression was interrupted only by the Nazi-German occupation in 1941-44, which also had dire consequences for the people of Estonia. During WWII Estonia lost an estimated 25 per cent of its total population. This figure includes people killed (by both Soviets and Nazis), refugees to the West, and population losses due to deportations and changed borders. In addition to this, after the war (1945-1953) an additional two per cent of the remaining population was killed and many more deported or otherwise repressed.⁴⁸⁰ This period caused wide-spread fear in Estonia and a demographic disaster. These two factors would have an enormous impact on the further developments, in both Estonia and the oil shale industry.

The official façade of those years, however, is difficult to describe and in order to give an idea, some newspaper clips will be quoted and presented below. An in-depth analysis of the

⁴⁷⁷ Arkivcentrum Örebro D2:139 p. 5.

⁴⁷⁸ Ibid.

⁴⁷⁹ Mertelsmann (2003).

⁴⁸⁰ Misiunas & Taagepera (1993/1983) p. 356, Valge Raamat (2005) p. 50, own calculations.

features of Stalinism is far beyond the scope of this work, but on the other hand the development of the Estonian oil shale industry can not be understood without entering upon that topic. The economic historian Alec Nove describes production under Stalin's rule as a tendency to try to increase only output. The easiest way to do this was by not altering any design. Also the structure of production remained more or less the same, because the system de facto encouraged conservatism. Getting hold of resources was, in the end, a question of wrangling at the top of the hierarchy, which usually resulted in those already powerful entrenching their positions further. Thus, for instance, the chemical industry could not take off, because due to its weakness, its representatives did not have the power to pour more resources into it.⁴⁸¹ Moreover, there was an element of constant fear for personal safety, which effectively hindered attempts to innovative action, or even economically justified improvements. Still worsening the overall performance was the persistent xenophobia in society, resulting in claims that more or less everything had been invented in Russia and thus there was nothing to learn from "the West". Statistical information became more or less impossible to find, because statistical publications were closed-down and made subject to heavy censorship. As a result there was very little reliable information on output, labor, income and population statistics.⁴⁸² Another aspect of this development is put forward by the Hungarian economist Janos Kornai. The classical (socialist) system is almost exclusively focused on investment-led growth, which as its flip-side requires curbing consumption.⁴⁸³ This *investment hunger* becomes the fundamental driving force of not only the leaders, but the entire bureaucracy.⁴⁸⁴ As a result *investment tensions* emerge, which could be described as a competition for investment goods. But the demand constantly exceeds supply because of the inherent characteristics of the system, i.e. the investment hunger. Thus numerous bottlenecks holding up production become a standard feature of the system.⁴⁸⁵

Starting in 1945, the Estonian and Russian-language parallel Communist daily newspapers *Rahva Hääl* ("The People's Voice") and *Sovietskaya Estonija* ("Soviet Estonia") published a

⁴⁸¹ Nove (1992) pp. 324-5. See also Tarschys (1978) p. 121.

⁴⁸² Nove pp. 325 – 6. Karlsson (2005/2003) mentions that a census was carried out in 1937 in the Soviet Union (which at that time did not yet include the Baltic States) showing a disastrous decline in the population. The result did not satisfy Stalin (who bore the utmost guilt to the decline), and as a consequence he had the statisticians executed. The results could only be made public during the openness in the late 1980's. Karlsson(2005/2003) pp. 180-1.

⁴⁸³ This is based on the assumption from basic economics that investment equals savings, which by definition is the part of income that has not been used for consumption. Thus restricted consumption allows for more investment.

⁴⁸⁴ Kornai (1992) p. 163.

⁴⁸⁵ Kornai (1992) p. 165.

sort of regional and professional daily newspaper under the name *Rohkem Põlevkivi!* (“More Oil Shale!”), which in its own peculiar way tells the story of life in and around the oil shale industry in the first years of Soviet rule.

Most issues of the newspaper are filled with reports on various production norms being exceeded by more than 100 per cent. Articles are often little more than different slogans being added to each other in an attempt to convey the impression of people exalted by happiness for living under the Stalinist regime. A couple of headlines from the front page may serve to illustrate:

“Towards an even more happy future under the leadership of the Bolshevik party”⁴⁸⁶

“Only in the family of the Soviet peoples, can the Estonian people remain free”⁴⁸⁷

It is hard to say whether the ruling structure actually believed that this kind of writing would have any impact on public opinion. If that really was the case, such slogans would have been intended to alter the informal institutions of Estonian society by which is meant cultural values or common perceptions, norms and beliefs. In 1946, Soviet rule was new to Estonia, where the institutional framework (both formal and informal) was different from that of the Soviet Union. Therefore it was in the interests of the new rulers to use various methods to try to change convictions deeply held by the Estonian population, like for instance the general attitude towards the only recently independent state. To be sure, the Soviet Union did not limit its attempts to newspaper headlines. Instead, extreme forms of violence was the norm, but those that were not targeted with physical repression had to be won over for the “Soviet cause”. Despite these efforts, this goal was never reached, which the modern history of Estonia unambiguously shows.

In line with the official policy, the newspaper was supposed to encourage ever greater output from the workforce. To reach this aim, headlines like the following were common:

“Constantly fighting to fulfill the monthly production plans”⁴⁸⁸

⁴⁸⁶ *Rohkem Põlevkivi!* 5.2.1946.

⁴⁸⁷ *Ibid.* 6.2.1946.

⁴⁸⁸ *Ibid.* 28.2.1946.

The supposedly loyal collective of workers was depicted in glorifying terms:

“The miners of Kohtla, who in honor of the election to the supreme soviet of the USSR gave themselves the obligation to exceed the plan by 2000 tonnes oil shale, have used all their strength to fulfill this promise”⁴⁸⁹

For one or the other reason, especially women were often presented as a sort of a backbone of production:⁴⁹⁰

“At the same time as the working collective of the Kukruse mine are straining themselves to reach an ever higher production, the women engaged in sorting and loading oil shale are not forgetting their working obligations. While skillfully rationalizing their own work and always keeping their working tools in good shape, the excellent women Adele Valme, Emmi Sallo, Emma Hirvi and Anna Hürro are purposefully loading oil shale 160 per cent above the given work norms.”⁴⁹¹

The international women’s day, celebrated in most Communist countries, was naturally paid attention to by the newspaper:

“The Soviet woman does also the heaviest jobs cheerfully, knowing that her work is appreciated. She has experienced that the Soviet government and the party have always particularly cared for women and therefore she mobilizes all her strength and skills in order to gracefully help securing the future of her homeland and with honor she bears the respected title of a Soviet woman”⁴⁹²

It was earlier claimed that women in these years were perceived as a cheap substitution for technology; their labor allowed for increased output without having to utilize technology, of which there was a permanent shortage. Statements of the kind quoted above must therefore be seen as a means of boosting women’s motivation to work. Whether this turned out to be successful or not is nonetheless an entirely different question.

⁴⁸⁹ Ibid. 9.2.1946.

⁴⁹⁰ Probably Soviet ideas of gender equality lie behind this fact. There was definitely no shortage of propaganda material in the Soviet Union praising the female industrial worker.

⁴⁹¹ *Rohkem Põlevkivi!* 30.1. 1946.

⁴⁹² Ibid. 8.3.1946.

However, the newspaper also focused heavy criticism on phenomena that for one or the other reason were seen as problematic. In this criticism, the real-life problems in the oil shale region are reflected and in its own strange way, this kind of official criticism can still today lend the system an aura of legitimacy. Some examples:

“The workers of Kohtla-Järve have no drinking water”⁴⁹³

The paper points out that 60 per cent of the wells are unsuitable and still the workers have to pay for their drinking water. But also other shortcomings are notified: there is a lack of waterproof clothes for those cleaning the factory.

Regardless of the mix of coercion and propaganda, problems with the workforce remained, as these two headlines indicate:

“To get rid of absence from work without reason”⁴⁹⁴

“Internal conflicts hamper work”⁴⁹⁵

Under the headline *For a higher working discipline* the seriousness of the problem of work absence is addressed:

“ Many cases can be found many cases in the oil shale industry when not enough attention is paid to strengthening working discipline. A blind eye is turned to those who are absent from work and nothing is done to maintain order. During one month in Kiviõli, Elmar Kibin has been absent from work for 21 days without permission! For those who violate the work discipline for the first time, the dishonour of their action should be made clear, but if this does not help tougher remedies should be applied.”⁴⁹⁶

The problems continue and are again paid attention a few months later under the headline *Hard combat against violators of work discipline*:

“In order to execute the struggle to fulfill the production plan, first of all a clear order has to be created for the work discipline in the enterprises and this should be done by

⁴⁹³ Ibid. 6.4.1946.

⁴⁹⁴ *Rohkem Põlevkivi!* 25.3.1946.

⁴⁹⁵ Ibid. 30.5.1946.

⁴⁹⁶ Ibid. 27.7.1946.

mobilizing all strength against the lazybones. Let's put up tables of shame, so that irresponsible people would feel ashamed and embarrassed in front of honest workers and through orderly work become equal to the exemplary workers.”⁴⁹⁷

A particular feature that can be observed is the rapid change between harsh criticism and praise (this phenomenon is certainly not limited to newspapers in the Soviet Union of this period, but it is still worth highlighting)

“Why is the Kohtla-Järve oil factory not fulfilling its production plan for September? There is lack of caring for workers. Not enough attention is paid to the shortcomings in the organizing of the work of youth brigades”⁴⁹⁸

The problems were obviously solved one month later. However, there is no deeper discussion about the methods how the more or less organizational problems mentioned above were addressed.

“The Kohtla-Järve oil factories are exceeding the plan”⁴⁹⁹

Several articles make no secret that the living conditions for the workforce are sometimes far from decent.

“It has to be said that excellent work has been done in all areas and results have been achieved, but one crucial area has been forgotten by the party economist – the living conditions in our oil shale industry. In other enterprises and here in Kohtla-Järve, 4000 persons are living in impossible conditions. Between the houses there are several square meters large ash heaps, which start smelling in the spring and spread diseases. No better is the situation with the toilets of the workers' houses, which because of broken drainpipes make whole houses smell. It is no exaggeration when I claim that the whole Kohtla-Järve smells”⁵⁰⁰

⁴⁹⁷ Ibid. 30.10.1946.

⁴⁹⁸ *Rohkem Põlevkivi!* 27.9.1946.

⁴⁹⁹ Ibid. 31.10.1946.

⁵⁰⁰ Ibid. 16.3.1946.

Under the headline *To cultivate every square meter of garden* the issue of the extra food production stemming from small private gardens so typical for the Soviet Union is addressed in the following way.

“The Soviet power has always guaranteed all workers the possibility and the right to an own, private garden, where he has the possibility to get needed additional food, because due to the limited possibilities as a consequence of the war, there are still some difficulties in providing for our labor force.”⁵⁰¹

“In the distribution of gardening land, there will be a strict adherence to the law: In the first place, extra land is given to invalids of the Patriotic war and families left orphan. In the second place come exemplary workers, who without violating the work discipline have constantly provided a large production.”⁵⁰²

In all of the issues of the newspaper *Rohkem Põlevkivi!* in 1946 there is only one major article to be found which could be described as a sober account of the present and future possibilities of the oil shale industry. This article, signed by the director of the technology department of *Kiviõli* (i.e. the factory, not the town with the same name), P. Lindvere, discusses the pros and cons of the various chemical products derivable from oil shale.⁵⁰³ The author assumes that the future of oil shale lies in the production of chemicals, not fuel. At the time the main products were: fuel, bitumen, diesel oil, and motor petroleum. Production could be expanded into producing cement from ash and plastic mass, explosives, paints, and anti-corrosion substances from phenols, while acetone could be extracted from water in the production. The various types of oils should be developed further into binding material for road cover, and insecticides (shale oil was supposed to be a lot more poisonous for insects than other oil). Burning the gas straight away is not recommendable, as a lot of valuable substances are lost, such as sulphur. Another type of products could be the production of various scents, such as strawberries and pineapple.⁵⁰⁴

⁵⁰¹ *Rohkem Põlevkivi!* 18.5.1946.

⁵⁰² *Ibid.* 18.5.1946.

⁵⁰³ Lindvere: “Mida saab põlevkivist” (“*What can be gained from oil shale*”) *Rohkem Põlevkivi!* 20.11.1946.

⁵⁰⁴ Mention of pineapples in a text from the Soviet time sounds strange, because pineapples were not a part of the general food supply. Pineapples were truly exotic in the Soviet Union well into the 1990s (this statement is based on numerous stories I have heard from people who lived in the Soviet Union in addition to my own experiences from the early 1990s, when giving somebody a can of pineapple conserve could open many doors).

A slightly different account of everyday life in the oil shale industry only two years later (1948) is given in the memoirs of the engineer Juhana Tomberg, director of the department of the production technology at the Kohtla oil shale combine (or company), who in an extract from his diary between 2 and 25 August 1948 recalls everyday activities:

*There is an inspection of the construction of retort no. 1 after unwanted riveting, inspection of the elevators together with the head of the technical inspection, an explanation of the riveting at Kohtla-Järve and Kiviõli procurator, receiving records on the renovation of retorts no. 1 and 2 from the chief mechanic, an analysis on how to avoid damage to the cover of the retorts after a heavy rainfall caused damage August 16. The next day there was no oil shale in the factory because of lack of explosives and also because a water-filled mine could not be emptied. An order on modernization of elevators in the boiler room is being sent to the company "Ilmarine", a letter is sent to the institute of scientific research and projecting, claiming that their preliminary calculation no. 45 is not in accordance with the needs. A letter to deputy minister Freiberg on the order sent to "Ilmarine". Specification of the electrical equipment still needed at the boiler house. Meeting of the commission on development of the technological regime in the mines. Production consultations at the director's office.*⁵⁰⁵

It probably goes without saying that drawing conclusions about the development and circumstances in the first post-war years is far from simple. The picture is confusing, a mixture of limitless praise and extremely harsh criticism. But somehow also a reality beyond the words can be sensed. Tomberg's account above serves as a reminder that life was not thoroughly politicised under Stalin. Instead, people had concerns of an everyday character at their jobs.

We can clearly see that criticism of various social problems under Stalinist rule was certainly not totally prohibited, and sometimes even encouraged. Nevertheless, the criticism obviously had a deeper political meaning and was likely a tool used against people or groups of people who were being targeted by the Communist Party. According to Paul Gregory and Andrei Markevich, this phenomenon was a fundamental feature of the Stalinist system. Because the

⁵⁰⁵ Tomberg (2002) p. 60. This is not a direct translation of the entire text, not a quotation, but an abridged version of the account. The aim has been to preserve the original style. Tomberg's account of other developments is as factual as this abstract, mostly totally impersonal. Thus, when explaining that for a long time he was always "deputy" at his positions because he was not a member of the communist party, he adds laconically with one single sentence: "Moreover, my father was arrested and deported to Siberia" (p. 19).

ideology claimed to be all-encompassing and absolute, failures had to be ascribed to individuals. In order to avoid being targeted, any manager would not hesitate to use whatever means available in order to please his superiors, including falsification of production statistics or blaming subordinates. As a consequence of the inherent logic of the system, no manager could survive without resorting to such methods. However, the dilemma for the system was that there were too few skilled managers and firing them (or worse) each time a breakdown in plans occurred, would have had devastating effects on the whole system. Instead:

“.../ the Soviet system created an elaborate ritual of blame (scapegoating), punishment, suggestion of remedial measures, and punishment reversal. The various players in this ritual usually understood their roles well.../ Deputy directors or chief engineers were more likely to pay the price of plan failure than the enterprise director. The lower the level of an “acceptable” scapegoat, the better.”⁵⁰⁶

The criticism in *Rohkem Põlevkivi!* never contains any analysis of facts, any discussion of pros and cons, nor any attempt to go beyond the obvious. It is never asked, for example, whether those holding political power could bear responsibility as a group, not to mention a discussion whether there were system failures. On the other hand, reports on fantastically filled production quotas probably serve the interests of local managers, who want to give *the impression* that production is increasing. The receiver of the messages in this kind of articles is not the workers, but Communist Party *apparatchiks* in various positions throughout the hierarchy.

It is tempting to ask whether the style in *Rohkem Põlevkivi!* is something that has had a positive impact on workers in Russia, i.e. that the language is actually Russian for certain social strata, but in this context with Estonian words. The way of expression is definitely not typical for the Estonian language and the Estonian style of communication. It is therefore relevant to ask whether these texts are simply written in a way that had proved at least partially successful among Russian workers. Because of the equalizing tendencies in the Soviet system, no attention has been paid to cultural differences. Another related aspect could be that in Russia literacy became common only in the 1920s and 1930s, while in Estonia that process took place at least one generation earlier, and consequently different reading

⁵⁰⁶ Gregory & Markevich (2002) p. 799.

traditions were established.⁵⁰⁷ Still in 1952, an estimated 14 per cent of the industrial workforce in Estonia consisted of de facto illiterates. These people were mainly immigrants.⁵⁰⁸ It should, nonetheless, be stressed that also highly educated immigrants arrived. In a sober account provided by the Estonian engineer Ivar Rooks after the collapse of the Soviet Union (i.e. with no need to follow any official line) the immigrants are described in the following way:

“The family of those who arrived was really colorful: from highly educated people to illiterates. In Russia and in Belarus the economic situation was very miserable and many of the new settlers stayed here with pleasure and became part of the workers’ collective of the combine that was being built. One of those I would like to recall with a kind word is Nikolai Pysin from the Urals, who in the 1930s was forced to leave his studies at the technical school after his father was branded a kulak, and to begin as a factory worker. At Kohtla-Järve, Pysin was soon promoted to foreman. His poor education was compensated with talent and entrepreneurial spirit.”⁵⁰⁹

Anyway, intense Russification of the oil shale region took place after WWII, which according to the Estonian-Russian sociologist David Vseviiov was the outright policy of Moscow. Especially in the easternmost town of Narva the very aim was to minimize the number of Estonians, because, as Vseviiov claims, it was initially supposed to become the location of a Soviet uranium enrichment plant (which later was located at Sillamäe in the vicinity).⁵¹⁰ Another explanation is put forward by the historian Olaf Mertelsmann, according to whom the combined effects of devastation caused by the war, huge population losses and the needs of industry led to a severe labor shortage, which was aggravated by the fact that few Estonians were attracted to the harsh living conditions in the oil shale region. The only remaining solution for the industry was to import labor from the rest of the Soviet Union, which occasionally found the conditions there more attractive than what they had experienced elsewhere in the Soviet Union. Moreover, the very existence of a Russian-speaking community in the region made settling down easier for the newcomers.⁵¹¹ Whatever the actual reason, the fact remains that the entire region became heavily Russified within a few years. But Russification was far from complete. In the 1940s and 1950s, the majority of the

⁵⁰⁷ Gerner & Karlsson (2002) p. 181.

⁵⁰⁸ Mertelsmann (2003) p. 156.

⁵⁰⁹ Rooks (2004) p. 20.

⁵¹⁰ Vseviiov (2002) pp. 96-7.

⁵¹¹ Mertelsmann (2007).

employees at three out of four factories at Kohtla-Järve, including the leadership, were Estonians. Even if Russian soon replaced Estonian as the language of administration in the Kohtla-Järve factories, on a day-to-day level, Estonian would still dominate well into the 1960s.⁵¹²

Whatever the reason for the particular way of expression in *Rohkem Põlevkivi!*, it can be said that there were obvious problems with labour productivity in the oil shale industry in 1946. Motivation was low, workers were absent to an extent that caused alarm, the living conditions were appalling and even basic needs were not met (such as drinking water). As a response, the newspaper tried to inspire the workers – and conspicuously often the women – to higher productivity. Thomas Hughes sees such conditions as something inherent in the Soviet system, but with an obvious pedigree from the machine culture that had developed in Western Europe and North America:

“Motivated by Marxist moral arrogance and empowered by authoritarianism, Soviet engineers and managers with American-style affection for megaprojects ran roughshod over workers and local communities as they built canals, railroads, hydroelectric projects, and industrial complexes. Construction workers often survived miserably in tents and mud surrounded by open sewers. The technocratic politicians insisted that the projects prepared the way for a socialist utopia.”⁵¹³

It is certainly not far-fetched to ask whether this is evidence enough in support of the hypothesis expressed earlier that the Soviet system, when it came to power in Estonia, could be seen as not only a foreign power, but a foreign institutional set-up, for many Estonians a collection of unfamiliar and unintelligible norms and values. In the case of the language used in *Rohkem Põlevkivi!* there are no references to traditional Estonian values, not to mention a deeper connection with the Estonian past. The break is more or less total, indicating an institutional shift on the formal level of enormous proportions. On the other hand, the account given by Tomberg, although in retrospective, hints that many informal institutions remained in place. Thus it can be sensed that there was a major rift between formal and informal institutions.

⁵¹² Roost (2004).

⁵¹³ Hughes (2005) p. 20.

One more aspect should be brought up in this context. Several articles in *Rohkem Põlevkivi!* call for increased production and depict heroic workers exceeding their quota. The American economist Mancur Olson finds this feature inherent in the Stalinist economy. When the state controlled both salaries and consumption, it could set very low initial salaries and high prices on consumption goods, of which there was a very limited supply, indeed. This was, however, just another way to levy a heavy, not to say extreme, tax burden. Thus ordinary salaries were below subsistence level, but to remedy this, the de facto tax level was relaxed on marginal income, i.e. for work in excess of the actual work. By working more than the actual regulations stipulated (and cutting leisure to a minimum) an individual could rise above the subsistence level and allow himself modest consumption. Of course, the actual circumstances could not be presented publicly, but instead the propaganda apparatus was given the task to try to convince the population that they were part of a heroic enterprise when they were simply struggling to survive. This policy produced a significant surplus for the state, which, however, was more or less squandered by the bureaucratic apparatus.⁵¹⁴

6.1.3. The conferences of 1946, 1951 and 1954

Almost immediately after the war, the Estonian scientific community took some steps to broaden the role of the oil shale industry towards the production of chemical substances. The underlying aim seems to have been to avoid being totally caught in the role of supplier of gas to Leningrad, although such positions were never disclosed publicly. But between the lines, cautious criticism can be sensed. A quote from A. Rannes' work from 1948 may serve to illustrate this careful approach:

“Thus oil shale turns out to be a very broad and diversified base for raw materials; for such a national economic application [of oil shale], the Communist Party and the Soviet order have created the basis and possibilities while the socialist economic system has opened up a free development path for the productive forces of the Estonian people. All this is guaranteed for us in a concrete way by the successful fulfillment and exceeding of the new Stalinist five-year plan now running for its third year.”⁵¹⁵ [words in brackets added]

In October 1946 the Academy of Sciences of Soviet Estonia laid down the principles for future development of the oil shale industry. This was explicitly decided to take place in

⁵¹⁴ Olson (2000).

⁵¹⁵ Rannes (1948).

cooperation with all-union institutions in order to do research, develop technology and working practices as well as finding new methods for using oil shale energy.⁵¹⁶ The overall directions given at the meeting in October 1946 for oil shale research were focused on efficiency in production. The division of tasks between individual actors was as follows; The Institute of Chemistry at the Academy of Sciences of the Estonian SSR was assigned the task to study shale oil as a motor fuel, lubricant and detergent. In addition to this, the Institute of Chemistry was also supposed to carry out research on extracting shale oil by *in situ* heating.⁵¹⁷ The Institute of Industrial Problems (later renamed the Institute of Energy Technology) of the Academy of Sciences was given charge of studying chemical components of oil shale. Tallinn Polytechnic Institute contributed with chemical research on the composition of shale oil and oil shale phenols. The Institute of Projecting and Scientific Research of the Ministry for Oil Shale and Chemical Industry of The Estonian SSR, founded in 1945, was delegated the task of analyzing the gas produced, and especially removal and capture of sulphur. This institute also put a lot of effort into developing the tunnel ovens. Outside Estonia, the Institute of Thermal Natural Resources of the Soviet Union was in charge of developing motor fuel, the Institute of Energy Technology of the Academy of Sciences of the Soviet Union was to develop a solid heat carrier.⁵¹⁸ The initial development work on developing a solid heat carrier had already got underway in Russia, when in the autumn of 1944 trials were made at the G.M. Krzhizhanovsky Power Engineering Institute at the Soviet Academy of Sciences to use this method for pyrolysis of brown coal, peat and oil shale.⁵¹⁹ Details from the conference in October 1946 are described in a newspaper article.⁵²⁰ According to the article, a certain J. Nuut of the Academy of Sciences stated that one aim of the Academy is to become the leading scientific institution on oil shale in the Soviet Union. Close contacts between the oil shale industry and the Academy of Science will make “empiricism” and “pottering” disappear from oil shale technology. The oil shale chemist Paul Kogerman speculated over the future of

⁵¹⁶ Undated document from after 1961, signed A. [Agu] Aarna, in Russian: *Issledovanye slantsevoi khimii i ispolzovanye produktov jejo termicheskovo razlozheniya* (“Research on oil shale chemistry and utilization of the products of its thermic decomposition”). From the papers of Helle Martinson, Estonian Academy of Science.

⁵¹⁷ This is the so called Ljungström-method, developed in Sweden (see the chapter on Swedish oil shale). This method never proved successful in Estonia, although it was in use between 1948 and 1954. See Kattai (2003a) p. 53.

⁵¹⁸ Undated document, most likely an Estonian translation of the document quoted in a previous footnote. The Estonian title is *Põlevkivikeemia ja tema termilise lagunemise produktide kasutamise uurimine*, which is exactly the same as the name of the document titled *Issledovanye slantsevoi khimii i ispolzovanye produktov jejo termicheskovo razlozheniya*. From the papers of Helle Martinson.

⁵¹⁹ Volkhov & Stelmakh (1999).

⁵²⁰ Lepikson, H. “Põlevkivi kasutamise probleemid (Nõupidamiselt Eesti NSV Teaduste Akadeemias põlevkivi kasutamise kohta)” *Rahva Häääl*, November 15, 1946 (“Problems of using oil shale (From the conference on using oil shale at the Academy of Sciences of the Estonian SSR)”, in Estonian).

oil shale and suggested that it may become a valuable raw material for the chemical industry. He also mentioned that gasification of oil shale was never aimed at in the “bourgeois” Estonia, except for in small quantities, and it was only to establish that it was technically possible. Kogerman also called for better coordination of scientific work and more possibilities for young scientists to gain experience in the all-Soviet “technological structures”.⁵²¹ A. Chernyshev, member of the Soviet Academy of Sciences, described a method how coal had been gasified under ground in Russia since the 1930s. This method could be tried in Estonia on oil shale, as was suggested by one speaker at the meeting of the Academy of Sciences. There is no further information on who the speaker actually was, but the article takes a rather surprising turn here, basically rejecting the idea with reference to the Swedish experiences from the Ljungström-method, which demands too much electricity for the production of oil. This method, it is claimed, can only be possible if there is an excess supply of hydropower. Moreover, in Estonia underground gasification is not worth trying, but maybe underground pyrolysis, because of the value of oil shale as a raw material. Kogerman added later at the meeting that electrical gasification should be tried on dictyonema oil shale, because that was also what had been done in Sweden. Then the article returns to quoting the speech by Chernyshev, who also recommends a method for using semi-coke from the pyrolysis process as fuel. This method is suitable for fine grained oil shale.

The first of the two major follow-up conferences, held in November 1951, was focused on using shale oil as motor fuel, lubricating oil and mazut (Russian fuel oil). But at the second one, in March 1954, focus had already shifted towards the possibilities of developing a chemical industry. The potential for products such as phenols, detergents and lacquer was particularly emphasized. The reason for this change was the ever-increasing supply of oil and natural gas from other parts of the Soviet Union. In May 1958 the Central Committee of the Communist Party of the Soviet Union formally approved the change of production profile of the oil shale industry.⁵²² This decision was immediately reflected in the Estonian daily *Rahva Hää*, where the technical director of the Kohtla-Järve oil shale combinat, K. Help remarked that producing household gas is uneconomical, while significant advances could be made in producing fertilizers for the agriculture, whereby also Estonian agriculture would become a

⁵²¹ Such ideas of developing a chemical industry can be found in a letter from Paul Kogerman to the Institute of Economy and Law at the Estonian Academy of Science from January 1947, where Kogerman suggests handing over the task of further development of gas production in chamber ovens to all-union structures (and not Estonian ones) in order to avoid waste of resources. Estonian scientists could instead develop new retorting methods with the goal of broadening the industrial output. From the papers of Helle Martinson, no 9743.

⁵²² The above-mentioned document by Aarna (in Estonian).

part of the oil shale complex.⁵²³ A few weeks later a certain professor H. Raudsepp went even further and claimed that the strong connection to the production of oil and gas was hampering the development of the Estonian chemical industry.⁵²⁴

To sum up, the focus on gas production from oil shale never gained full acceptance throughout the Estonian engineering community. Already in the first years after WWII, a certain covert resistance against gas production emerged. At first, criticism was rather vague, but with time passing, it became more open and direct. Another trend is worth particular attention, namely that the development of oil shale technology was soon institutionalized and divided between several bodies, while technological development in pre-WW II Estonia had basically been carried out by several companies.

6.1.4. Research

Immediately after WWII, in the summer of 1945 the Estonian Academy of Sciences was re-established (with the change of name to the “Academy of Sciences of the Estonian Soviet Socialist Republic”). Only one of the members of the Academy had been a member of the Estonian Academy of Sciences during the period of the independent Estonian state; the oil shale chemist Paul Kogerman (who had been persecuted by the Soviets between 1941 and 1945). Of the remaining members of the pre-war Academy eight members were refugees in the West and four were dead.⁵²⁵ In 1947 an institute of chemistry within the Academy of Sciences was created, chaired by Kogerman. One of its three sectors was oil shale chemistry (the two others being chemistry and technology as well as chemical-pharmaceutical). Kogerman was appointed director of the institute of chemistry. One of the most difficult problems facing the institute was the shortage of scientists in the field immediately after the war.⁵²⁶

In April 1948 a “research and projecting” institute under the Ministry for Oil Shale and Chemical Industry of the Estonian Socialist Soviet Republic was established. Its tasks were rather specifically laid down by the authorities. A task list dating from 1950, was rather detailed, containing 24 points on which research was expected. Among other things, the

⁵²³ *Rahva Hääli* 1.7.1958.

⁵²⁴ *Ibid.* 29.7.1958.

⁵²⁵ Kaasik (2004) p.88.

⁵²⁶ *Ibid.* p. 89.

institute was to produce research on gas mixtures, the improvement of lacquers, relevant technology, new methods for producing bitumen, the production of phenols in tunnel ovens, the development of a local petroleum stabilizer, the production of lacquer from phenols, experimental devices for shale oil, gas extraction, to carry out a comparative study of oils for further refinement, tanning agents, and the technological regime for tunnel oven no 1.⁵²⁷

Meanwhile, the Tallinn Polytechnical Institute was redesigned to meet Soviet policy. Already in the autumn term of 1945 an influx of personnel from other parts of the Soviet Union became conspicuous, especially because the newcomers often lacked higher academic degrees. Their tasks were instead to promote the Soviet rule.⁵²⁸ A few years later, around 1950, a renewed campaign of sovietization at the Tallinn Polytechnical Institute was launched by the Communist Party of Estonia. The accusations directed against several scientists mainly followed typical Stalinist choreography. Kogerman had to leave his position as the head of the institute of chemistry. Several other scientists were made redundant, thus further draining the Estonian science community. On the other hand, in the years 1946-1951 a total of 120 chemists received their education at the faculty of chemistry.⁵²⁹

A summary of this period and the destiny of Kogerman is provided by Peep Varju:

“The witch-hunt of the 50s began for bourgeois nationalists, capitalists and other parasites on the Soviet regime also at Tallinn Polytechnical Institute and the Academy of Sciences of the Estonian SSR. Renowned Estonian specialists were harshly accused of lack of qualifications and the wrong fostering of the young cadres.

Such was that time: people were fired and imprisoned, provoked, replaced with unqualified careerists brought in from Russia. In a forced labor camp in Narva, our well-known composers, doctors, authors, and school teachers were working as prisoners. These circumstances taken together caused the too early and unexpected death of our respected scientist”⁵³⁰

Thus, the scientific community which had emerged around oil shale was seriously weakened due to war and repressions, but nevertheless enough people survived to maintain and reproduce knowledge. Judging from the Estonian experience, even a severely diminished

⁵²⁷ ERA R-1825-1-168 p. 115, 121.

⁵²⁸ Kaasik (2004) p. 86.

⁵²⁹ Ibid. pp. 92 –4.

⁵³⁰ Varju (2004) pp. 197-8.

scientific and technological community with much of its physical infrastructure in ruins (and even under extreme political coercion) is still capable of utilizing and transferring the bulk of its know-how.⁵³¹ But both in pre-WWII Estonia and under the Soviet rule, scientification of oil shale was an important issue.

6.1.5. Comments

In the aftermath of WWII the Estonian oil shale industry (as well as the rest of Estonia) was in disarray. Not only had the war caused human and material devastation, but also a sense of loss of the very reason to exist for the oil shale industry, which had been so successful within the framework of a nation state. A new role was sought after, but this process became extremely complicated in a society without free speech and with constant fear of repression, even if some degrees of freedom for discussing technological issues were maintained.

The task of the oil shale industry was no longer the domestic production of fuels and to generate earnings from exports. Without these two elements the entire *raison d'être* had been lost. A new function, which probably was meant to be a temporary arrangement from the beginning was the production of household gas for the city of Leningrad. Whatever moral objections the Estonian engineers and technicians could have entertained privately, the fact is that they committed themselves to the task of rebuilding the oil shale industry under the new conditions. Such a mood is reflected in an article by Paul Kogerman in 1946, where he in an unobtrusive and resigned tone discusses the possibilities of using those gases that are left over from the production for Leningrad for the purpose of developing the Estonian chemical industry.⁵³²

A delicate question that would require an answer is whether the entire scheme of producing household gas for Leningrad actually was of Estonian origin. Some evidence presented above hint in this direction. First, there is the issue of how the Soviet authorities figured out about the possibilities to extract gas from oil shale. It is unlikely that the Soviet regime would have started experimenting with an unknown technology immediately after the war. Second, the pace of the build-up of the gas industry point at engineering skills efficiently used, basically skills stemming from the oil shale industry before 1940. Third, Ilmar Öpik admits without hesitation that he and other Estonian oil shale specialists were treated very well indeed in the

⁵³¹ The parallel with the rapid rise of Germany and Japan after WWII is obvious.

⁵³² Kogerman (1946).

Soviet Union during the war.⁵³³ Finding a thorough answer to the question of the origin of the gasification of oil shale is made even more complicated by the fact that contemporary Soviet sources tend to downplay everything non-Russian, while Estonian sources today probably have a tendency to avoid looking too closely at such a connection. A plausible scenario is that the initiative to develop and construct the gas industry came from within the Estonian oil shale community (or rather parts thereof), from people who nurtured hopes of being able to continue their professional tasks, and to find some replacement for the *raison d'être* lost. However, soon it turned out that the Soviet structures demanded a high price, i.e. to take control over most of the industry and in the end, Russification of the oil shale industry.

Behind the scene a tug-of-war took place on how big a chunk of the oil shale sector was to be surrendered to bodies outside Estonia. The existence of such power struggles can be derived from the frequent mentioning in the sources of technology developed in Russia that was presented as suitable for Estonia. From a Soviet point of view it was logical to harness the Estonian oil shale to mitigate the serious shortage of energy in North-Western Russia while at the same time tie Estonia up to the rest of the country. The plans to develop a chemical industry from the oil shale industry could be seen as an Estonian countermove to maintain at least some space for manoeuvring. But the stress on chemical industry could also be said to expose a cultural trait in Estonia, namely that resulting from the German heritage in the industry.

In this context it should be emphasized that these developments took place simultaneously with political infighting within the Communist Party in Estonia. The first secretary of the Estonian Communist Party, Nikolai Karotamm, made some attempts to reduce the impact of Soviet power, however small. In the end, he lost out to the Stalinist hardliners. The historian Hain Rebas depicts the developments in the following way:

“It is hardly surprising that Estonia was regarded as the most Westernized of Soviet Union’s republics. Five years on from the renewed occupation, the party organ *Rahva Hääl* engaged in a long and fateful tirade regarding the persistence of independence-minded attitudes within the educational sector. This statement/.../points to the existence of large numbers of people who refused for as long as possible to follow the Party line. The same

⁵³³ Öpik (1999) p. 36.

fact is demonstrated even more graphically by the arrests and massive deportations of the 1940s and the 1950-51 purge of the Soviet Estonian political and cultural sectors⁵³⁴

The war and the occupations had dramatically changed the formal institutions of Estonia, while the physical infrastructure was seriously damaged. But despite these changes the oil shale industry recovered in a short period of time. This could be attributed to routines in the sense discussed by Richard Nelson and Sidney Winter. Routines are the mechanism behind continuity in organisations. Thus, without routines, every large organisation would soon encounter coordination problems of such a magnitude that it would most likely be dissolved by inner tensions. Routines are the organizational memory, organisations “remember by doing”.⁵³⁵ No written rules could ever match the importance of simply doing. All members of the organisation share a certain behavioural code – they know, for example, what is meant within the organisation by vague concepts such as “more”, “sufficiently”, “closer” etc. Thus in order for the organisation to be productive it is not enough that everybody understands the way it functions. Knowledge exists in numerous documents, but also in equipment, which, when kept in proper shape, enhances organisational knowledge, because employees get used to the equipment and develop a capacity to manage it. This continuity can be broken under unexpected circumstances. But it is still the shared experiences of the employees, the aggregate individual knowledge that is most important.⁵³⁶

Routines, then, could explain not only the survival of the oil shale industry but also the rapid reconstruction under circumstances that can hardly be described as anything but abnormal. Despite the destruction caused by the war, knowledge and routines were retained by the Estonian labour force. Probably this aspect was also understood by the Soviet leadership, causing it to pay attention to the Estonian oil shale industry for quickly finding energy suppliers to the war-torn areas of North-Western Russia. And perhaps to the surprise of the Soviet leaders, parts of the Estonian engineering community were rather responsive.

To sum up, the Estonian oil shale industry survived the devastation caused by WWII and could rapidly be rebuilt, albeit with another orientation, i.e. the production of household gas for the city of Leningrad. Here it is argued that this was made possible by the existence of

⁵³⁴ Rebas (2005).

⁵³⁵ Nelson & Winter (1982) p. 99.

⁵³⁶ Ibid. p. 105.

routines. Despite enormous population losses, there still remained enough skilled labor in place to guarantee the continuation of the oil shale industry.⁵³⁷ Can this be seen as evidence of path dependence? Evidently, Estonia had no other choice than to obey the orders from Moscow in producing household gas. But as has been speculated above, the initiative was perhaps of Estonian origin. It should be stressed that in Estonia it was known already before WWII that gas could be extracted from oil shale (actually oil and petroleum production is based on the technology of the gasification of oil shale), but no large-scale efforts were made to construct a pipeline network for the direct consumption of such gas. The profound change in the institutional arrangements had made production of household the best fit under the new circumstances. Consequently, if the oil shale industry was to have a future, for a while it seemed to be in household gas.

Especially the scientific community took a notable interest in developing the chemical strain of the industry. Despite the totalitarian system, a little space still remained for those scientists who were looking for various additional options to the production of household gas. Ideas in this direction could even be put forward in public. Therefore a tug-of-war can be sensed beneath the Soviet jargon – a claim further strengthened by evidence that within the Communist Party of Estonia a related power struggle took place. One strand of the oil shale community sought a new purpose for the oil shale industry in full compliance with the Soviet rule, while another strand tried, however tacitly, to develop an industry more inclined towards Estonian needs. As will be shown below, for a while this latter strand seemed to get the upper hand.

Beside the issues dealt with above, there is one particular aspect on path dependence that requires addressing, namely: would there have been a large-scale build-up of the gas industry had the oil shale industry and a certain amount of skilled labor not already been in place? The answer to this question can by necessity only be speculative, of course. First, without the industrialization and technological and scientific work carried out during the two decades of Estonian independence, there would not have existed detailed information on the characteristics of the kukersite oil shale; it would probably have remained a largely unknown substance. Had the Soviet power still decided to utilize oil shale, the learning process would have had to start more or less from zero. Second, despite the enormous destruction caused by

⁵³⁷ This claimed is, *inter alia*, based on the memoirs by Tomberg (2002, p. 22) and Õpik (1999, p. 37).

the war, the fundamentals of an industrial infrastructure were in place, such as mines and railways. Had these not existed, enormous investment would have been required. Recalling that the Soviet system often shunned new, risky enterprises it is questionable whether valuable resources would have been allocated to something as unknown as Estonian oil shale.⁵³⁸ As has been shown, the Soviet power encountered significant difficulties despite the existing knowledge and infrastructure.⁵³⁹ Had these been absent, the picture would probably have been entirely different. Thus, one can tentatively argue that the policy of reconstruction of the oil shale industry to meet Soviet needs was fundamentally based on the legacy of the industry in the Estonian republic before 1940. It was the institutional environment that had changed, which then harnessed existing technological structures for new purposes.

6.2. The Chemical Industry 1953-1965

As a consequence of increasing energy shortage in the Western parts of the Soviet Union, where most of the population and industry were located, the enormous energy resources in distant parts of the country were gradually harnessed. A network of supply lines was constructed (both pipelines and other means of transport) from western Siberia to the European parts of the country. The five-year-plan 1956 – 1960 called for a quadrupling of gas production in the Soviet Union. One of the main obstacles was the enormous amount of steel required for the pipeline network, while there were serious concerns that the steel industry would not be able to live up to its commitments. Until 1962 the pipes were imported, but as a result of an embargo by NATO countries, the Soviet Union had to start constructing them domestically, not without success.⁵⁴⁰

In the late 1950s a large-scale build-up of a pipeline network for natural gas was commenced in the Soviet Union, as a result of which the North-Western parts of the country could be supplied with gas from North Caucasus and the Ukraine.⁵⁴¹ With increasing availability, the price relation between natural gas and oil-shale gas was significantly altered. By 1958 the cost of household gas extracted from oil shale had become significantly higher than the price for

⁵³⁸ In his work on the economic history of the USSR, Alec Nove (1992: p. 297 ff) points out that reconstruction was rapid all over the Soviet Union (and not only in the Estonian oil shale industry). The point is, however, that this process was more or less reconstruction, not creating new industries or new technologies.

⁵³⁹ The reconstruction of the oil shale industry proved burdensome for the Soviet system. Production quotas were not met, discipline was poor, coordination between various sectors of the industry failed, labor was unavailable or absent. A litany of all the alleged shortcomings was published by Sazonov (1946).

⁵⁴⁰ Gerner & Lundgren (1978) pp. 33-4.

⁵⁴¹ Lyndolph & Shabad (1960).

natural gas and despite attempts at lowering the costs, estimates pointed towards a permanently higher cost, with a factor 2 as a minimum.⁵⁴² By 1960 the price for one tonne of mazut, Russian fuel oil, was 70-90 roubles, while the price for the corresponding amount of shale oil was 290 roubles. Similarly, the price for natural gas that year was 3-4 kopeks, while the price for oil shale gas reached 13 kopeks.⁵⁴³ Thus, there was little doubt that the oil shale industry had to transform itself in order to survive. The production of household gas came under the threat of becoming superfluous. By the end of the 1950s, domestic consumption in Estonia demanded only one-fifth of the total production at Kohtla-Järve.⁵⁴⁴ One possible path to achieve reasonable competitiveness was the transformation into a chemical industry complex, characterized by efficient utilization of all the components of oil shale. In addition to this, economies of scale could contribute to make this chemical complex competitive vis-à-vis raw materials (i.e. crude oil, natural gas) from other parts of the Soviet Union.⁵⁴⁵

These developments must be contrasted with the overall situation in the Soviet Union at this time. These were the years of the regime of Nikita Khrushchev, characterized by a political thaw, increasing personal safety of the individuals from the state, but also increased chaos in many spheres of the society. The historian on Soviet economy, Alec Nove, describes the economic planning in the Soviet Union under Khrushchev as a rather confused process, with only few clear directions. For instance, supply and production plans did not match, production and demand did not meet, labor and wages were not coordinated with the output plans. Quantitative targets effectively stopped any new design.⁵⁴⁶ In May 1958, the plenum of the central committee of the Soviet Communist Party had decided to enhance the growth of the chemical industry while reshaping the fuel balance of the entire union from coal towards oil

⁵⁴² Umblija (1961).

⁵⁴³ Kivit (1960). Prices in the Soviet Union were not set in the market, but were instead administratively regulated. This caused uncertainty as to what production was actually profitable. There were several methods for estimating prices, among which the perhaps most common for industries processing raw-materials were the so called "natural indicators", which were based on parameters such as weight, energy value, mineral content etc. The overall price policy in the early 1960s was expressed in the following way by the Communist Party of the Soviet Union: "*Prices must to an ever higher degree reflect socially required use of labor force, compensate for production and related activities and guarantee every normally functioning enterprise a certain profit*" (Rozenfeld (1964)).

⁵⁴⁴ Miil, Talts & Vaik (1960).

⁵⁴⁵ Umblija (1961). One might ask how much insight a chemist from Sweden, despite having an Estonian name, could possibly have about developments in the closed society of Soviet Estonia. First of all, Umblija refers to sources in both Estonian and Russian from within the Soviet Union. Second, Umblija's article triggered at least some response in Estonia, because among those documents Helle Martinson presented to me (October 2005), there was also a translation of this particular article into Estonian. A summary had been added, stating that Estonian oil shale could compete with other raw materials only if the entire oil shale industry turned into a broad industrial complex. In my opinion this shows that Umblija's reasoning was given serious consideration.

⁵⁴⁶ Nove (1992) p. 365.

and natural gas. A parallel development was the highlighting of the need for increased production of consumer goods. This attempt at diversifying the Soviet economy and to meet consumer demands put more pressure on the planning authorities, who now had to be involved with the production of all sorts of basic goods, such as frying pans. Starting in 1957, the Soviet Union was divided into so called *sovnarkhozy*, which basically were regional economic planning organs. In March 1959 the central Committee of the Communist Party of the Soviet Union reiterated its aim at enhancing the chemical industry. All companies were obliged to look over their production and use of equipment as well as their products.⁵⁴⁷ The new system was intended to allow for greater flexibility in planning and production. In Estonia, approximately 80 per cent of total industrial production was subordinated to the Estonian *sovnarkhoz*.⁵⁴⁸ This arrangement meant in reality that even if the operational management of a large part of the industry was now in Estonian hands, the overall control remained in Moscow.⁵⁴⁹

In 1965, these experiments with limited regional autonomy in economic matters came to an end. As a result, the companies found themselves in a situation without control from above (and neither from below).⁵⁵⁰ In the case of Estonia this led to a situation where the Estonian industry became split up between several all-Union organs. In brief, there was no longer any possibility for a comprehensive view on Estonian industrial policy. By 1984, Estonian industry was directed by a total of 19 all-Union departments and 23 local or mixed departments.⁵⁵¹ The power production was, nevertheless, throughout this period not subordinated to the Estonian *sovnarkhoz*, but to a structure comprised of the Baltic Republics plus Leningrad and Kaliningrad districts (*oblast*, in Russian)⁵⁵²

In his study of policy changes in the Soviet Union, the Swedish political scientist Daniel Tarschys points out that still in 1970 the Soviet Union lagged behind most of the world (including developing countries) in the production of plastics, despite significantly improved capacity to exploit oil and natural gas. In 1960, *Pravda*, the organ of the Central Committee of the Communist Party of the Soviet Union, called for more attention to the development of the

⁵⁴⁷ ERA R-1841-1-64. "O merakh po rekonstruktsii predpriyatii khimicheskoy promyshlennosti i osnashenyu ikh sovremennym oborudovaniem" Decision no 330 by the central Committee of the CPSU and the Council of Ministers of the SSSR. (in Russian). March 26, 1959.

⁵⁴⁸ Nove (1992) pp. 362-9.

⁵⁴⁹ Eesti Ajalugu VI p. 300.

⁵⁵⁰ Nove (1992) pp. 362-9.

⁵⁵¹ Eesti Ajalugu VI p. 317.

⁵⁵² Misiunas & Taagepera (1993/1983) pp. 187-8.

chemical industry. This attention continued for at least a decade and in 1970 *Pravda* called for increased production of industrial fertilizers. For some reason *Pravda* also repeatedly criticized the poor functioning of chemical laundries.⁵⁵³ *Pravda*, not being a traditional daily newspaper, but the organ of the rulers of the Soviet Union, played a crucial role in setting the agenda in the Soviet Union.⁵⁵⁴ Thus it is probably no coincidence that demands expressed in *Pravda* were also reflected in the discussion on the future of the Estonian oil shale industry. Instead of producing oil, the oil shale industry was supposed to become a chemical conglomerate, producing numerous chemical substances, including plastics, detergents and fertilizers. This viewpoint is also confirmed by the oil shale chemist Helle Martinson, according to whom the decision by the Communist Party congress in 1956 to develop the chemical industry also led to a major increase in funding for chemical research in Estonia.⁵⁵⁵

In 1956, the XX congress of the Communist Party of the Soviet Union called for the *complex utilization of raw materials*. By this phrase it was basically meant that waste from raw materials should be reduced and by-products increasingly made use of. In Estonia this was perceived as permission to develop new sectors of the oil shale industry, in particular the production of chemicals. Despite the occasionally panegyric Soviet tone, A. Kivit, director of the Department of Estonian Oil Shale and Chemical Industry probably still rendered the prevailing attitudes correctly when in 1960 he wrote:

“There is still a lot to do, and especially because our chemical industry has to embark on a road not trod before, to reach its goals in most branches with entirely new creation. On a global scale, the complex chemical use of oil shale first takes place here.”⁵⁵⁶

E. Ristmägi, secretary of the Estonian Communist Party, interpreted the new directives as a call for increased economic efficiency in the oil shale industry. This would be implemented by opening new open pits (instead of underground mines), increased utilization of oil shale ash in construction, automatization of production and the development of technology suited for the treatment of chemicals extracted from oil shale, such as phenols.⁵⁵⁷ This viewpoint was later backed up by an article by a certain J. Tubenslak, according to whom most

⁵⁵³ Tarschys pp. 121-2.

⁵⁵⁴ Tarschys pp. 64 -9.

⁵⁵⁵ Helle Martinson, personal communication October 11, 2005.

⁵⁵⁶ Kivit (1960).

⁵⁵⁷ Ristmägi (1956).

enterprises in the oil shale industry would be loss-making unless focus was shifted towards a more broad-based production of chemicals, especially phenols, which in turn would allow for the development of a particular chemical industry complex. However, at the time, there was no suitable technology for large-scale production of phenols, which would require more resources for developing the technology needed.⁵⁵⁸ A further opinion supporting that of Ristmägi was written by Agu Aarna, a leading scientist on oil shale chemistry, who suggested what he called an energy-technological approach, meaning that high calorific parts of oil shale should be processed in order to extract valuable products, while semi-coke and low calorific parts should be used as fuel for instance in power plants.⁵⁵⁹

In an article in the wake of the reiteration of the Communist Party of the Soviet Union in 1957 to develop the chemical industry, Aarna put forward a vision where several branches of Estonian industry cooperated in order to create a strong chemical industry. This would not be based on oil shale solely, but also phosphorite, wood, peat, dichtyonema oil shale (i.e. low calorific) and several mineral resources. The ultimate aim would be not to produce only semi-manufactured products, but to produce a great variety of goods for end-users. In order to reach such a goal, more resources should be directed to the scientific community to make it possible to exchange experiences within the Soviet Union.⁵⁶⁰

Derivates from oil shale, such as hydrocarbons, phenol, aromatic hydrocarbons or ketons could be extracted more favorably than from crude oil, according to Aarna. In 1958, preparatory work was conducted at Kohtla-Järve in order to gain knowledge and experience from using shale oil for a broad chemical production. The following products were supposed to be possible to produce from the above-mentioned chemicals: 1) from phenols and formaldehydes: construction material such as tiles, artificial parquet, plastics, lacquer 2) detergents and soap 3) from synthetic tanning substances: synthetic leather 4) bitumen of various sorts for construction industry, road cover, production of casting forms (for the metal industry) and roof lacquer 5) from aromatic hydrocarbons in the production of plastics: paint,

⁵⁵⁸ Tubenslak (1956). The article does not disclose any information on the writer, but the organ, *Eesti Kommunist* is unlikely to have published an article without a prior check on the conformity of the opinion expressed with the prevailing political trends.

⁵⁵⁹ Aarna (1956).

⁵⁶⁰ Aarna (1957). This article is basically the same as Aarna (1958) quoted below. The latter was published in Russian and therefore gained some attention outside the community of Estonians involved in oil shale chemistry.

synthetic fibers 6) antiseptics to impregnate the railway sleepers, construction materials 7) glue for the products of the wood industry (furniture etc.) 8) insecticides, pesticides.⁵⁶¹

Moreover, Aarna turned his attention to the need for more consumer-friendly products:

“It is particularly important to broaden the output of plastic fabricated goods. An important task in relation to this concerns artists and designers. It is impossible not to notice that plastic goods are offered for sale, which regarding their artistic design could be dated to the previous century. Our artists and designers have to learn the characteristics of plastics and provide the population with practical, beautiful and inexpensive goods.”⁵⁶²

Aarna also criticizes the production methods:

“The Tallinn lacquer and paint factory has an extensive experience of producing lacquer of high quality, but the production facilities of the firm do not allow for variation of the product selection”⁵⁶³

The Estonian chemical products were not wholeheartedly embraced by the consumers. In the early 1960s there were repeated newspaper articles on the poor quality or availability of Estonian chemical consumer goods. A certain choreography followed: newspapers would publish highly critical articles, the contents of which were then repudiated by the directorate of chemical industry in a remarkably aggressive tone, which caused the newspapers to back off in the particular case only to return to a similar topic a little later. Such disputes were numerous and indicate a widespread dissatisfaction with the situation with chemical consumer goods.⁵⁶⁴ It is worth stressing that despite there being no real competition on the consumer market, there was still a notion of quality among the Estonian consumers.⁵⁶⁵

⁵⁶¹ Aarna (1957) and Aarna (1958).

⁵⁶² Aarna (1958).

⁵⁶³ Ibid.

⁵⁶⁴ ERA R-1841-1-13, 18, 23, 29, 35.

⁵⁶⁵ Nove (1992), p. 366, notes that throughout the Soviet Union consumer goods were sometimes unsaleable because of poor quality or over-production. The reason for this was that the entire system was not created to react to consumer demands.



Glue based on oil shale. (Photograph by the author).

The process of transformation into a chemical complex is also addressed in an article by Boris Tyagunov⁵⁶⁶ of the company *Kiviõli* and one of the principal developers of the UTT process (see chapter 6.4.1.). These concerns about the future of oil shale had emerged as a result of the poor competitiveness of shale oil compared to crude oil and natural gas.

“However, the principal products of oil shale processing remain oil products – household gas, car petrol, oil. The costs [of these products] are high and at present they cannot compete with natural gas and crude oil. As a result, the oil shale refining industry can not develop on its old path – products used as fuel. In addition to this, also existing companies in the oil shale industry have to remake the profile of their activities, prepare to produce new products of high quality”⁵⁶⁷[words in brackets added]

The focus on production of chemicals constantly gained more momentum. In 1958, S. Epstein, vice director of the Department of the Oil Shale and Chemical Industry of Estonia pointed out that the development of the oil shale industry was hampered by two factors,

⁵⁶⁶ Tyagunov (1959).

⁵⁶⁷ Tyagunov (1959).

namely poor technological standards in the retorting factories and lack of modern equipment in oil shale mining. The best possible new technology, Epstein claims, would be the newly-developed UTT, which will be described later. This method would be crucial for any further efficiency gains.⁵⁶⁸

The concerns for the future of the oil shale industry as an energy producer only and the increasingly promising outlook for a broad chemical industry eventually materialized in the form of an oil shale specialists' conference in Tallinn in early 1959,⁵⁶⁹ ahead of the meeting of the Central Committee of the Communist Party of the Soviet Union (in June 1959), where guidelines on the development of the chemical industry were drawn up. The situation indicates an attempt to coordinate proposals and activities with the overall aim to rescue the Estonian oil shale industry and to push it in a new direction. Tyagunov finds support in a recent statement made by an expert commission of the economic and technological division of the all-union planning commission, Gosplan,⁵⁷⁰ according to which, chemical products derived from oil shale can be produced at costs equal to those applying to crude oil and natural gas. The conference in Tallinn was informed that this viewpoint had found support also at the council of the technological and economic division of Gosplan, which confirmed that a development of the chemical industry from oil shale was in line with requirements for economic efficiency.⁵⁷¹ One particular aspect dealt with at the conference was the need for an ammonium-producing factory in connection with the oil shale industry. Such an industry, important for the production of fertilizers, was missing in the North-Western parts of the Soviet Union.⁵⁷²

A previous decision by the Central Committee of the Communist Party of the Soviet Union in May 1958 to develop the chemical industry was perceived as a call to increase the value added in the oil shale industry. The process was not entirely smooth. Between 1955 and 1965 the production of shale oil increased by 65 per cent, while the production of impregnating oil increased more than eightfold. Meanwhile, production of fuel oil decreased to one third in the same period. This development was reasonable for the oil shale industry, because of the

⁵⁶⁸ Epstein (1958).

⁵⁶⁹ The conference was named "All-union scientific-technical conference on the utilization of oil shale and refined products for chemical synthesis". According to Tyagunov's information, most of the participants were Estonians or people in direct contact with the Estonian oil shale industry.

⁵⁷⁰ The full name of the organ in Russian is "Ekspertnaya komissiya Sovieta tekhniko-ekonomicheskoy ekspertizy Gosplana SSSR".

⁵⁷¹ Tyagunov (1959).

⁵⁷² Stepanov (1959).

higher value added in impregnating oil. This was also reflected in the (administratively managed) price mechanism, which had set the price for oil shale-based fuel oil at 290 roubles per tonne and the price for impregnating oil at 585 roubles per tonne. However, despite the rapid increase in production of impregnating oil, the bulk of oil (60 per cent in 1960) was still made up of fuel oil. Only in 1965 had the share of fuel oil dropped to 19 per cent. This relatively slow transition in output was attributed to friction caused by various administrative barriers. The production of gasoline for motor vehicles also faced a gradual decline in favor of synthetic compounds, which were then used in new chemical factories.⁵⁷³

There were, nevertheless, some concerns voiced against a large-scale development of a chemical industry. In 1958 the researchers L. Vaik and E. Landra at the Institute of Energy (at the Estonian Academy of Science) claimed that the chemists had so far failed to prove that chemical products extracted from oil shale would be of higher quality or cheaper than similar chemical substances obtained from elsewhere. The only thing that had been proven so far, Vaik and Landra claimed, was that a large number of various chemicals could be extracted, which in itself would not justify developing a large-scale industry. In addition to this, it was likely that electricity produced from oil shale at the *Balti* power plant (which was still under construction in 1958) would be cheaper than electricity produced from other sources, which in turn would make the position of the chemical branch even weaker.⁵⁷⁴

Also other critical voices were raised. High ranking Communist officials, such as Johannes Käbin and Valter Klausson, claimed that the mines were not prepared for a larger utilization of oil shale⁵⁷⁵, while in 1964, A. Kivit, director of the Estonian Department for Oil Shale and Chemical Industry informed that emissions of industrial exhaust gasses and particulates in the air, as well as industrial waste water could be reduced in the period 1964-1970.⁵⁷⁶ Moreover, the planned development of a large chemical complex would have to rely on imports of hydrochloric acid. Estonian producers of wood and phosphorite feared a limited supply in case a larger share of these imports were to be assigned to the chemical complex.⁵⁷⁷

⁵⁷³ Tarmisto ed. (1959) pp. 83 – 4.

⁵⁷⁴ Vaik & Landra (1958).

⁵⁷⁵ ERA R-1841-272 pp. 114-5.

⁵⁷⁶ ERA R-1841-1-248 pp. 91-4.

⁵⁷⁷ ERA R-1841-1-90 pp. 55-9

In 1962-63 an experimental device for the conversion of oil shale gas into ammonium was tried at Kohtla-Järve. The tests were conducted in cooperation between the Institute of Chemistry and the Oil Shale Institute. Encouraged by positive results, a factory was planned. The ideas were presented in public by chief engineer Nikolai Serebrjannikov and the chemist and chief engineer for the planned new factory Vladimir Sheloumov, but the idea was finally turned down by “Moscow”. Instead, the factory was supposed to produce nitrate fertilizers from natural gas according to well-tried methods. The construction works commenced in 1964, but the technology chosen for ammonium production was from the 1930’s and outdated. Serebrjannikov is supposed later to have claimed that the reason for this was that the Soviet Union simply did not have enough resources to provide all factories with appropriate equipment.⁵⁷⁸

6.2.1. Comments

There was long-lasting confusion about the direction of the oil shale industry because of the increasing competition from other energy sources in the Soviet Union. Transforming the oil shale industry into a chemical conglomerate would have corresponded with the official policy of the time, but evidence suggests that the initiative in this attempt at transforming the oil shale industry came from within Estonia and the oil shale industry, while official policy only more or less followed suit. Moreover, in the chapter on the Swedish oil shale industry, it will be shown that also in Sweden there were similar attempts at transforming the oil shale industry into a chemical industry. It thus seems that not only Soviet policy decided the direction, but that there were other objectives present as well. The success was, however, limited in both Estonia and Sweden. One crucial reason for this might be, as Helle Martinson has pointed out, that oil shale is a highly complex matter, which does not easily accommodate profitable research and development.⁵⁷⁹

After WWII the American chemical industry grew rapidly and produced increasingly important strategic products. As the Soviet Union tried to keep pace with the USA in any field that could have a strategic bearing, it is highly plausible that the group connected to the oil shale industry saw a niche here. The Americans were ahead, the Soviets lagging seriously

⁵⁷⁸ Rooks (2004) p. 64.

⁵⁷⁹ Helle Martinsson, personal communication, Tallinn, October 11, 2005. The slow progress in oil shale chemistry caused some concern already in the late 1950s, as was mentioned by Stepanov (1959).

behind and at this juncture the Estonians had a possibility to promote their own interests. Such thoughts can be sensed in the quotation below from the Estonian geographer V. Tarmisto:

“Regarding Soviet Estonia, its economic perspectives are tied first and foremost to the development of the oil shale industry./.../In a not so distant future, the Estonian oil shale basin together with the oil shale deposits in Leningrad oblast, will become the production base of fuel-energetics, chemical products and mineral construction materials for the whole of the North-Western Soviet Union”⁵⁸⁰

One conclusion to be drawn from the shift of focus of the oil shale industry is that it had become obvious that there was an urgent need to increase the value added in production in order to survive. This is in line with Ralph Landau’s and Nathan Rosenberg’s account, which attributes the following characteristics to the chemical industry: it is science-intensive, it gains from university-industry collaboration, it requires big markets, wars have a major impact on the direction of development, it requires economies of scale, and finally learning is crucial when developing new technologies. The existence of a large single market in the USA gave the American chemical industry an advantage over its European competitors in the decades after WWII. As a consequence of the war, the American chemical industry developed new products in the fields of aeronautics, electronics and a number of intermediate bulk chemicals. Moreover, the links with universities were lively and profoundly important.⁵⁸¹

It cannot be left without comment that most of these attributes would apply to the situation of the chemical industry in Estonia in the post-WWII period. First of all, Estonia was, however involuntarily, part of a large market (although the actual concept was not in use). Second, the contacts between research centres, universities and the industry were strong and the production met a demand created by a political system trying to keep pace with American development. Third, to some extent the cold war can be claimed to have been a war-like situation, especially in the Soviet Union.

The foundations allowing the Estonian oil shale industry to focus on chemistry had been laid in the years preceding WWII and in the immediate post-WWII period, when it represented a kind of alternative to the production of household gas with the ultimate hope of safeguarding a domestic Estonian knowledge-intensive branch of industry. By the mid-1950s it looked for a

⁵⁸⁰ Tarmisto (1957).

⁵⁸¹ Landau & Rosenberg (1992).

while as if this strategy had been successful, with the oil shale industry once again in tune with the prevailing institutional arrangements (including the international situation), as it had been in the 1920s and 1930s. Accumulated knowledge, both tacit and codified in combination with previously developed technology had made it possible for the chemical strain of the oil shale industry to survive the extreme institutional turbulence of the past years and even thrive.

6.3. Electricity 1965-1991

In the 1920s and 1930s, oil shale was not seriously considered as a major source for electricity generation in Estonia. Generating electricity from oil shale only took place on a smaller scale before WWII at Püssi in Ida-Virumaa and Kehra, not far from Tallinn. The bulk of electricity was generated from either peat or by hydro-power plants.⁵⁸²

Beginning in 1945, a number of small power production units were taken into use especially for providing industry with electricity, but these were more or less ad hoc arrangements. In 1949 the first oil shale-based generator with a capacity of 12 MW was taken into use at Kohtla-Järve (with a planned future capacity of 48 MW) while in 1951 the first generator with a capacity of 22.5 MW was started at nearby Ahtme (the planned future capacity was 75.5 MW)⁵⁸³ and a transmission line to Tallinn was constructed. In the late 1950s, the total number of power stations (of all sorts) neared 800, most of which were very small and producing electricity at a cost approximately 10 times higher than what would be the case in a big power station.⁵⁸⁴ The power stations at Kohtla-Järve and Ahtme were based on technology used for the pulverized firing of coal and brown coal, originally constructed by the American company *Relay-Stocer*, while the generators were developed by *General Electric*.⁵⁸⁵ Although some modifications of the equipment were carried out by the Russian *Lenproenergoprojekt*, substituting oil shale for coal turned out to be problematic because of the higher ash content of oil shale and ensuing corrosion. Repeated production stops and breakdowns caused the boilers to be used below capacity. Initially, most of the improvement of the equipment was

⁵⁸² Kala (1974) p. 30.

⁵⁸³ Kala (1974 p. 108) see also Paju (1991) p. 135 and Ots (2006) p. 17. Full production capacity was reached only towards the end of the 1950s (Kala (1974 p. 108).

⁵⁸⁴ Siitan (1958).

⁵⁸⁵ Paju (1991) p. 135. The existence of American machinery in post-WW II Soviet Union was most likely a consequence of the lend-lease agreement between the United States and the Soviet Union, which was ended only in August 1945. Within the framework of the lend-lease, the Soviet Union was provided not only with military equipment during the war, but also machinery, tools, metals, cable and wire etc., which contributed to maintaining industrial production. See Nove (1992) p. 281 & 295.

carried out by companies and structures outside Estonia. Gradually, however, it became clear that the complex structure of oil shale, both the mineral and the organic part, did not allow for the direct implementation of coal technology in the oil shale sector. This experience would give rise to the emergence of a particular oil shale combustion technology.⁵⁸⁶

Oil shale combustion is mostly conducted by pulverized firing, as is the case with most other solid fuels. The lessons learned from the first power stations was that medium pressure boilers had to be replaced by high pressure boilers if a large scale electricity generation was to be developed.⁵⁸⁷ In particular, the problem with ash had to find a solution before further oil shale-based electricity generation could be built. Ash wore on equipment and caused repeated breaks at the power plants.⁵⁸⁸

The Estonian historian Kulno Kala describes in his work on the history of the electrification of Estonia, published in 1974, how technological developments in the first oil shale-based power stations at Kohtla-Järve and Ahtme made it possible later to develop large-scale power plants. Such important improvements were, among others, automatization of the boilers, enhanced water supply, equipment to control the temperature of steam, and automatization of condensation of the turbines and pumps. This development not only paved the way for bigger production units, but also increased total productivity and reliability. As a result, production costs per unit dropped by 50 per cent between 1950 and 1959 and electricity generated at the first oil shale power plants became “several times” cheaper than electricity produced by industry or municipal plants.⁵⁸⁹ Despite the fact that Kala paints a suspiciously positive picture about the general developments (this was, after all, in 1974), his account of the technological developments sounds plausible. Technological improvement has never come fully operational from the outside, but instead it has to be adapted to local circumstances, while experience based on trial and error has to be gained. Such a process took place at the power stations of Kohtla-Järve and Ahtme, allowing bigger plants to be constructed later.⁵⁹⁰

At Tallinn Technological Institute (as it was called at the time) a team led by Ilmar Õpik had developed a system that allowed for heating 220 tonnes of water to 500°C in one hour. This

⁵⁸⁶ Ots (2006) pp. 17-9. See also Paju (1991) pp. 135- 7.

⁵⁸⁷ Ots (2006) p.19.

⁵⁸⁸ Kala (1974) p. 111.

⁵⁸⁹ Kala (1974) pp. 115- 123.

⁵⁹⁰ An interesting parallel with paper production today can be found in Laestadius (1998).

became the basis for the first big oil shale-powered electricity plant, *Balti*, with an initial effect of 100MW. This first unit was claimed to have become operational in the end of 1959.⁵⁹¹ In the coming decade and a half, seven similar aggregates were added plus four blocks of 200 MW each, which consisted of two boilers, each of which could heat 320 tonnes of water to 500°C in one hour. Total installed effect was thus 1624 MW, but actual effect had to be written down to 1390 MW.⁵⁹² The reason for this was that because there was no previous experience to draw upon in constructing such a large scale oil shale-heated boiler, a tug-of-war developed between the engineers at Tallinn Technical Institute and various all-union ministries responsible for the allocation of metals and other resources. Finally the oil shale engineers had to give in to demands to use less metal in the boilers, which in turn limited their capacity. Reductions of effect occurring already in the construction stage amounted to roughly 10 per cent of the total.⁵⁹³ Öpik recalls being very concerned that he, as the team leader in this project would, according to Soviet traditions, be blamed for the failures, but in the end the construction team were even awarded for their achievements.⁵⁹⁴ When the second oil shale power plant, *Eesti*, was constructed between 1964 and 1973, such conflicts over resources were avoided and the actual effect of the plant corresponded with the planned effect, 1610MW.⁵⁹⁵

The use of oil shale for large-scale electricity generation was decided upon in February 1956 by the congress of Communist Party of the Soviet Union and laid down in the five-year-plan 1956-1960. With the construction of the *Balti* power plant in the vicinity of Narva in North-Eastern Estonia, a united electricity system for the North-Western Soviet Union was created.⁵⁹⁶ At this time the Estonian capital Tallinn still suffered from poor availability of

⁵⁹¹ Öpik says that this official starting date is simply not true. Among the power engineers it was joked that power generation started on December 32, 1959, because due to various delays no generation had started before new year. But for some reason official communiqués insisted that power generation had started in 1959. Source: Öpik (2000) p. 72. For instance, in *Tehnika ja Tootmine* (12/1960), a monthly specialized in technology, it was claimed that power production started on December 9, 1959.

⁵⁹² Hamburg, Metusala & Tamkivi (2000) p. 109.

⁵⁹³ Öpik (2000) pp. 71-2.

⁵⁹⁴ In 1980 the leading constructor of the boilers, a certain engineer Reznik, lost his job and good standing after his son had emigrated to Israel. Source: Öpik (2000) p. 73.

⁵⁹⁵ Hamburg, Metusala & Tamkivi (2000) p. 109.

⁵⁹⁶ Toome & Öpik (1958).



The Balti power station today. (Photograph by the author).

electricity.⁵⁹⁷ A fact that strongly favored power plants based on oil shale were the calculations which estimated production costs of electricity as being significantly lower compared to costs when using either coal or peat. The costs when using oil shale were supposedly two-thirds of the costs for using coal and only half of the costs for peat.⁵⁹⁸

Between 1957 and 1971 some decision-making powers for electricity generation were transferred to local Estonian structures, but in 1971 Moscow took total control, leaving Estonia with basically no say in its own electricity generation.⁵⁹⁹ The fact that management of the Estonian power generation had been returned to Estonian hands for 14 years, at least partially, opened up a window for local officials in Estonia to turn their attention towards electricity generation.⁶⁰⁰ In 1959, the central committee of the Communist Party of the Estonian SSR, although officially sticking to the path laid down by the all-union Communist Party, declared that there were numerous obstacles to a large-scale development of the

⁵⁹⁷ Kaelas (1958) p. 61.

⁵⁹⁸ Ristimägi (1956). Despite the fact that these figures are presented by a high ranking Communist Party official, there is no obvious reason to doubt them.

⁵⁹⁹ Hamburg, Metusala & Tamkivi (2000) p. 108.

⁶⁰⁰ Misiunas & Taagepera (1993/1983) p. 187.

chemical industry. One crucial obstacle was the lack of scientific staff. Further advance along this path was therefore judged too difficult.⁶⁰¹

In 1965, the first heat-electricity power plant, *Balti*, became fully operational while the second plant, *Eesti*, was taken into use in 1973. The exile-Estonian Aleksander Kaelas describes this development as a measure to tie the Baltic energy system closer to the Russian one. This was certainly one aim, but at the same time his account notes a severe shortage of electricity in Tallinn in the late 1950s, which would point to the existence of significant domestic (Estonian) needs.⁶⁰² Already in 1960 transmission lines to Leningrad and Riga were constructed from the *Balti* power station.⁶⁰³

Between 1962 and 1988 approximately two thirds of the electricity generated in Estonia was consumed outside the country, while Estonian domestic consumption per capita remained below the average of the Soviet Union. This fact has been interpreted as an indicator as clear as any that the actual character of the build-up of the Estonian oil shale power system was to



Outside the Eesti power plant, this small wall informs (in Russian only) the power plant was constructed according to directives issued by the 13th and 14th congresses of the Communist Party of the Soviet Union. Not a single word in Estonian can be found here, which can be interpreted as proof of the character of the Soviet regime in Estonia (Photograph by the author).

⁶⁰¹ ERA R-1841-1-64 "O khode vypolneniya postanovleniya plenuma TsK kompartii Estonii ot 1 iulya 1958 goda".

⁶⁰² Kaelas (1958) p. 62.

⁶⁰³ Hamburg et al. (2000) p. 109.

allow for the exploitation of Estonian natural resources.⁶⁰⁴

But the generation of power and heat from oil shale was questioned already at that time. In 1962, the researchers Vaik and Landra at the Institute of Energy Technology counted with the possibility that nuclear power would increase dramatically, thus leaving oil shale and other natural resources to be exploited by future generations.

“The fuels would last for longer if today’s energy industry did not use them in such a wasteful way. From primary energy resources we can make use of only less than a quarter – the rest is lost. Future generations might blame us for wastefulness, but at present we are unable to do otherwise”⁶⁰⁵

Vaik and Landra put their hopes to increased energy efficiency both in production and consumption. Even among other scientists and technicians it was argued that oil shale would be better used as a raw material for the chemical industry instead, replacing mainly crude oil. On the other hand, also this option was complicated by the fact that crude oil was still cheaper,⁶⁰⁶ although shale oil has been claimed to have some properties which make it superior to crude oil in some branches of chemical industry.⁶⁰⁷

After the completion of the *Eesti* power plant in 1973, the growth of the oil shale sector came to a virtual standstill, mainly because of developments in nuclear energy elsewhere in the Soviet Union.⁶⁰⁸ This development was anticipated already in 1974 by the power engineer Ilmar Õpik, who assumed that the role of the Estonian power plants was to become that of

⁶⁰⁴ Ibid.

⁶⁰⁵ Vaik & Landra (1962).

⁶⁰⁶ How important the question of price actually was remains to be answered. To what extent was there an overall understanding of real prices in the administrative apparatus? Obviously this discussion took place mainly within the community of oil shale professionals in Estonia, who might have held a quite realistic view on the role of prices and costs. The reason for this assumption originates from Misiunas & Taagepera (1993/1983), who claim that Estonia in the 1960s and 70s together with Latvia was a sort of an economic laboratory for the Soviet Union, and for instance after 1969 the planning of the Estonian economy was to an increasing extent based on econometric models (!) A similar statement is provided by the exile-Estonian Rein Tünn (1978): “*In the area of experimental adoption of computerized methods to economic management, Estonia is one of the leading Soviet republics. .../Increasingly, ministries of the Soviet Union are turning to Estonia and the other two Baltic republics for relatively small-scale implementation of computer applications that will eventually be expanded to embrace the whole country. In this respect, the Baltic republics of the Soviet Union are becoming laboratories for the development of national economic-management systems*” (p. 402). Evidence for this can be found in A. Gelb’s proposal in the Communist monthly *Eesti Kommunist* (nr. 2, 1963) to turn to cybernetics in the entire production process in the oil shale industry.

⁶⁰⁷ Järvesoo (1978) p. 165.

⁶⁰⁸ Ibid.

“maneuvering power”, i.e. they would mitigate peak loads.⁶⁰⁹ In 1981 the nuclear power plant at Sosnovyj Bor (in Russia, between Estonia and St. Petersburg) was taken into use, and as a consequence of this, the plans for a third oil shale-fuelled power plant in Estonia were never realized. Instead, oil shale excavation was cut back upon. In 1980 a total of 31 million tonnes of oil shale was excavated, in 1985 26 million tonnes and in 1990 22 million tonnes. This trend was above all a result of decreasing demand for oil shale for energy production, while the demand for oil shale for oil production or in the cement industry remained relatively stable.⁶¹⁰ An estimated 50 - 60 per cent of electricity generated in the 1980s was used outside Estonia in the North-Western parts of the Soviet Union.⁶¹¹ By the mid 1970s, the Estonian power plants supplied some 20 per cent of electricity in Russia’s North-West.⁶¹²

Table 6.1. Production and consumption of electricity in Estonia 1950-1985.

Year	Electricity Production (million kWh)	Electricity Consumption (million kWh)	Domestic Consumption (per cent of production)
1950	435	435	100
1955	941	950	101
1960	1,950	1,513	78
1965	7,104	3,025	43
1968	9,191	3,727	41
1970	11,574	4,624	40
1980	18,898	8,195	43
1985	17,827	9,424	53

Sources: *Eesti NSV rahvamajandus. Statistiline kogumik 1957, Eesti NSV rahvamajandus 1968 aastal, Eesti NSV rahvamajandus. Statistika aastaraamat 1985. Own calculations.*

From table 6.1., it can be concluded that most electricity produced from Estonian oil shale was consumed outside Estonia. Statistics from the Soviet period define the difference as “electrical energy released outside the republic”.⁶¹³ But starting in the 1980s, the share

⁶⁰⁹ Öpik (1974).

⁶¹⁰ Kattai (2003a) p. 60.

⁶¹¹ Tenno & Laur (2003).

⁶¹² Tenno (1978) p. 34.

⁶¹³ The term in Russian is: “otpushseno elektroenergii za predely respublikii” while the Estonian wording is: “antud elektrienergiat väljapoole vabariigi”. Especially the Estonian wording hints at electricity given away. Source: *Statistika aastaraamat 1985*. It should be added that there was also some exchange of electrical power between Estonia and other parts of the Soviet Union, i.e. Estonia also received some electricity, but significantly

consumed in Estonia started rising again, which undoubtedly was a consequence of the arrival of Soviet nuclear power plants. Gradually, electricity generated from oil shale was about to lose its role within the institutional framework comprised of the Soviet Union.

Towards the end of the 1960s, the lion's share of oil shale was used for electricity generation, while the chemical and processing industry was clearly left behind. The figures in table 6.2. below stem from 1965 and hence the figures for 1970, 1975 and 1980 are planned amounts. The decision behind this development was made by A. Kivit, chairman of the Bureau for the Oil Shale and Chemical Industry of the Estonian Sovnarkhoz.⁶¹⁴ Despite the calls for a massive development of the chemical industry, the counterarguments prevailed in the end in favor of electricity generation.

Table 6.2. Total production of oil shale and its use for electricity production and processing.

	1963	1965	1970	1975	1980
Total production of oil shale	12,842	15,790	23,000	28,000	32,000
For electricity generation	6,260	9,090	15,700	20,400	23,900
<i>% for electricity</i>	48.7	57.6	68.3	72.9	74.7
For processing	4,780	5,030	5,700	6,000	6,500

Source: ERA R-1841-1-271 p. 131, own calculations.⁶¹⁵

To sum up, the construction of large-scale power generation based on oil shale was to a large degree not compatible with the plans to develop the chemical branch of the oil shale industry. Basically all of the increase in output from the early 1960s onwards went to electricity generation, while other sectors stagnated, at least in terms of size. This development could be

less than the amount transferred away. But before 1960, Estonia was a receiver of electricity. Hein (ed.) (1991) p. 31.

⁶¹⁴ The title in Russian is: "Nachalnik upravleniya slantsevoy i khimicheskoy promyshlennosti SNKh ESSR", ERA R-1841-1-272 p. 131.

⁶¹⁵ Differences in total amounts and sums of individual figures stem from losses but also from the fact that other industries used some oil shale.

interpreted as an indication that Soviet-style large-scale industrial production had prevailed over the attempts at focusing on a more technologically and scientifically sophisticated chemical industry. However, as will be shown later on in this work, precisely this development turned out to be of significant importance for Estonia, when the Soviet institutional framework crumbled and Estonia regained its independence.

6.3.1. Research in later Soviet times

The expansion of both the chemical and the electricity generating industries was followed by a parallel build-up of scientific institutions, the most important of which was the Tallinn Polytechnical Institute, where several departments were mainly working with oil shale-related topics, such as the laboratory for oil shale chemistry and technology (led by Agu Aarna, who has been quoted elsewhere in this work), the department of chemical technology, the department of thermal energy and the department of geology and mining. Towards the end of the 1950s, oil shale-related research was favored over other areas of technology.⁶¹⁶ A case in point is a rare overview in English of science in Estonia published in 1965, which emphasizes oil shale-related science in several fields, not only those directly connected with the oil shale industry. For instance, it describes how a lot of R&D efforts are directed towards developing new construction materials, which will supposedly replace so-called Portland cement. Or, similarly, how chromatography is applied in order to determine the chemical composition of oil shale.⁶¹⁷ This development was also observed by the exile-Estonian Heino Susi, according to whom activities related to oil shale kept a considerable part of the Estonian technological and scientific community going. Therefore, for instance, the department of chemistry of the Estonian Academy of Sciences directed most of its funding to oil shale-related projects. As a consequence Estonian scientists gained a solid reputation within this particular field both within the Soviet Union as well as internationally.⁶¹⁸

Throughout the latter half of the 20th century, Estonia produced a significant pool of experts in the oil shale industry, and for instance since 1984, a scientific periodical “Oil Shale” has been published by the Estonian Academy of Sciences.⁶¹⁹ Especially oil shale chemistry became the

⁶¹⁶ Lepikson (1958).

⁶¹⁷ Kahk (1965).

⁶¹⁸ Susi (1978) p. 372.

⁶¹⁹ *Oil Shale* is probably the only periodical in the world entirely specialized in various aspects of oil shale. It was initially overwhelmingly in Russian, but beginning in the early 1990s, English has become dominant. In the

“Estonian National Science”.⁶²⁰ Today there are fears that the achievements will be lost, as most scientists belong to the older generation and little replacement is taking place.⁶²¹

In 1958, a special oil shale institute was founded at Kohtla-Järve in the oil shale district. Some tensions immediately occurred within the oil shale scientific community, because already in 1959, the secretary of the Communist Party at Kohtla-Järve, I. Belyayev, complained that the institute was overlooked from the beginning by the Estonian Academy of Sciences, which allegedly did not take responsibility for providing the institute with adequate scientific staff.⁶²² These tensions might well have been a consequence of the fact that during the Soviet period the oil shale institute was not subordinated to the research administration of Estonia, but to all-Soviet structures. In one sense such a development was far from surprising. As has been discussed before, starting in 1957, the local Estonian authorities gained increased influence on the economy, which resulted in a competition with Moscow over which particular institutions would be controlled by whom. The oil shale institute was therefore probably perceived as an attempt at draining the Estonian scientific institutions of qualified staff. However, this development should probably be seen in conjunction with the fact that also the entire oil shale industry – because it was perceived as “heavy industry” – operated under closer scrutiny of the central authorities in Moscow than other sectors of the Estonian economy at the time.⁶²³

Today the Oil Shale Institute is a department under the auspices of Tallinn Technological University. It has only recently started to educate students in oil shale-related topics systematically.⁶²⁴ On the other hand, this field has had some difficulties in attracting young researchers as the salary level is perceived as low.⁶²⁵ One could argue that it is hardly surprising that young Estonians turn their back to this branch of industry, which is perceived as outmoded and “Russian” (see chapter 8.6. on attitudes toward the oil shale industry).

post-WWII years there was a periodical named “Goryuchii slanets” (i.e. oil shale in Russian) published by the Estonian Academy of Science (Source: Kattai 2003, p. 52).

⁶²⁰ This expression was used by Helvi Uibopuu of the Estonian Academy of Sciences, personal communication October 11, 2005.

⁶²¹ Koidu Tenno, personal communication April 6, 2005.

⁶²² See Beljajev in *Eesti Kommunist* Nr. 10/1959 p. 71.

⁶²³ Susi (1978).

⁶²⁴ Jüri Soone, director of the Oil Shale Institute, personal communication, April 7, 2005.

⁶²⁵ Prof. Arvo Ots, Tallinn Technological University, personal communication April 8, 2005.

But a tug-of-war took place not only between Estonian authorities and Moscow, but also between political institutions, the scientific community and industry. The Estonian oil shale chemist Helle Martinson argues that R&D in the Soviet Union was often directed by the various departments and usually this research produced results in accordance with political priorities rather than the actual needs of the industry.

“In the countries of command economy, industrial enterprises are risk-averse, they are only interested in some rationalization, in development that does not include fundamental changes. Furthermore, the Soviet industrial policy as a whole did not favor risk taking. The government policy of protectionism, helping out unsuccessful enterprises and keeping them afloat regardless of their efficiency suppressed any personal initiative”⁶²⁶

On the other hand, there was a continuous process of concentrating all research in the hands of central authorities in Moscow. Every branch of research was subordinated to a central institution. One striking outcome of this highly centralized and hierarchical system was that very few people, if any, had an overall picture of what research was actually carried out. Towards the end of the Soviet rule in Estonia, there were up to 10,000 active researchers in Estonia. Less than half of them remain. On the other hand, such figures are also misleading. At the Oil Shale Institute an estimated 50% of the researchers employed in the mid-1970s were not at all engaged in oil shale research, but with such distant activities as for instance bakery (!). Numerous persons were simply provided jobs at the institute for reasons that had nothing to do with scientific activity.⁶²⁷

Another aspect of this issue is that students of chemistry were given higher grants – at least during some periods in the USSR. This increased the popularity of the subject. The standard of the education was good, *better than in the West*. During the bid for chemical industry, some of the educated chemists needed were basically brought in from Russia. Today there is a serious shortage of oil shale chemists, especially young ones, who could lead the development of a shale oil-producing company such as *VKG (Viru Keemia Grupp)*.⁶²⁸

⁶²⁶ Martinson (1992) p. 28.

⁶²⁷ Helle Martinson, personal communication, October 11, 2005.

⁶²⁸ Ivar Rooks, personal communication, October 13, 2005.

Research was ultimately led by the USSR Ministry for Petro-Chemical Engineering. Adding to the rigid structures was the ever-present surveillance by the authorities, or in Helle Martinson's words:

“The first department at every institution was de facto the KGB. Thus there were no possibilities to communicate openly. Only what we used to call “kitchen discussions” were possible.”⁶²⁹

Moreover, there was a tacit attempt at Russification of the oil shale research. People holding senior research positions were increasingly brought in from Russia.⁶³⁰ As a kind of reaction against this development,⁶³¹ the Estonian oil shale community succeeded in organizing an international symposium on oil shale in Tallinn in August 1968 under the auspices of the UN and with participants from 29 countries.⁶³² This was widely considered a major achievement not only among Estonian oil shale professionals, but also the general public. The perhaps most long-lasting result of this symposium was that Estonian researchers managed to get in touch with their colleagues outside the Soviet Union, which enhanced their self esteem.⁶³³ The symposium was named “The First Symposium on Oil Shale” (the second one was held 34 years later, in Tallinn 2002). The aim of the organizers was to promote the interests of Estonia in a discreet way. Thus there were cultural events and excursions included in the program, which to a large extent served as a possibility to get in contact with foreign researchers.⁶³⁴

Soviet policies tried to enforce a particular notion of “Soviet science”, which basically meant discouraging scientists from developing contacts abroad.⁶³⁵ A typical feature of this policy

⁶²⁹ Helle Martinson related that when working at a chemical laboratory in Moscow around 1970, she had to report daily to the authorities about whom she had met. This official paranoia went to such extremes that when foreign delegations visited the laboratory, she was not allowed to meet anyone, *because* she was fluent in English. The authorities feared improvised communication they could not supervise. Personal communication, October 11, 2005.

⁶³⁰ It is reasonable to assume that these scientists from Russia were attracted by the generally more open atmosphere in Estonia in the first place, and therefore did not perceive themselves as being pawns in the rulers' games.

⁶³¹ Helle Martinson, personal communication, October 11, 2005

⁶³² Kattai (2003a).

⁶³³ Misiunas & Taagepera (1993/1983) p. 239.

⁶³⁴ Helle Martinson & Helvi Uibopuu, personal communication October 11, 2005.

⁶³⁵ An elucidating example of Soviet attempts at presenting technological developments as originating in the Soviet Union can be found in the technical monthly “Tehnika ja Tootmine”, 11/1958. In an article by Heil and Brodskaya, underground gasification of oil shale is claimed to have been a Soviet invention. According to the article, such processing started at Tula (Russia) in 1942. Following the Soviet Union, the article continues, also other countries started using this technology, including Sweden in 1940. It is not mentioned how Sweden managed to emulate Soviet technology a couple of years *before* it was taken into use in the Soviet Union. The

was that Russian was promoted as the *lingua franca* within the science community, thus creating an *invisible barrier limiting the intellectual exchange between the Soviet and East European scientists with colleagues in Western Europe and other continents*⁶³⁶. This process of “sovietization” of the scientific life in Estonia was lengthy and was not finished until the mid-1980s, when the Estonian research institutions lost whatever autonomy they had left, while at the same time any contact between Estonian and Western science was made increasingly difficult.⁶³⁷ One striking feature of this was that no researcher was allowed to publish any results in foreign periodicals, unless they had previously been published in the Soviet Union. This process could take up to three years. One way to circumvent this hurdle was to publish abstracts in international periodicals. Traveling abroad was perhaps even more complicated. Those who were allowed to do so were carefully chosen (often on other grounds than actual merits) and in the end they lacked the financial resources to achieve much. Thus there was no serious attempt at any significant transfer of technology. Occasionally equipment bought abroad was rendered as obsolete, because those who were supposed to operate it were not allowed to go abroad to learn. In the end, technology transfer to the Soviet Union was to a large extent more or less illegal copying.⁶³⁸

But even in the years preceding the oil shale symposium, the Estonian scientific community in oil shale-related sectors showed significant interest in international developments. When molecular spectroscopy and gas chromatography for analyzing organic materials such as kerogen (i.e., the organic matter in oil shale) were developed in the West around 1950, scientists at the Estonian Institute of Chemistry quickly adopted this new technique, much faster than anybody else in the Soviet Union. Further development of gas chromatography took place in Estonia in the 1950s, which despite not being internationally unique, was of significant importance in the Soviet Union. Also this development was closely related to oil shale, because this project was initiated by the need to analyze the more than 500 components of kerogen. It was claimed that the improvements carried out in Estonia reduced the time needed for an analysis from three years to twenty-four hours.⁶³⁹ In Helle Martinson’s words:

technology in question is, by the way, the so-called Ljungström-field, which by and large was a Swedish invention (see chapter 9.4.).

⁶³⁶ Dageyte, Kristapsons & Martinson (2000) p. 138.

⁶³⁷ Martinson (1992).

⁶³⁸ Helle Martinson, personal communication, October 11, 2005.

⁶³⁹ Susi (1978) pp. 373 – 4.

*We did it with our own hands.*⁶⁴⁰ However from the 1960s onwards, such occasions became increasingly rare.

6.3.2. Comments

Electricity generation, which in the pre-WWII period had been a minor, almost experimental technology within the oil shale industry, became the dominant branch in the 1960s. The reasons for this development were basically to be found outside Estonia, namely the shortage of electricity in the North-Western Soviet Union before the large-scale build-up of nuclear capacity. For many Estonians, both then and now, the sheer size of the power plants is evidence enough of the colonial character of the Soviet rule. But Soviet power neither invented oil shale-based electricity generation, nor did it decide details.⁶⁴¹ However the perspective was a Soviet one, not Estonian. The mere fact that more than half of the electricity generated was consumed outside Estonia speaks for itself, especially against the background that there is no mention in the sources about compensation. In addition to this, electrical power production was never entirely handed over to the Estonian authorities, but instead in the latter half of the 1960s, Estonia lost basically all influence on its power production.

The fact that Estonia was occupied and the fact that there is little evidence of any significant compensation paid for the utilization of Estonian resources support the viewpoint that Soviet policy was a typical example of colonialism, but it can not be overlooked that several Estonian engineers, scientists and officials participated in this process. From the Soviet point of view, oil shale should in the first place have been used as raw material for energy production for the entire North-Western region of the Soviet Union, but several Estonian (including many Russian-speaking) scientists and engineers preferred putting an emphasis on increased value-added production with a strong connection to science. This also meant a broader product range. It would not be jumping to a conclusion to argue that this latter option served Estonian needs at the time much better than the former. The question whether the Soviet authorities actually understood this political undertone has probably no unambiguous answer. In a formal sense, the Estonian drive for developing a chemical complex was fully in

⁶⁴⁰ Helle Martinson, personal communication, October 11, 2005.

⁶⁴¹ For example, in a newspaper article from 1964, signed by Õpik and Toomaspoeg, the energy imbalance in the North-Western Soviet Union is recognized as the basis for the construction of the *Balti* power plant. They also discuss the possibility of constructing power plants which would utilize the enormous resource of low calorific dictyonema oil shale, instead of valuable kukersit oil shale. If such plans had been realized, the Estonian power generation industry would most likely have become even bigger. *Rahva Hääli*, 5.8.1964.

line with the Soviet policy, but the Soviet reality was oftentimes not on a par with officially-stated goals. This was certainly well understood by certain strata of the Soviet leadership and therefore it is justified to investigate the tensions behind the scenes regarding the development of the oil shale industry. In the end, these at least sometimes conflicting goals led to increased diversity of the oil shale industry.

The fact remains, however, that in occupied Estonia, a large power generation industry was created outside Estonian control, except for the period between 1957 and 1971 - and even then Estonian influence was restricted. Therefore, the present-day Estonian claims that the development of the oil shale industry was the result of colonial rule do not lack justification. There is no scope for an analysis of theories on imperialism in this work, but there is good reason to remain skeptical to some of the simplified statements in present-day Estonia about the colonial character of the Soviet regime in this respect.⁶⁴² The leadership of the Soviet Union undoubtedly pursued a policy that can hardly be called anything but imperialistic, but it did not necessarily dictate the details for the actual measures; those were left to the people in the field, who could be won over to act in the overall interest of the system without forcing them to make too big compromises with their convictions. It is highly unlikely that Estonian engineers would have had any wish to support the Russification of Estonia, but as professionals in the energy sector, they could still act indirectly for such a purpose. Even within the Estonian oil shale community opinions diverged. The turn to electricity generation was met with support and perhaps even enthusiasm in some circles. In a newspaper article published in 1958, Ilmar Öpik concludes that the staff of the energy research laboratories is predominantly young and therefore in need of more cooperation with other scientific institutions and industry in the Soviet Union. Moreover, the achievements made by the energy engineers at Tallinn Polytechnical Institute could in Öpik's opinion be of greater magnitude if the Institute directed more resources to energy and electro technological research laboratories.⁶⁴³

Similar situations have gained a lot of attention in the by now vast literature on the conditions in the former socialist countries. In this context it suffices to refer to Vladimir Tismaneanu, a scholar on Eastern European societies and their past:

⁶⁴² An overview (in Swedish) of theories on imperialism can be found in Magnusson (2002).

⁶⁴³ *Rahva Hää*l 8.7.1958.

“The vast majority of the people who lived under communism were participants in the systemic self-reproduction: some were active supporters of the status quo. Others were just “cogs in the wheel”, adjusting themselves to the existing constraints and trying to secure for themselves and their families minimal form of decent survival. This is not to say that everybody was equally responsible for the system’s actions. Some people were traitors, others were betrayed.”⁶⁴⁴

Addressing such topics is important (in all post-socialist societies), Tismaneanu continues, because:

“To ask for a serious coming to grips with the past is not simply a moral imperative: none of these societies can become truly liberal if the old mythologies of self-pity and self-idealization continue to monopolize the public discourse/.../ The return to normalcy, or the building of liberal polities, means the courage to face abdications, betrayals, and self-delusions that turned so many individuals into accomplices of an evil system.”⁶⁴⁵

6.4. Innovation and debate in Soviet Estonia – the case of the UTT

6.4.1. The development of the UTT

One of the most important technological developments in the oil shale industry during the Soviet period was the introduction of the UTT-process,⁶⁴⁶ which was perceived to be the technology needed for a versatile production, i.e. allowing for a broad-based chemical industry. This technology also became the focal point of surprisingly overt controversies, especially in the 1960s. A long-lasting problem had been that small fine grained oil shale (with a diameter less than 25 mm) was actually wasted in the processing of oil shale. Until the introduction of the UTT process, fine grained oil shale was often left in the mines and quarries, thus reducing the overall efficiency of the entire industry. With the UTT process this fine grained oil shale could be processed efficiently. In addition to this, the UTT made it

⁶⁴⁴ Tismaneanu (1998) pp.114-5.

⁶⁴⁵ Ibid. p. 116.

⁶⁴⁶ The acronym UTT is derived from Russian “ustanovka s tvjordym teplonositelem” which translates as “construction with a solid heat carrier”. The Russian acronym is the most common and will therefore be exclusively used in this text. Occasionally English or Estonian acronyms can be seen in various articles. These acronyms are: SHC (solid heat carrier) or TSK (tahke soojuskandjaga seadme).

possible to reuse hot oil shale ash as fuel (heat carrier) instead of exhaust gases or shale oil (i.e. the end product). Thus the UTT increased productivity by allowing for the full utilization of all oil the shale and by recycling ash which still contained enough organic material to burn. Therefore, in order to reduce overall production costs, the UTT was perceived as crucial were the Estonian oil shale industry to become something more than an uncompetitive provider of gas and oil.

The UTT would still produce gas, but in a manner allowing for the extraction of a greater variety of chemicals at a lower cost.⁶⁴⁷ The main methods for processing oil shale used before the UTT were rotating retorts,⁶⁴⁸ tunnel ovens, chamber ovens and generators. The rotating retorts were taken out of use in 1961 due to their low productivity. The tunnel ovens survived longer, because they had the advantage of producing shale oil of high quality,⁶⁴⁹ but were finally shut down in 1975.⁶⁵⁰ The chamber ovens were specifically designed for the production of household gas.⁶⁵¹ The generators were the technology allowing for the highest productivity, but the energy content of the gas extracted was rather low and correspondingly the oil yield was small and it could be used as heating oil only. On the other hand, the construction of generators was quite simple, which allowed for long uninterrupted use, which had a positive impact on overall productivity.⁶⁵² This technology mix had allowed for certain flexibility in oil shale processing, but it became increasingly clear that new technology and new methods had to be introduced in order to make the oil shale processing industry economical (if not profitable). The generators, the rotating retorts and the tunnel ovens were constructions originating from the 1920s or even further back in time. The chamber ovens, despite producing a novelty – household gas from oil shale – were also constructed on the basis older technology. The UTT, on the other hand, was technology taken a step further – in other words, an innovation.

The UTT is based on what is known as the Galoter-process, which goes back to 1944 and the *G.M. Krzhizhanovski Power Engineering Institute* at the Soviet Academy of Sciences (abbreviated ENIN, nowadays *ENIN Ltd.*), when I. Galinker (after whom the process was

⁶⁴⁷ Kivit (1960).

⁶⁴⁸ These so-called Davidson horizontal rotary retorts were at use in Kohtla-Nõmme only.

⁶⁴⁹ Iirak (1962).

⁶⁵⁰ Yefimov, Rooks & Rootalu (1994). The tunnel ovens at Silamäe were shut down already in connection with WWII, while those at Kohtla-Järve were in use until 1968. At Kiviõli the last tunnel oven was closed in 1975.

⁶⁵¹ The last chamber oven was closed down in 1987 (Yefimov, Rooks & Rootalu).

⁶⁵² Iirak (1962).

named by combining with the word “thermal”⁶⁵³) developed methods for semi-coking brown coal, peat and oil shale by using a solid heat carrier. Later Galinker described the method how to use oil shale ash as the solid heat carrier.⁶⁵⁴

This method was tested at a pilot unit in Tallinn, built in 1947 by B. Tyagunov, D. Voronina and E. Grigoryeva. The pilot unit processed 2.5 tonnes of oil shale daily and was located in connection with the *Ilmarine* engineering plant, but under the auspices of ENIN. The responsibility for the development work was shifted to the Kiviõli oil shale plant in 1953 in order to put a much bigger unit into operation. The result was the UTT-200 (the number refers to the amount in tonnes that can be processed daily).⁶⁵⁵ Thus, relatively soon after WWII, the development of the UTT became closely connected with Estonia. However, the original concept had to be modified when it turned out that dust got mixed with shale oil in the process.⁶⁵⁶ In 1963 the UTT-500 was constructed, while the UTT-200 was shut down. The UTT-500 was in use until 1981.⁶⁵⁷

Calls for speeding up development on the UTT came from the political sphere as well. In 1958, S. Epstein, deputy director of the Estonian Department of Oil Shale and Chemical Industry, characterized the UTT as the key to a successful chemical industry and assumed that the reason for the hitherto slow progress was a result of insufficient coordination between research groups and called for a concentration of Estonian scientific endeavours in order to solve the remaining problems with the UTT.⁶⁵⁸

The retorting (that is, decomposing oil shale by heat) takes place through the introduction of a solid heat carrier. A short, precise description of how this works is provided by Tomberg:

“The oil shale to be retorted is led into the reactor, where the heat carrier is added – hot ash. Oil shale turns into semi coke from heat stemming from the heat carrier (hot ash). The retorting products – gases and steam – are separated and the semi coke together with the

⁶⁵³ Rooks p. 114.

⁶⁵⁴ Volkhov & Stelmakh (1999). In the sources I have used for this work, there is no evidence of the UTT being developed anywhere else than in the Soviet Union. However, because there was a strong tendency in the Soviet Union to ascribe innovations exclusively to Soviet (or Russian) origins, there is a possibility that the version presented here fails to identify any non-Soviet contribution.

⁶⁵⁵ Rooks (2004) p. 70.

⁶⁵⁶ Aarna (1956).

⁶⁵⁷ Yefimov, Rooks & Rootalu (1994).

⁶⁵⁸ Epstein (1958).

used heat carrier are led into ovens, where they are burnt. The combustion gases are separated and the heat from the combustion increases the temperature of the ash. Hot ash is led into the reactor and is blended with oil shale etc. Excess ash is removed from the process⁶⁵⁹

The development of the UTT technology was to a large extent a result of incremental learning at Kiviõli and Narva. The large metallic structures of the devices were produced in Russia, while the rest was developed in Estonia. Finally, between 1976 and 1980 the UTT-3000 was developed.⁶⁶⁰ During a first, start-up phase at the Narva factory, which lasted from 1980 to 1986, significant improvement in the efficiency was reached. The amount of processed oil shale increased from 4 thousand tonnes in 1980 and 16 thousand tonnes in 1981 to 128 thousand tonnes in 1986. The oil yield increased from 8.8 per cent in 1981 to 11.9 per cent in 1986. In 2001 the corresponding figure was 11.0 per cent, but at this time also gas was extracted, which should be added to the overall efficiency. The second phase, starting in 1987, was a process of incremental improvement of the technology. Between 1986 and 1992 an estimated 50 per cent of the equipment used was actually reconstructed on-site on a learning-by-doing basis. Meanwhile, operating time of the UTT-3000 had increased significantly from 61 hours in 1981 and 130 hours in 1981 to 2,982 hours in 1992 and 6,177 hours in 2001. The incremental improvement of the technology resulted in more environmentally friendly production processes, economic efficiency, increased quality (or purity) of end-products with less water in the oil and higher calorific value of the gas, higher throughput per production unit and finally, a capacity to treat rubber and petroleum waste.⁶⁶¹

At present, two of these devices are in operation in connection with the *Eesti* power plant near Narva. They allow for the efficient use of fine grain oil shale and are the largest existing oil shale processing units in the world.⁶⁶² Ivar Rooks claims that one important reason why the UTT-3000 was finally put in place despite opposition from some engineers was the close connection between the creators of the device, working at the Moscow Institute of Energy, and the central authorities. The scepticism from Estonian engineers in the industry was mainly a practical question – the UTT-3000 was regarded as too complicated, while the generators

⁶⁵⁹ Tomberg (2002) p. 50.

⁶⁶⁰ Volkov & Stelmakh (1999).

⁶⁶¹ Golubev (2003). It should perhaps be mentioned that Golubev is employed by *Narva Elekirjaamad AS*, the company operating the oil shale processing units.

⁶⁶² Volkov & Stelmakh (1999). There is a modified version of UTT-3000 in Slantsy, Leningradskaya oblast, Russia (close to the Estonian border).

due to their relatively simple technology allowed for longer uninterrupted use.⁶⁶³ As a kind of a countermove, the Estonian Oil Shale Institute took action in the early 1970s in order to develop a new, bigger generator with a processing capacity of 1,000 tonnes daily. Rooks recalls opposing a construction of this size, because enhancing the capacity of smaller, 200-tonne generators could be more feasible. He feared that technical complications in connection with a 1,000-tonnes generator would be the result. In the end, the bigger generator was constructed, which led to plans to construct an even bigger one, of 3,000 tonnes, but these plans never materialized.⁶⁶⁴

Another aspect is brought forward by the energy researcher Koidu Tenno, according to whom fuel extracted by the UTT (both fluid and gas) would enhance the generation capacity of the power plants at Narva. This would allow for utilization of the power plants to meet “half-peak loads” (i.e. allowing for greater flexibility in generation). The remaining question was then how to secure base load, which Tenno suggested would have to be increased through increased extraction of oil shale.⁶⁶⁵ In the end, the generator technology gained the upper hand at both Kohtla-Järve and Kiviõli while the UTT remains in use at Narva.⁶⁶⁶ In brief, the UTT, despite its advantages, was also seen to serve the interests of the power generating branch of the oil shale industry. This fact would to some extent explain the suspicion on the part of many Estonian engineers towards the new technology.

The intense debate following the introduction of the UTT technology is reflected in the section below (6.4.2.). At present, the UTT-3000 technology is perceived to be the perhaps most suitable technology when the aim is to reduce emissions of sulphur from gases produced.⁶⁶⁷ But there is still no general technological agreement. The competing technology, the generator, or the Kiviter process remains in use. In addition to this, the Canadian Alberta-Taciuk process (ATP) has also been given some consideration, although only small-scale experiments with Estonian oil shale have been made so far.⁶⁶⁸ Due to the different

⁶⁶³ Rooks (2004) p. 70.

⁶⁶⁴ Rooks (2004) pp. 80-1.

⁶⁶⁵ Tenno (1978) p. 37.

⁶⁶⁶ Yefimov, Rooks & Rootalu (1994).

⁶⁶⁷ Meelika Nõmme, R&D Project Manager, Viru Keemia Grupp, personal communication, January 17, 2007, Kohtla-Järve. See also the chapter on present development of the shale oil industry.

⁶⁶⁸ Mölder (2004) .

composition of various oil shales, transferring technology is a highly complicated process. Using Estonian oil shale in the ATP would likely result in even higher emissions of CO₂.⁶⁶⁹

6.4.2. The debate of 1968

A relatively open debate on the future of the Estonian oil shale industry took place in the Estonian national daily *Rahva Hääl* during 1968. It was certainly no coincidence that this debate took place the same year as the UN conference on oil shale was held in Tallinn. In connection with the publication of a full page article on the future of oil shale, the editors of the newspaper added a call for readers' views on the topic. The subsequent articles published in 1968 were more or less free from the Soviet lingo and they give the impression of a certain openness. However, it stands clear that there were limits to what was allowed to be said. For instance, there was not a single opinion published questioning why Estonia should produce energy for the entire North-Western Soviet Union without unambiguous information about what it got in return, i.e. payment. It can therefore be assumed that the debate at least to some extent mirrored official Soviet policy.

The debate should also be seen in relation to the development of the UTT-process described above, because most of the opinions expressed can be divided along the fault line created by the introduction of the new process. Even if certain politically sensitive issues are treated with the utmost care by those participating in the debate, it can still be claimed that at that particular time a more or less open debate on the future technological development of a leading industry in Estonia was allowed. For such reasons a thorough presentation of that debate is recapitulated here. However, this does not indicate that such debates would have been typical for the Soviet Union, although the climate occasionally allowed for moderately critical opinions to voice their concerns in the technological field.⁶⁷⁰

The first article, published on May 19, 1968, under the headline *The future of oil shale* was written by the economist J. Väljataga⁶⁷¹, who claimed that a recent price reform for producers in the Soviet Union had caused difficulties for the Estonian oil shale producers, that now received a price for domestic oil shale equalling the average for the entire Soviet Union. This

⁶⁶⁹ Puura (2000).

⁶⁷⁰ Gerner & Lundgren (1978) present a thorough analysis of the environmental discussion in the Soviet Union, which did not lack critical points of view, despite political restrictions.

⁶⁷¹ Väljataga "Põlevkivi tulevik" (*The future of oil shale*) *Rahva Hääl* 19.6.1968.

had led to a de facto cost increase because Estonian oil shale has a higher energy content than other oil shales of the Soviet Union. As a result, Estonian producers received less in terms of payment per unit of energy. As a consequence, Väljataga pointed out, the difficulties faced by the Estonian oil shale industry were aggravated, because crude oil and natural gas had become clearly more competitive.

“The Swedes liquidated their small-scale oil shale processing industry as uncompetitive. We should not approach the question in that way, even if the industry does not justify itself economically today, tomorrow there might be a need for developed technology for oil shale processing in some other region and for technical advice. Oil shale is the world’s largest reserve fuel and with a view to the future, the technology has to be complemented.”

On the other hand, too large an expansion of the oil shale industry into the field of chemical industry would have been problematic as there was a shortage of energy sources in the region (i.e. before the build-up of large nuclear power plants in North-Western Russia). Moreover, chemical industry requires vast amounts of energy. A second stumbling block was the shortage of labour. The recipe would be, according to Väljataga, a more efficient use of existing resources and a diversified production. There are plenty of examples of successful products, such as impregnation oil, glue or solvents. Further efficiency gains could be achieved through modernization of the machinery and equipment, both in mining and processing. Especially the tunnel ovens should be shut down and replaced with more efficient generators, which would make oil production profitable.

Väljataga concludes with the suggestion that processing equipment should be placed near or even inside the mines in order to be able to use oil shale of low energy content, the transport of which would imply a proportionally big loss of energy. This new way of processing would, according to the calculations presented in the article, lead to an annual profit of 17-18 per cent of the turnover. This particular idea is also mentioned by Ivar Rooks. The idea took a concrete form when Väljataga suggested erecting a new factory at the open pit at Viivikonna. Ash and semi-coke from the production could then be directly stored at exhausted areas of the open pit. The problem was that these rest products in contact with water produce alkaline substances, which could have had a devastating effect on ground water.⁶⁷²

⁶⁷² Rooks p. 64.

A reply was published on July 6, by Ulanen and Tānav, leading engineers at the Kiviõli oil shale factory.⁶⁷³ They opposed the idea of processing oil shale in or in the immediate vicinity of the mines, because mines are relatively quickly exhausted, while the factories and the related infrastructure should be constructed with a longer perspective. The authors admitted the problem with poor oil shale (of low energy content), which could not be processed in an efficient way, but this problem was the consequence of the lack of adequate equipment in the Soviet Union. However, the problem with poor oil shale should also be tackled with respect to the mines, where greater attention should be paid to mining richer shale instead of choosing the way of least resistance.

Ulanen and Tānav continue that the issue of processing oil shale in a generator or by a solid heat carrier (the previously mentioned UTT process) seems to turn in the favour of the latter. A “half-industrial” device had been operating at the Kiviõli factory and the results were encouraging in the sense that the gases extracted did not lose their calorific value because they would not interact with flue gases. Further experiments were to be carried out on the processing of even poorer oil shale. The UTT had shown a higher ratio between the thermal energy contained in the useful products and the amount of thermal energy used in their production. Ash, which constitutes at least 60 per cent of the processed oil shale, cannot be utilized in a generator, but in a UTT the ash can be collected and used in the production of building materials. This in turn could further enhance the profitability of the oil shale industry. If, on the other hand, generators were to be used more in the future, this would narrow the chemical branch of the oil shale industry, because oil produced from generators practically lacks those components that boil at lower temperatures. Thus, a number of chemical products (such as detergents) could not be produced in that case. If shale oil were to be used on a larger scale against land erosion throughout the Soviet Union, there might emerge a need for co-production both in generators (for bigger chunks) and in UTT (smaller chunks). Finally, the authors claimed that there is a responsibility to take an approach as broad as possible in order to allow future generations to choose from a set of technologies.⁶⁷⁴

Another reply to Väljataga was signed M. Gubegrīts and V. Tjagunov, both from the G. Krizhizhanovski Institute of Energy Technology, who criticize Väljataga for counting with

⁶⁷³ Ulanen & Tānav “Kas generator, tahke soojuskandjaga utteseade või mõlemad?” (*Generator, solid heat carrier retorting device or both?*) *Rahva Hääli* 6.7.1968.

⁶⁷⁴ The authors do not specify how shale oil can be used against erosion.

the generators only. The need to develop the UTT was made even more urgent by the fact that estimates from the USA implied that oil shale would make up 5 per cent of the American energy consumption in 1975 and reach 35 per cent by the year 2000.⁶⁷⁵

The economist P. Lageda observed on August 9 that this time there was a more critical debate on the oil shale issue than before.⁶⁷⁶ Earlier there were no attempts to analyse the arguments of others, which now was the case, he wrote. In his opinion, the fundamental question was why the oil shale industry should be developed at all. He answered the question by specifying two underlying issues. First, there was the question of all-union experimental activity with the aim at gaining experience. Second, there was the task of developing oil shale chemistry in such a way that it would correspond with the overall possibilities and be in conjunction with other industries in Estonia. Lageda was concerned that dwindling oil reserves might rapidly turn into a supply problem of liquid fuels. The Estonian oil shale research had meanwhile been split on too many tasks and would therefore not be able to produce an alternative quickly enough.

“If a group of only 10-15 scientist are dealing with some problem, one can be quite sure that reaching positive results will take several years. By concentrating more power to the task, it can be solved quickly.

I think that if a need emerges to produce liquid fuel on a larger scale from oil shale in the Soviet Union, then methods for a broader scientific and industrial search will be found. Without doubt then several new regions with oil shale industry and corresponding scientific centres will emerge. In the near future it is unlikely that one can hope for this. As a consequence, Estonian SSR remains the most important and almost sole research centre for oil shale industry in the Soviet Union”

From this would follow, according to Lageda, that the oil shale industry should focus on a few relevant sectors. There were no possibilities to develop a large-scale energy-technological industry. If Estonia were to try to develop any large-scale industry, there would most likely be an even bigger industry built elsewhere with more favourable economic indicators. Instead, industrial units of moderate size should be developed in Estonia, which would not be threatened by economies of scale. Production of gas would favour this development, while production of heating oil would require large production units.

⁶⁷⁵ *Rahva Hääl* 14.7.1968.

⁶⁷⁶ Lageda “Missuguste põlevkivikeemiatsehhidele orienteeruda?” (*Towards what kind of oil shale chemistry production units?*) *Rahva Hääl* 9.8.1968.

On August 18, M. Korv expressed concerns that the relatively high price for shale oil hampered its position. Moreover, modern synthetic chemistry was more and more based on individual chemical components and therefore shale oil produced from generators would not serve this purpose. But there were also a number of unresolved problems with the solid heat carrier (the UTT), especially economic problems. For this reason the tunnel ovens should remain in use, as they produced oil of the best quality.⁶⁷⁷

The oil shale chemist Agu Aarna observed on January 10, 1969 that a global shift from solid fuels towards oil and natural gas was taking place, which was the result of the more complicated production process, transport and utilization of solid fuels.⁶⁷⁸ However, the issue at hand is for how long resources will last, and according to Aarna, estimates of global oil shale resources indicate that they exceed the combined resources of oil, natural gas and coal at least one thousand times. Thus oil shale should be seen as the future energy of mankind, not a low quality substitute for other fuels. While oil shale is on the retreat elsewhere, Estonia has developed into a unique centre, with all aspects of oil shale production, utilization and research. Thus the tasks for the oil shale industry are twofold. First, to function as an experimentation base for the development of oil shale industry in the entire USSR and the developing countries. Second, to meet the requirements to develop the base in Estonia and the North-Western Soviet Union for energy and chemical industry.

Aarna criticizes those who had suggested stopping the generation of electricity and concentrating the resources on developing the chemical industry. Instead, he suggests the solution should be the establishment of an energy-technological complex, which could produce oil both for electricity generation and for the chemical industry. The gains for the electricity industry would be that it could thus be provided with heavy oil. Heavy oil is easier to burn than unprocessed oil shale, which wears on the equipment, resulting in higher costs. At the same time the chemical industry would have lighter oils and gas for further processing. A consequence of this would be the need for large scale retorts, which could process between 1000 and 3000 tonnes of oil shale a day. Both generators and UTT had developed considerably – the former could be constructed to process 1000 tonnes of oil shale in a day,

⁶⁷⁷ Korv "Missugusele uttesüsteemile orienteeruda?" (*Towards what kind of retorting system?*) *Rahva Hääli* 18.8. 1968.

⁶⁷⁸ Aarna "Põlevkivitööstuse tänapäev ja tulevik. Kokkuvõtteks mõttevahetusele 'Põlevkivi tulevik'" (*The present and future of oil shale industry. A summary of the exchange of thoughts 'The future of oil shale'*) *Rahva Hääli* 10.1. 1969.

while there were plans to increase the capacity of the latter to 3000 tonnes. In the end there was the question of what was produced elsewhere in the Soviet Union. Oil and gas exist in very large quantities, which made the question of economy crucial. In particular, natural gas was not utilized to its full potential, which would imply that the future perspectives for gas production from Estonian oil shale looked uncertain. Another problem stressed by Aarna was that petroleum produced from oil shale is not of the quality required for motor vehicles. Especially the sulphur content is a problem. For the above-mentioned reasons the processing of shale oil should be matched with the needs of the chemical industry.

One of the critical issues in this respect was the utilization of heavy shale oil. It can be burned, but this is uneconomical. It should rather be the basis for several chemical products such as lacquer, impregnating oil, latexmastics and perhaps a binding material in the ground for use in erosion-ridden areas. The lighter fractions of oil could meanwhile be used for the production of aromatic hydrocarbons, especially benzene. The lighter fractions could also form the basis for a number of consumer oriented detergents. Moreover, another part of chemical industry is the production of phenols, mainly for producing glue. The problem is that the amount of phenols derived from oil shale is so great that there is no demand, and in addition to this the chemical composition of these phenols is such that they have an unstable character reducing the quality of the final products.

Aarna arrives at the conclusion that the future of the Estonian oil shale industry lies in developing products with higher value-added. In order to achieve this, clean substances should be produced from which it would be possible to extract synthetic substances. The oil shale industry should also be as flexible as possible, developing the capacity to switch from one type of products to another in accordance with the interests of the national economy.

“At the moment and even more so in the future the quality of the production will be in the foreground. Occasional substitutes are bound to be replaced with substances of higher quality and the future of the whole industry should not be based on the former. For this reason particular emphasis should be put on processing existing products and guaranteeing them a stable niche in the national economy. This, however, requires a fundamental change in the labour practices of the workforce in the oil shale industry. Until now, large-scale

products with low demand have been put in the foreground./.../ Further development of synthetic chemistry requires, however, even higher work culture and greater precision.”⁶⁷⁹

At the end of this article, Aarna recognizes the problems created by the giant ash heaps that are the result of the large-scale oil shale industry, expressing hopes that one day there will be methods to utilize both ash and the remaining substances. He concludes with remarks that may sound strange for today’s readers, but they seem to have been a more or less required part of any comprehensive article.

“From what has been said, it becomes clear that oil shale as a natural resource is becoming increasingly important. At present it is obvious that the Soviet Union is a big step ahead of other industrially-developed countries in the field of oil shale excavation, chemistry, technology, and energy. The international symposium showed everyone that the USSR is at the moment the only country in the world which has a capacity to give qualified support to developing countries in the establishment of an oil shale industry. It was not a coincidence that the American representatives tried to bring into the resolution of the symposium a statement that the success of the USSR in utilizing oil shale are a result of the specific characteristics of the local raw material and thus not transferable to the circumstances in other countries. The participants of the symposium comprehended the intentions behind such a manoeuvre and refused to give this formulation.”⁶⁸⁰

6.4.3. Comments

There is little room for doubt that the discussion, referred to in such detail above, actually was a discussion on Estonian industrial policy, as if the country was making its own decisions about the future. The actual arguments were more or less openly presented, only barely shielded with political rhetoric. The ultimate goal was clearly to increase the value added in production, to develop Estonian know-how and to maintain something of a separate Estonian industry. Moreover, some arguments reflect concerns about too big a growth of the oil shale industry. Such worries should be set against the background of the massive Russification through immigration into the oil shale-producing part of Estonia. An argument strongly coloured by such national aspirations is, for example, when the economist Väljataga claims

⁶⁷⁹ Aarna, *Rahva Hää* 10.1. 1969.

⁶⁸⁰ Ibid.

that development into a large scale industry is not on the agenda because of labour shortage. There was probably no overall shortage of labour in the Soviet Union in the late 1960s, but there was likely a shortage of Estonian labour. Väljataga then continues by stating that his aim is to:

“based on economic calculations prove that several generations of scientists and engineers have not worked in vain when creating this industry”⁶⁸¹

It is also worth underlining comments made by Lageda that the oil shale industry should develop in conjunction with other Estonian industries. It should not be based on scale but instead remain of modest size, specializing in only a few sectors.

Aarna stresses Estonia as a unique centre for oil shale research, utilization and production. This role might be strengthened in the future, when oil shale will bounce back on the global agenda, because of exhaustion of other resources. It is interesting to note how he arrives at this conclusion:

“In many capitalist countries such as England, Sweden, France, Australia etc. where an oil shale industry had developed, the companies were shut down, because they could not stand the competition from oil concerns. Immediately after the Great Socialist October Revolution, in accordance with V.I. Lenin’s directives, the oil shale industry was established in the USSR and an institute of scientific oil shale research was founded. Even if the oil shale industry constitutes only a small fraction of energy production in the USSR, it has always been considered an industry with good potential, the development of which should be carried out in the interests of the future.”⁶⁸²

These lines follow a clear Soviet choreography. First, the “capitalist” countries have failed. Second, Lenin had identified the problem and given instructions. Third, what is done in Estonia is “small”, but it is done under the benevolent supervision of the Soviet state. Whatever the arguments, the aim here is the same as in previous articles, namely to discuss how to promote *Estonian* industrial policy. It was probably no secret to the Estonian oil shale community that on an international level there existed a perspective that oil shale could one day become one of the most important fossil fuels (as for instance Galbraith had speculated,

⁶⁸¹ Väljataga, *Rahva Hääli* 19.6.1968.

⁶⁸² Aarna, *Rahva Hääli* 10.1.1969.

see chapter 4.1.). Were this to happen, Estonia, and the Estonian scientific community in particular, would probably have gained a stronger position against Sovietization. This aspect was also observed by the exile-Estonian chemist Heino Susi:

“Although the Estonian oil-shale reserves are relatively small, vast amounts are found in other parts of the world, including the United States. Given limited petroleum reserves, huge untapped oil-shale reserves might well attract considerable attention in the near future. New technology must be developed; problems of economical refinement, utilization of by-products, and handling of pollution must be faced. In this area, technology developed in Estonia might well prove to be of considerable global importance”⁶⁸³

The issue of supporting developing countries to develop their oil shale industry is also worth paying attention to. Aarna mentions particularly Brazil, from where a sample of oil shale had been processed in Estonia. Although this aspect could be interpreted as simply being nothing more than what is actually written, it is more likely that there was a growing sense among Estonian oil shale scientists of having found a way to develop international contacts. At this time Estonia was basically sealed off from the rest of the world and there was hardly any direct interaction between Estonia and the world outside the Soviet Union. The issue of oil shale could become the bridge sought by the Estonian scientific community.⁶⁸⁴ Aarna continues, referring to the UN-led symposium on oil shale held in Tallinn in the summer of 1968:

“At the recent symposium, a decision was made to turn to the Soviet Union with a proposal to assist developing countries in developing oil shale industry. In the practical realization of this proposal, the specialists in our Republic naturally have an important role.”⁶⁸⁵

From the debate recapitulated above, it can be concluded that a sense of an emerging crisis for the oil shale industry had taken root in Estonia. Hopes were increasingly tied to possible developments in the surrounding world. It was recognized that oil shale was inferior to liquid fuels and that even the chemical industry might demand another type of raw material. This sense of a troubled industry has actually survived to the present time, even if the oil shale industry has experienced a profitable period in the 2000s.

⁶⁸³ Susi (1978) p. 372.

⁶⁸⁴ Ratnieks (1978) mentions that the Estonian oil shale industry had drawn attention in both Brazil and Canada. It should be stressed that Ratnieks is a “Western” observer.

⁶⁸⁵ Aarna, *Rahva Hääli* 10.1.1969.

6.5. Stagnation

The late 1960s witnessed an increasing sense of emergency among those managing the oil shale industry. In order to improve competitiveness against the other energy sources (crude oil, natural gas and nuclear power), in 1976 plans were drawn to even further increase the capacity of the Estonian oil shale industry. These plans were based on three pillars; to open more mines, to construct one more big power station, and to bring the UTT technology into wider use. Oil shale mining in Estonia was supposed to increase to 40-45 million tons annually (the current rate at the time was somewhat above 20 million tons). In the end, these plans were never realized due to the poor economic perspectives of the Soviet Union.⁶⁸⁶

In the mid-1970s construction began at Kohtla-Järve of a large generator with the capacity to process 1,000 tonnes of oil shale daily as a response to increased demand. A joint project between the Oil Shale Institute and the shale oil factory at Kohtla-Järve together with a Russian counterpart (*Lengiproneftekhim*) first developed a prototype and later two generators (or retorts) called GGS-6. The first experimental device started production in 1981 and was followed by the two GGS-6 retorts of industrial size in 1987.⁶⁸⁷ Experience from the smaller generators processing 200 tonnes formed the basis for the larger generator. An alternative solution would have been to enhance the capacity of the existing 200-tonne generators, which experiments had shown could be increased with between 5 and 10 per cent.⁶⁸⁸

In 1978 the Kohtla-Järve shale oil “combinat” (i.e. company) was renamed, officially becoming “*Oil shale chemistry production association named after V.I. Lenin of the October Revolution order*”. This name was rarely used, but instead the Russian acronym *PO Slantsekhim*.⁶⁸⁹ In the late 1970s and early 1980s the number of employees grew rapidly. While the factory at Kohtla-Järve had employed 3,600 persons in 1966, the figure was up at 4,500 a decade later reaching a maximum of 5,386 in 1985. A decade later, in 1996, the number of employees had dropped to 3,350.⁶⁹⁰

⁶⁸⁶ Reinsalu (2000b) p. 95.

⁶⁸⁷ Yefimov, Rooks & Rootalu (1994).

⁶⁸⁸ Rooks (2004) p. 80.

⁶⁸⁹ Rooks (2004) p. 84 This name is equally complicated in Estonian as well: “*Oktoobrirevolutsiooni ordeniga V.I.Lenini nimeline Põlevkivikeemia Tootmiskoondis*”.

⁶⁹⁰ Rooks (2004) p. 95.

In 1981 the Council of Ministers of the USSR issued an order to increase the use of oil shale.⁶⁹¹ In order to achieve this goal, the chamber ovens that had remained in use at Kohtla-Järve were to be replaced with generators between 1982 and 1985, which would increase total output and reduce the amount of gas extracted. The problem with gas was overproduction that found no demand to meet. After failures to reach an agreement with Kohtla-Järve district heating, gas was simply burned.⁶⁹² The reason behind the decision to increase production of oil shale remains a little obscure. One possible explanation would be that it simply was a consequence of the Soviet ideological preference for large-scale production. Another explanation has been presented by the England-based scholar Henry Ratnieks, according to whom the policy of expanding the role of fuels like oil shale should be seen in connection with Soviet attempts to increase export earnings from crude oil. In such a case, the increased use of shale oil domestically would have freed crude oil for export.⁶⁹³ Oil exports were an important source for hard currency revenues for the Soviet Union, which otherwise had relatively few products demanded in the world market. The situation was further complicated by the fact that the Soviet Union delivered oil to other socialist countries at prices far below the world-market prices in the late 1970s and early 1980s.⁶⁹⁴ Hence, it was logical that the Soviet Union should replace the domestic consumption of crude oil with whatever alternatives were possible, including oil shale.

When the world market price for oil started to fall in the 1980s, so did Soviet export earnings, too. Gradually also the Estonian oil shale industry was losing most of its relevance despite increased production. Increasingly cheap oil and natural gas from elsewhere in the Soviet Union made shale oil and gas unprofitable. In 1988 processing oil shale made up less than 20 per cent of the profits of the combined oil shale companies (companies) of Kohtla-Järve and Kiviõli, while chemical products accounted for more than 50 per cent.⁶⁹⁵

Chemical products faced another dilemma, because a certain share of production had to be consumer oriented. Especially glue and carbamide (a fertilizer) were to be distributed to consumers, but with unsatisfactory results. In order to fulfill the plans, carbamide was sold to

⁶⁹¹ Rooks (2004) p. 89.

⁶⁹² *Ibid.*

⁶⁹³ Ratnieks (1978).

⁶⁹⁴ Nove (1992) p. 392.

⁶⁹⁵ Rooks (2004) pp. 102-3. As has been mentioned previously, there existed a notion of profits in the Soviet Union, but this concept meant something different, namely an administratively set amount of money, which the company was supposed to be rewarded with, if fulfilling its targets.

state farms (kolkhozes) in other parts of the Soviet Union, but accounted for as consumer goods.⁶⁹⁶ Despite the fact that new production units or factories designed for the production of various chemicals had been taken into use at Kohtla-Järve and Kiviõli, ever new problems emerged (in 1968 a new production unit for nitrogen-based fertilizers was started, in 1978 ammonium, in 1979 sulphur oxide, in 1982 the production process of phenols was improved, and in 1985 a benzene production unit started).⁶⁹⁷ Already in the mid-1970s the list of chemical products produced by the Estonian oil shale industry contained around 50 entries, such as lubricants, paraffin, timber preserves, synthetic leather, paint, pesticides, bitumen, resins, antiseptics, pharmaceuticals, detergents, ammonium sulphate and many more.⁶⁹⁸ In the 1980s, when elements of market economy increasingly penetrated the Soviet Union, the Estonian oil shale industry found it ever harder to pay for additional substances used in the chemical processes, because Western companies, which had become active in the Soviet Union, paid the producers better.⁶⁹⁹

Even electricity generation faced an uncertain future when nuclear power was built on a large scale, especially the power station at Sosnovyi Bor near Leningrad. The future role of Estonian power generation seemed to become to level peak loads in the northwestern parts of the Soviet Union.⁷⁰⁰

But the most profound change in the mid-1980s was the democratization of the society. The first signs came with local meetings against the environmental hazards caused by the oil shale industry. The environmental problems connected with the oil shale industry were recognized already in the 1970s. In an article from 1974 the prominent scientist on oil shale-based power technology, Ilmar Õpik, expressed concerns about the environmental consequences resulting from the use of fossil fuels. Nuclear power would replace a large part of other fuels, allowing for the use of electricity in transport, agriculture, heating etc. This development would have allowed for more environmentally friendly utilization of oil shale. When less is burnt, Õpik argued, only oil shale of the best quality need be used. Moreover, there would also be a possibility to use shale oil as fuel in the power plants, which could lead to diminished

⁶⁹⁶ Rooks (2004) p. 91.

⁶⁹⁷ Rooks (2004) p. 95.

⁶⁹⁸ Ratnieks (1978). A comprehensive list can be found in the booklet published by the Kohtla-Järve oil shale factory: "Produktsiya kohtla-jarveskogo ordena oktyabrskoy revoljutsii slantse-khimicheskogo proizvodstvennogo objedineniya imenii V.I.Lenina. Reklamnyi prospekt" (in Russian).

⁶⁹⁹ Rooks (2004) p. 102.

⁷⁰⁰ Ratnieks (1981). This development was anticipated already by Õpik (1974).

atmospheric pollution.⁷⁰¹ The environmental hazards were also identified by the oil shale researcher Koidu Tenno. In her account from 1978 she identifies the following hazards: pollution of water, emissions of ash and sulphur oxides, threats to human health especially by carcinogens and threats to the ecological balance in the region.⁷⁰²

With increasing freedom of the press, the entire oil shale district was now labeled “disaster district”, which might have aggravated problems even further, because this caused potential new investors to stay away from the region.⁷⁰³ The oil shale factories made some attempts to mitigate the problems and for instance a plan to lead waste water directly into the sea was stopped.⁷⁰⁴ Environmental concerns were not new to Estonia. In 1977 a letter written by 18 anonymous Estonian natural scientists was sent to colleagues in Western Europe as a protest against the environmental destruction in the oil shale district, which was said to have become a moon landscape.⁷⁰⁵ In 1983, the nature magazine *Eesti Loodus* published a call to utilize natural resources in a responsible manner.⁷⁰⁶ Soviet plans to build up a new gigantic mining industry further to the west from the actual oil shale district became the watershed. The actual environmental concern was related to the widespread pollution of a great deal of the ground water in Estonia, but ethnic and demographic factors also played an important role, because the plans, if materialized, would have led to an even larger immigration into Estonia, thereby causing a dramatic change in the sensitive population balance. The protests in Estonia started in academic circles, but soon even local Communist Party officials joined in. Protest actions could also be seen in the streets. In 1987, students at the university in Tartu swapped the red flags meant for the annual May 1st demonstrations for green ones. In October 1987, the Estonian protests achieved their first major victory when the Council of Ministers of the Soviet Union halted the plans to enlarge the industrial operations.⁷⁰⁷

One interesting aspect of the more outspoken environmental protest was that while the overall responsibility for production lay in Moscow, the individual Soviet republics were in charge of environmental issues.⁷⁰⁸ In the Soviet times, this was probably perceived as an indication of hierarchy (i.e. production over environment), but with released national sentiments combined

⁷⁰¹ Öpik (1974).

⁷⁰² Tenno (1978) pp. 34-5.

⁷⁰³ Rooks (2004) p. 100.

⁷⁰⁴ Ibid. p. 98.

⁷⁰⁵ Misiunas & Taagepera (1997) p. 268.

⁷⁰⁶ Ibid. p. 294.

⁷⁰⁷ Ibid. pp. 305-6, see also Raun (1991) p. 223.

⁷⁰⁸ Ibid. p. 293.

with serious environmental concerns, the local protests actually contained an element of support for the local leadership against the central authorities in Moscow. The process that started as a protest against environmental hazards in the oil shale region soon became an Estonian movement for independence. The remarkable story of this peaceful and democratic independence movement is truly fascinating, but to a large degree beyond the scope of this study. It is fair to claim that environmental issues and restoring national independence became closely knitted in Estonia, while the oil shale industry often was assigned the role of the villain. Because the aim of firms operating in the Soviet Union was not profit making,⁷⁰⁹ their successes and failures have to be evaluated against other benchmarks. In addition to being a supplier of energy and chemical products, the oil shale industry had been “the national technology” of Estonia. But in the last decades even this role of the oil shale industry was being eroded when the scientific work was controlled from the center (i.e. Moscow) and consequently chemists from Russia increasingly took over the sector that had been perceived as an Estonian sphere.⁷¹⁰ The historian Robert Smurr describes the developments in the following way:

“Advertisements for most industrial jobs in the northeast frequently promised lucrative pay and housing benefits in an area that was suffering from lack of employment opportunities and inadequate housing. But as if deliberately rubbing salt in the wounds of an already insecure nation, these advertisements were often found only in the Russian Republic. Thus, because Estonians had so little say as to what transpired within their borders, and because Slavic-speaking immigrants enjoyed privileges denied to most ethnic Estonians, there developed a peculiar link between environmental threats to the republic and to the economic and cultural existence of the nation itself. The fact that the uninvited newcomers were frequently employed in environmentally destructive phosphate, oil-shale, fuel and chemical concerns did not help to ameliorate tensions”⁷¹¹

In the 1980s, the oil shale industry had run out of its resources, its very basis for existence – being neither perceived necessary for the economy nor particularly Estonian. This situation is

⁷⁰⁹ It was rather the other way round – the administratively set prices were supposed to be on a level that would guarantee a certain profit.

⁷¹⁰ Helle Martinson, personal communication, October 11, 2005. This development is reflected in Rooks (2004). Among the engineers and technicians only one in 14 spoke Estonian in the 1980s (p.101). During personal communication on October 13, 2005 Rooks confirmed this development. According to him, one contributing reason was that the grants for students of chemistry in the USSR were higher than for others, which led to an increasing number of chemists in general, which resulted in an influx of Russian-speaking chemists into Estonia.

⁷¹¹ Smurr (2004) p. 401.

surprisingly similar to phenomena encountered in modern management research. For example, according to Shelby Hunt and Robert Morgan, such resources-come-nonresources probably account for a very large share of failures, from individual firms to entire societies.

“An asset that is a resource in one environment can become a nonresource in another if it no longer contributes toward the creation of value in the firms’ market offerings. Even more seriously, something that was previously a resource can become what we label a “contra-resource” and actually inhibit the creation of value in the firm’s market offerings”.⁷¹²

The quotation above, originating from an analysis of individual firms in a market environment, could equally well capture the dilemma of the Estonian oil shale industry in the final years of the Soviet Union. What once had been a source of national pride had turned into a focal point of societal ills. Environmental concerns, closely related to the oil shale industry, became a catalyst for national revival, with the ultimate aim of national independence. In other words, it can be said that an informal institution had altered. What had at least been perceived as Estonian had turned into the opposite in peoples’ minds.

6.6. The Soviet years – a summary

Summarizing the entire Soviet period in the Estonian oil shale industry from 1944 to 1991 is definitely no straightforward task. The Soviet Union, despite its monolithic appearance, did not differ from other human societies in the sense that throughout its existence conflicting interests pulled in various, and often opposite, directions. Repeated policy changes were the result of permanent clashes of interests. Institutional change was actually a relatively frequent phenomenon in the Soviet Union, even on the level of informal institutions and probably happened in conjunction with the rising level of education.⁷¹³ On the other hand, the Soviet institutional framework lacked what Douglass North calls “adaptive efficiency”, by which is meant a capacity to absorb shocks and uncertainty.⁷¹⁴ To be more precise, the Soviet system was actually relatively successful in absorbing some types of shocks, such as WWII, but

⁷¹² Hunt & Morgan (1995).

⁷¹³ I make this assumption based on descriptions made by Braudel (1995/1987) pp. 560-2 on the rapidly changing behavioral codes in the Soviet Union in the 1950s and 1960s.

⁷¹⁴ North (2005) p. 78. The Soviet system lacked adaptive efficiency which eventually led to its demise. (North (2005) p. 154).

failed entirely when encountering other types, such as the paradigm changes in technology, industry, and ecology.

The Hungarian economist Janos Kornai points out that the certain fundamental features of the socialist system, such as rigid ideological doctrines, total state ownership in the economy, bureaucratic control, shortage, forced growth and withdrawal from the surrounding world, created a system with its own inner logic. This in turn produced a process of “natural selection” among institutions. For instance, in order to avoid sloppiness in details in production, the supervising body had to dig deeper and deeper into details, simply for the sake of control (because there was no use for control stemming from the production unit itself). This in turn reinforced the bureaucratic machinery. In brief, the all-encompassing bureaucratic planning left less and less room for any other activity (such as private companies). They were simply squeezed into extinction by the inherent logic of the institutional set-up.⁷¹⁵ The functioning of the bureaucratic apparatus could also be interpreted as largely autonomous, especially if the ruling elite had been weakened. The apparatus had its own specific interests, not necessarily coinciding with those of the rulers. Maintaining the status quo was the prime motive for the apparatus. This in turn implied a power balance between the ruling elite, the apparatus and the general population, of which the latter was the target of coercion from the apparatus.⁷¹⁶

Another tool for understanding the development of the Estonian oil shale industry could be by interpreting those active in the industry as a sort of a pressure group. The aims of the group were not directly economic in a traditional sense, but were an overall aim at preserving an industry they had personally invested in through education and commitment (though not pecuniary investment). The aim of such actions was to find room to maneuver for the oil shale industry. This was made possible by the relatively homogeneous background of those having such interests, but also because of the negligible size of the oil shale industry in a Soviet perspective. Therefore the rather small tight-knitted group of oil shale specialists could succeed in carving out room to maneuver as a result of the occasionally relatively limited interest in the issue by those structures holding power in the Soviet Union. Following the reasoning of the American economist Mancur Olson, it could be appropriate to talk about a lobby group, which successfully provided its members with a share of a public good. As these

⁷¹⁵ Kornai (1992) pp. 366-7.

⁷¹⁶ Kaminski & Strzalkowski (1993).

developments were taking place in the Soviet Union, there was of course no formal lobby group (it would have been persecuted) and the collective good in question was the permission to act (because all organized activities had to be approved by the state structures).⁷¹⁷ A decisive factor behind the success was the relatively small size of the group and its professional and to some extent ethnical homogeneity. The bargain that had to be made in order to preserve the oil shale industry was to supply areas outside Estonia with energy products. Therefore, following this line of thought, the Estonian oil shale industry “bought” the right to exist by selling its products, albeit at a price that under other circumstances would probably have been considered prohibitively low. Another price that had to be paid was the increased Russification of Estonia, because most of the labor force demanded had to be imported from elsewhere in the Soviet Union.

It can be seen that the way technology developed in the Soviet Union shares characteristics with technological development elsewhere. This is, after all, rather self-evident. But there were some important differences as well, one of which was the question of patenting. As there was no recognition of private ownership in the Soviet Union, patents were more or less superfluous. But despite this and despite the lack of direct connection between innovation and private (monetary) gain, technological development still existed, although probably on a narrower scale than could have taken place under other institutional arrangements. But having said this, one important observation follows from what has been discussed above, namely that incitements for innovation are not necessarily pecuniary (as was observed already by Schumpeter).⁷¹⁸ Innovators can be spurred just by the technological challenge itself. However, it is extremely difficult today to assess possible personal gains made by successful innovators in the Soviet Union such as perhaps increased personal freedom, foreign travel, prestige etc, but still there is little evidence in literature and personal memoirs that even successful innovations would have resulted in major personal gains, at least not as a rule. Although the institutional arrangements of the Soviet Union were rather hostile to spontaneous innovation, they favoured some aspects of institutionalised innovation, which the process behind the UTT shows. To some extent this is a phenomenon related to in-house technological development of major corporations in market economies.

⁷¹⁷ Olson (2000) calls the actions of such unofficial pressure groups in communist systems “covert collusion”.

⁷¹⁸ Schumpeter (1993/1934).

The Estonian oil shale industry developed in the Soviet years through competition, although not precisely in the same manner as usually is meant with the concept. As has been shown, the Estonian oil shale industry was no monolith, but rather an economic-technological system consisting of several competing objectives and technologies. Within the system, competition never really allowed for the sort of idleness that is often said to be the hallmark of Soviet industry. No particular technology gained universal acceptance, but instead every technology had to fight for its existence. Contrary to an often presented simplified picture of the nature of the Soviet system, there is evidence that industry anticipated changes in demand from the central authorities and acted accordingly. A common view of the functioning of the planned economy is that companies follow instructions laid down by the authorities in five-year plans. However, in the 1960s, the industry in Estonia received some freedom to decide about output and it was even allowed to make profits, which were supposed to be reinvested in one way or the other. This prompted production to pay increasing attention to customer demand.⁷¹⁹ The Soviet attempts to create a strong chemical industry were influenced by global processes, to which the Estonian oil shale industry made an attempt to adjust. One can safely claim that Estonia was at least culturally one of the most Western-oriented parts of the Soviet Union and thus had a certain preparedness to relatively quickly respond to foreign influences, which probably played a role in the dynamics of the oil shale industry.

The Director of the Estonian Oil Shale Institute, Jüri Soone, claims that the Estonian oil shale industry survived because of the Soviet Union. Otherwise it would not have survived.⁷²⁰ In the light of what has been presented so far, this statement could be somewhat modified – the Estonian oil shale industry survived the conditions of the Soviet rule, due to its inherent dynamic capacity. This could be explained by routines (in the sense introduced by Nelson and Winter) stemming from the period before the incorporation of Estonia into the Soviet Union. A change in routines always contains the risk of losing control, which is necessary in order to guarantee the smooth running of any system and therefore changes of routines are often avoided. But this also explains why routines from a period preceding the Soviet rule in Estonia could survive. However, the Soviet authorities increasingly distrusted the innovation capacity of the country and feared that the West would gain a crucial technological

⁷¹⁹ Järvesoo (1978) p. 143. Some 98 per cent of the industrial output in Estonia was produced by industries operating under such a scheme. Ibid.

⁷²⁰ Jüri Soone, personal communication April 7, 2004.

superiority. Their solution was to imitate and replicate.⁷²¹ Soviet chemical industry, in particular, was seriously lagging behind its Western counterparts and was therefore trying to catch up, not only through own innovation, which could have been a waste of time and resources, but also through replication and imitation. Nevertheless, also replication may fail because even if all the external attributes of a particular process are in place, there may still be tacit knowledge lacking, seriously hampering the replicated process, i.e. not creating the routine sought after.⁷²² Helle Martinson comments on the difficulties:

“The material basis for research was often non-existent. In the Soviet Union the best equipment was used for military purposes. Moscow decided everything about buying equipment. There were chemists who travelled abroad to find out what was being done elsewhere and then tried to copy it, of course not officially, though. They did so because there was no money to buy the equipment”⁷²³

Judging from Martinson’s account, this activity was not perceived as spying, but rather as a way to solve the problem of lacking equipment. Another source tells about being given the task to gather information on the Swedish oil shale industry in the 1960s in connection with a couple of journeys to Sweden.⁷²⁴ This lack of self-confidence in the Soviet Union in its own innovation capabilities might be the ultimate reason why the relatively dynamic industrial policy of the 1960’s was eroded and replaced with stagnation. In the last decade and a half of the Soviet period in Estonia did Soviet *gigantism* really set in, when the aim became basically to produce more of the same.⁷²⁵ By this time the Estonian scientific community had been subdued, too, which is no coincidence (see chapter 6.3.1.). The Estonian perception of the oil shale industry was from the very beginning related to knowledge creation and accumulation, or in other words, increasing the value added in production. Therefore it can be concluded that

⁷²¹ Castells (1999) p. 32.

⁷²² An interesting account of a failed routine can be found in Castells (1999) p. 32. The Soviet union tried to replicate and imitate the Western production of computers in the 1970s, but failed partially because of very crude methods. When chips in U.S.-built computers were 1/10 inch apart, the Soviet bureaucracy simply rounded this up to 0.25 mm, which distorted all further replication and imitation.

⁷²³ Helle Martinson, personal communication, October 11, 2005, Tallinn. Observe that in chapter 6.1. there is a brief discussion on American equipment received by the Soviet Union during WWII and how it was probably used for such reverse engineering.

⁷²⁴ I have chosen not to reveal the name of this person for ethical reasons.

⁷²⁵ The fascinating background of Soviet focus on size and its American origins has been described by Hughes (1989). In brief, the style of Soviet industrial ideology was a sort of interpretation of Taylorism, but with its own logic. Hughes writes (p. 264) “*The Soviet effort, however, took a new turn in concentrating on the importation of entire systems of production and incorporating them in hydroelectric regional complexes. Observers who labeled this simply “gigantomania” missed Lenin’s point that to be modern was to be large-scale and to be large-scale was to introduce the material conditions for the transformation from capitalism to communism.*”

it took the Soviet system roughly three decades to establish conformity with respect to the Estonian oil shale industry. In a situation where informal and formal institutions are conflicting, the former can support to maintain existing structures despite the latter pulling in another direction. In the case of Estonia under Soviet rule, the informal institutions from earlier periods survived, which made it possible to operate an industry housing several characteristics stemming from the period before. The formal institutions introduced by the Soviet Union were obeyed, at least superficially, but the tie between informal institutions and the structure in Estonia was strong enough to delay the implementation of the set of formal institutions perceived as alien. It can be speculated whether or not the mismatch between the formal Soviet institutions and the informal Estonian institutions actually created a peculiar situation, in which, after all, industrial dynamics could thrive. The particular niche that thus emerged could be interpreted in terms presented by Denzau and North, according to whom multiple equilibria emerge because:

“Individuals with common cultural backgrounds and experiences will share reasonably convergent mental models, ideologies, and institutions; and individuals with different learning experiences (both cultural and environmental) will have different theories (models, ideologies) to interpret their environment. Moreover, the information feedback from their choices is not sufficient to lead to convergence of competing interpretations of reality”⁷²⁶

The development of the chemical industry is worth particular attention. Despite seemingly responding to a call from the Soviet leadership to develop the chemical industry and to pay increasing attention to consumers' needs, the Estonian oil shale industry, including related science, tacitly embarked on a path which contained the hope of breaking with the immediate past. The oil shale industry had increasingly become a millstone for Estonia. Opting for the chemical industry seemed to make it possible to develop the industry in a more independent direction, allowing for more value-added production and broadening the scope of cooperation between Estonian science and industry, i.e. R&D. In addition to this, the standard of living in Estonia could be enhanced by consumer-oriented production stemming from a greater variety of producers, or in brief, a more dynamic domestic industry. But in doing so, the Estonian oil shale community at the same time further entrenched Soviet rule. Therefore, both in the case of cooperation and in the case of non-cooperation with the Soviet rule, the outcome would have been similar, namely strengthening the Soviet grip. Sticking to the energy path only

⁷²⁶ Denzau & North (1994) pp. 3-4.

would perhaps have emphasised the sense of being subdued, while on the other hand, developing the knowledge-intensive chemical industry led to certain complacency with the political situation. Breaking away from these alternatives would have required the closure of the industry or some other dramatic measures, but this was never an option, either for the Soviet rule or for the Estonian oil shale community.

7. The demise of the Soviet Union and the re-birth of Estonia

Estonia regained its independence in August 1991 in connection with the rather sudden demise of the Soviet Union. The Estonian society had to adjust rapidly to the new circumstances, which included radical market reforms. This process was far from simple, especially in sectors which had got accustomed to the Soviet institutional set-up and the Soviet mode of production. The process is described in the following way in an internal newsletter in a shale oil company:

“Similar to our entire young re-established Republic of Estonia, also we come from a period of command economy and ideological absurdity. Many economic notions, which for half a century seemed to be the only possible, suddenly ceased to function. In reality the economic laws were there, like all other laws of nature, even in the Soviet Union, but it was the lack of compliance with them that led to the collapse of that state.”⁷²⁷

Immediately after the re-independence, Estonia embarked on a road of thorough economic reform, including privatization of state-owned assets. In the beginning, starting in 1991, small businesses were privatized, but with the establishing of the Estonian Privatisation Agency in 1993 also bigger companies were sold according to a scheme which originated from the German Treuhand arrangement. The aim was not only to sell to the highest bidder, but also to secure employment and long-term production. In the decade following 1991, some 80 per cent of the formerly state-owned companies found private owners. This process was relatively transparent and it found strong support in the society. In 1998 the Estonian government started privatizing infrastructure enterprises, but *Eesti Energia*, now the owner of the power plants in Narva, was left under government control.⁷²⁸

Steven Solnick compares the rapid collapse of the Soviet Union with a bank run. In the hierarchical system of the Soviet Union, with only highly limited property rights, those having access to assets quickly grabbed them (“privatized”) when the system started crumbling, causing the all too familiar phenomenon of robber barons in many of the successor states to

⁷²⁷ “Juhtima peavad asjatundjad” *Õli ja Kivi*, Nr. 1, Veebruar 2003.

⁷²⁸ Leiman, Santalainen & Baliga (2003) pp. 59-60.

the Soviet Union. Allegiance to the state evaporated with the loss of control.⁷²⁹ Nevertheless, this development was largely avoided in Estonia. Without idealizing the process of transfer of assets in Estonia from state to private hands, it can still be claimed that by and large this process went according to transparent rules.⁷³⁰ This development should be attributed to the institutional set-up, or rather the informal institutions, that re-surfaced when the formal institutions of the Soviet Union eventually failed.

7.1. The present structure of the Estonian oil shale industry

In today's Estonia oil shale is used both for electricity generation and the production of shale oil, as was done during earlier periods. In addition to this, smaller amounts are also used in the construction industry. The total amount of oil shale mined has varied in recent years between 10.7 million tonnes (in 1999) and 14.4 million tonnes (in 1997)⁷³¹. There is, however no clear indication of a continuous decline in recent years, but rather an annually fluctuating production volume, with a new peak in 2004 of 14 million tonnes.⁷³² Out of this, approximately 80 per cent is used for electricity generation, while most of the remaining part is consumed by the shale oil industry. Only 1 – 2% is used by the construction industry.⁷³³

The amount of oil shale in the ground in Estonia is always a question of measurement, because oil shale can be found either in easily reachable deposits with high energy content or deep under ground with small energy content, and all the stages in between. Thus an often-used division is to divide oil shale deposits in active and passive. Only the former are economically reasonable to explore. A more recent approach is to make the division according to energy contents. Active deposits contain over 35 GJ/m³ while passive are above 25 GJ/m³. This would give a figure of 1.4 billion tonnes of oil shale, which would last for one hundred years if the present annual rate of excavation at 13 million tonnes is maintained.⁷³⁴ A more cautious (official) estimate puts the time span until the exhaustion of active reserves in

⁷²⁹ Solnick (1998).

⁷³⁰ For example, an overview of the privatization in the Estonian electronics and telecom sector can be found in Högselius (2005) pp. 92-107. A more general description can be found in Smith (2001) pp.126-133.

⁷³¹ "Eesti põlevkivenergeetika restruktureerimise tegevuskava 2001 – 2006" ("Action plan for restructuring of the Estonian oil shale energy sector 2001 – 2006"), EV majandusministeerium 2001 (Estonian Ministry for Economic Affairs).

⁷³² Home page of the mining company Eesti põlevkivi <http://www.ep.ee/?id=19892> (Accessed April 28, 2005).

⁷³³ These numbers vary slightly with various sources, but the overall picture remains the same. According to Soone & Doilov (2003) the figures are: 86 per cent for electricity generation, 12 per cent for shale oil and the remaining 2 per cent for construction. estimations of these figures might be a little distorted by the fact that there are some imports of Russian oil shale to Estonia.

⁷³⁴ Reinsalu, Enno (2000a) .

present mines at 15 years, while the total potential resources would allow for oil shale exploitation for 40 years, estimating annual consumption at 15 million tonnes.⁷³⁵

The biggest oil shale mining company is *AS Eesti Põlevkivi*, which is 100 per cent controlled by the government-owned *Eesti Energia*. Mining is at present carried out in two open pits and two underground mines. The company has three subsidiaries, which are closely connected to the mining activity. Around 80 per cent of the oil shale mined is used for electric power and heat production while the remaining 20 per cent is used for shale oil production.⁷³⁶ There are also other actors in mining oil shale, including *Kiviõli Keemiatööstus OÜ*, *VKG Aidu Oil OÜ*,⁷³⁷ and *Kunda Nordic Tsement*.⁷³⁸

The government-owned energy monopoly *Eesti Energia* also owns 100 per cent of the power production company *AS Narva Elektriijaamad* (“Narva power plants”), which includes the two big power stations *Balti* and *Eesti*. These two power stations produced 7603 GWh of electricity in 2001, which equals 93 per cent of the total production in Estonia. Installed capacity is 2700 MW electricity and 589 MW heating. A shale oil factory known simply as “the oil factory” also belongs to this branch. The shale oil produced is mainly used in boiler houses in all the Baltic States.⁷³⁹

Electricity generation from oil shale had risen to 9360 GWh in 2003, which amounted to 92 per cent of the total electricity generated in Estonia. The share of electricity generated from oil shale for domestic consumption only was 90 per cent, but generation for exports increased the figure. Electricity generated from gas was 5 per cent while renewables represented less than 1 per cent, despite the fact that generation from renewables had increased 2.7 times in one year’s time. Electricity consumption per capita in Estonia is three times lower compared to the corresponding figures for the Scandinavian countries (with more or less the same climate).⁷⁴⁰

⁷³⁵ “Eesti elektrimajanduse arengukava 2005 – 2015” Available at www.mkm.ee/index.php?id=2619 (accessed January 23, 2006).

⁷³⁶ See the home page of “Eesti Põlevkivi” www.ep.ee.

⁷³⁷ “Eesti elektrimajanduse arengukava 2005 – 2015”.

⁷³⁸ “Lääne-Virumaal alustatakse põlevkivi kaevandamist” (“*Oil shale mining to begin in Lääne-Virumaa*”) press release July 29, 2005 by Kunda Nordic Tsement, homepage www.knc.ee.

⁷³⁹ “Narva Elektriijaamad” (2002).

⁷⁴⁰ “Eesti elektrimajanduse arengukava 2005 – 2015”.

During the latter part of the 1990s far reaching plans were made to sell a significant minority stake (49 per cent) of the power stations in Narva to the American company *NRG Energy*. After several years of intense debate, in early 2002 the Estonian government withdrew its support for this privatization scheme with the motivation that it would have been harmful for Estonia. Fierce resistance to the intended deal came in particular from *Eesti Energia* and academic circles with a connection to the power generating industry (although support to the planned deal was also expressed within the same circles). Formally the debate was focused on financial issues and whether *NRG Energy* was reliable enough for being entrusted basically all power generation in Estonia, but also aspects not directly related to the core issue were important. The Estonian government, which initially was in favor of selling the stake to *NRG Energy*, would have welcomed significant American business interests in the North-East, while both *NRG Energy* and representatives of the US administration expressed some political pressure on Estonia to carry out the deal. In the end this seemingly strong support was not enough to break the resistance within the power industry and its supporting structures. The perhaps most important argument against the deal can be illustrated with an extract from a public letter by a number of professors at Tallinn Technological University in early 2001:

“Relying on its own strength, and if needed by amassing investors, Estonia is capable of switching to new circulating fluidized bed technology at the Narva power stations, thereby securing both continuation of oil shale energy technology and meeting environmental demands”⁷⁴¹

One reason for the resistance to *NRG Energy* was that the company would perhaps not have been able to raise the funds needed for the reconstruction of the power plants. The outspoken scientist Endel Lippmaa claimed in a newspaper interview in 2001 that *Eesti Energia* would be better suited for attracting new money than *NRG Energy* and therefore there is no need to sell 49 per cent of the power stations. Any lender would still have perceived *Eesti Energia* as the ultimate guarantor.⁷⁴² When the deal was about to be called off, the American ambassador to Estonia claimed that the USA would not interfere in the issue. It has been speculated

⁷⁴¹ “Eesti loobub Narva Elektriijaamade erastamise tehingust NRGga” (*Estonia steps down from the privatization affair with NRG*) by Aivar Reinap, Postimees 8.1.2002, available at www.postimees.ee.

⁷⁴² “NRG-tehing võib lõppeda energiakriisiga” (*The NRG affair may end in an energy crisis*) by Aivar Reinap, Postimees 14.6.2001, available at www.postimees.ee.

whether what had been perceived as American pressure actually stemmed from the Estonian government itself.⁷⁴³

It should be emphasized that resistance to the privatization plans came from within the power industry in particular and related academia and it went contrary to the intentions of the government, which received at least some American backing. This indicates that there exists a remarkably strong interest group connected to the oil shale power industry. Even assuming that the picture as forwarded by media is correct, i.e. that *NRG Energy* lacked the financial resources to make it a serious partner, it is still a remarkable show of force from the side of the oil shale community to challenge the own government and American interests over an issue with strong security policy dimensions.

7.2 Bankruptcy and a new start

The turnover of the entire oil shale industry, including its infrastructure (such as transport) comprised 7 per cent of the Estonian GDP at the end of the millennium, or 6 billion Estonian kroon.⁷⁴⁴ In the 1990s parts of the oil shale industry, especially the shale oil production, faced a serious threat from the very low oil prices in the world market. Shale oil had primarily to compete with Russian crude oil and could not prevail in the price competition. The situation was further aggravated by the increase in the price of oil shale, which basically was a result of decisions made by the Estonian government, which controls the oil shale mining company *Eesti Põlevkivi*.⁷⁴⁵ The crisis reached its climax in 1998, when the world market prices for crude oil fell below \$10 per barrel, while the price for mazut, or Russian fuel oil, which has a crucial impact on the price for Estonian shale oil, fell by 36 per cent in the autumn of 1998.⁷⁴⁶

In 1994 the industries at Kohtla-Järve and Kiviõli were merged into the shale oil producing company, *Kiviter*. In 1997, 50 per cent of the shares in this government-owned company were sold to a company *Eriõli*, which, according to Rooks, was unknown to the oil shale people.

⁷⁴³ "Selge sõnum" (*A clear message*) by Marek Dreving, *Postimees* 27.12.2001, available at www.postimees.ee

⁷⁴⁴ Öpik & Öpik (2001). The authors give the figure 10% of GDP. This does not fully correspond with figures presented in a report "Overview of Estonian economy 2004" (p.5) by the Estonian Ministry of Economic Affairs and Communication and Ministry of Finance. See www.mkm.ee/index.php?id=1323 (accessed on May 16, 2006).

⁷⁴⁵ Rooks p. 117.

⁷⁴⁶ Rooks pp. 128 -130.

The new masters were both young and inexperienced.⁷⁴⁷ Their first task was to cope with the dramatically worsening market conditions. In the spring of 1998 two shale oil factories shut down their production and one was conveniently closed for long-term renovation. The production of bitumen continued at Kiviõli, thanks to the demand in road construction. In order to earn money, the company now collected and sold its scrap metal. In October 1998, a further shale oil factory was shut down, while the demand for bitumen ceased because of the seasonal character of road construction.⁷⁴⁸ An attempt to restructure the debts to *Eesti Põlevkivi* failed despite goodwill from the latter, which feared what the loss of a big customer would do to the whole industry. In the beginning of 1999 *Kiviter* eventually went bankrupt, with debts exceeding assets almost four times (424 million EEK against 118 million EEK).⁷⁴⁹ This company was the direct successor of the shale oil industry created in the 1920s. It was the predecessor of this company that the Estonian government had intensively promoted in the 1920s and 1930s, and which various Estonian interest groups had protected during several decades of Soviet rule, and saved by switching production in new directions. In 1998, the Estonian government had no obvious interest in *Kiviter* any longer, or at least no interest worth paying for. In August 1998 *Kiviter* asked the government for financial support, 64 million EEK, in order to cover losses, to increase the tariffs on imported fuel oils and to prohibit the imports of sulphurous fuel oils. Were these pleas not met, a total of 3000 people would lose their jobs, the company claimed.⁷⁵⁰ The collapse of *Kiviter* left thousands of people unemployed, which prompted action from the government (more on which in the chapter 8.5 on social conditions). What once had been a central element in the Estonian national aspirations was without remorse wiped out by the market forces. Soon what remained of *Kiviter* was taken over by a newly-established company, *Viru Keemia Grupp*, (*VKG*), but this time the prime mover was the dynamics of the market. National aspirations played no longer the decisive role. Today, *VKG* naturally stresses its links back in time, and its important function in the local society, but in contrast to its predecessors, *VKG* is just a private company operating in today's market-oriented Estonia.⁷⁵¹

⁷⁴⁷ This is after all a rather modest wording. In Estonian press it has been hinted that assets were actually transferred from the company through a rather complicated scheme, which would point at experienced people, although not in the shale oil business. See for example "Margus Kangro astub Hanschmidti jälgedes" (*Margus Kangro goes in the footsteps of Hanschmidt*) by Peeter Raidla, *Äripäev* 29.9.2005. Available at www.aripaev.ee

⁷⁴⁸ Rooks pp. 129 – 131.

⁷⁴⁹ "Kiviter venitab pankrotiprotsessi", (*Kiviter drags on bankruptcy process*), *Eesti Päevaleht*, February 2, 1999.

⁷⁵⁰ "Kiviter seisumise äärel" (*Kiviter at the verge of a stop*), *Eesti Päevaleht*, August 12, 1998.

⁷⁵¹ The owners of *VKG* are a group of Estonian investors. See *Äripäev* 29.9.2005 as referred to above.

This situation is to some extent reminiscent of the situation in the first post-WWII years. A sudden change more or less wiped out previous institutional arrangements to an extent that virtually no fundamental formal institutions remained in place. Still production of shale oil was soon resumed. Had the Soviet system been the only guarantee for the existence of the shale oil producing industry, it would have ceased to exist at this juncture in history. But despite initial problems, the shale oil producing industry adjusted to the new conditions and it has up to this day found its niche. High prices for oil on the world market, in particular, have made this industry profitable. In a somewhat similar fashion to their predecessors in the second half of the 1940s, the engineers, chemists and blue or white collar workers of the 1990s went on with their everyday tasks, thus keeping up the routines despite lay-offs and bankruptcy.

8. The political economy of Estonian power production

As has been mentioned earlier, Estonia generates approximately 92 per cent of its electricity power from the combustion of oil shale. This issue has lately been far from uncontroversial. One of the main objections to continuing oil shale-based power generation is the environmental concerns. But the environmental concerns have to be weighed against other issues such as security of supply, alternative energy sources, social concerns in the region of Ida-Virumaa, dominated by the oil shale industry, and where the vast majority of the population is Russian-speaking. Moreover, the oil shale industry is one of the very few areas where Estonian industry is a world leader. Thus, claiming that changes in any one aspect of the oil shale industry will have repercussions in several other areas is definitely no overstatement. In order to be able to paint the full picture of the situation, the following chapter will deal with each identified component separately. It does not take too much imagination to see that effectively the issue is a real-world example of a system, where numerous, seemingly unrelated, components together make up a whole. The system, i.e. the Estonian oil shale industry, interacts with the surrounding world, but contrary to several other systems of a similar kind, it can relatively easily be studied as an entity of its own with clearly defined borders, not only because of its technological uniqueness, but also because of the social and political characteristics it has developed over time.

8.1. Security of supply

All of the Baltic States are concerned about the security of supply of energy. This is clearly manifested in the common declaration of the Prime Ministers of the three countries in February 2006, which calls for EU support in case there are disruptions in the energy supply in a member state. Moreover, the Baltic Prime Ministers call for utilizing the vast storage capacity for natural gas in the Baltic States as a security measure against disruptions.⁷⁵² In addition to this, the Baltic Prime Ministers support the idea of a harmonized EU external

⁷⁵² It should be kept in mind that the Ukraine faced gas delivery disruptions from Russia in the winter of 2006, probably due to political reasons.

energy policy, making it possible to “speak to the suppliers of energy resources in a single strong voice”.⁷⁵³ Similar reasoning is to be found in the following statement by the Estonian Foreign Ministry, 22, June 2006:

“The gas disputes at the beginning of 2006 between Russia and some of its neighbors stress the importance of energy security for all Europe. Estonia considers matters of energy security very important. As a complex issue, energy security will remain a matter of concern in the foreseeable future and continue to have an increasing impact on the overall security of the European Union. For Estonia as well as for Latvia and Lithuania the need to connect Baltic gas and electricity grids with the rest of the EU internal market remains an important issue of energy security.”

The statement continues:

“An essential element of the common energy policy should be enhanced solidarity between Member States in order to deal with difficulties related to the physical security of infrastructure and security of supply. All actions must be considered in the framework of that primary goal. Establishing best guarantees of energy security requires setting clear criteria for situations where solidarity measures will be applied”⁷⁵⁴

By the end of 2006 the ESTLINK cable connection with Finland was taken into use, which eased the pressure on the Baltic electricity grid, while at the same time reducing dependence on Russia.⁷⁵⁵

The fear of being dependent on Russia is certainly not groundless. In 1992, Russia introduced world-market pricing for exports of energy also to countries that had been a part of the Soviet Union. An agreement with Estonia on barter trade at world market prices in December 1991 did not become effective until the following spring, and meanwhile industrial production in Estonia dropped by roughly 40 per cent.⁷⁵⁶ David J. Smith, in his work on political developments of present-day Estonia, is straightforward about this point:

⁷⁵³ Declaration of the Prime Ministers of Lithuania, Latvia, Estonia on security of supply in the Baltic States and common European energy policy. 27 February 2006, Trakai, Lithuania” available at www.ena.lt/pdfai/Declaration.doc , accessed on September 8, 2006.

⁷⁵⁴ www.vm.ee/eng/euro/kat_486/2760.html , accessed on September 8, 2006. The homepage of the Estonian Foreign Ministry www.vm.ee.

⁷⁵⁵ “Eesti elektrimajanduse arengukava 2005-2015” .

⁷⁵⁶ Smith (2001) p. 116.

“In raising prices whilst simultaneously cutting exports, Russia made no secret of its intention to use energy policy as a lever for realizing its political aims with regard to Estonia”⁷⁵⁷

Whether the Russian price hikes were economically justified or not, from an Estonian perspective they strengthened the understanding that continued reliance on Russia was risky. But apart from oil shale, at present Estonia has few domestic options.

Nuclear power has up to the present not been considered a viable option for Estonia. Nuclear technology simply comes in too large units for Estonia – a 1000 MW reactor is too big. Present total generation capacity at the oil shale-fuelled power plants is 2400 MW, but generation takes place in several units, or blocks. Any one block can be shut down and restarted according to demand. Moreover, there is the question of popular support. People have many reasons to prefer oil shale to nuclear power, especially with the memory of Chernobyl still very much alive, because several people from Estonia were sent to clean up after the disaster.⁷⁵⁸ The outspoken academic and internationally renowned physicist Endel Lippmaa warned in a newspaper interview in March 2006 against having many stakes in nuclear cooperation with Lithuania on the Ignalina power plant. The Lithuanian energy system is too closely connected with the Russian one and moreover:

“In reality it is Russian electricity, because we are a part of the electricity system of the Russian Federation. The regulation of the power plants is done in Moscow. In the first place, this should be overcome and only then can we talk about a Baltic market. At present it does not exist. Ignalina and Sosnovyi Bor, as well as Chernobyl, are not power plants, but tritium factories, which Russia needs for the renewal of its hydrogen bombs. Energy is only a by-product.”⁷⁵⁹

However, Lippmaa sees oil shale as the best option at present and in the near future. If and when the resources are exhausted and unless new technology has been developed by then, the best option would be to cooperate with Finland, perhaps with a joint nuclear power plant.

⁷⁵⁷ Ibid.

⁷⁵⁸ Tõnis Meriste, Environmental Manager of Eesti Energia, personal communication, Tallinn, January 15, 2007.

⁷⁵⁹ “Lippmaa: mõelgem tuumaenergiale, kui põlevkivi lõppeb” (*Lippmaa: Let's think about nuclear energy when oil shale is exhausted*) by Liisi Poll, *Postimees* March 7, 2006.

According to Einari Kisel, director of the Energy Department of the Estonian Ministry for Economic Affairs, the Baltic energy systems are interdependent. The Baltic States have each their own policy, but in reality any new producer will have to compete with Russian electricity unless limitations on the imports from Russia are introduced, because the Baltic states still form a common electricity grid with Russia. As a result, there are no new Baltic producers in sight. Today, Russian energy companies have bigger influence in Latvia and Lithuania than in Estonia, mainly due to the existence of the oil shale-based generation capacity. However, it is possible that in 10-15 years' time, imports from Russia might decrease significantly because of ever more outdated generation facilities in Russia. This would to some extent speak in favor of a common Baltic nuclear power plant in Lithuania, but mainly for political reasons Estonia will favor domestic electricity generation - preferably from multiple sources, but where modernized oil shale-based generation would form the backbone.⁷⁶⁰

8.2. Energy resources⁷⁶¹

8.2.1. Fossil energy alternatives

Estonia's energy import reliance is approximately 1/3, while the corresponding EU average is 2/3. The relatively low reliance on imports for Estonia is mainly due to the extensive use of domestic oil shale. Thus, Estonia is relatively self-reliant and less exposed to price fluctuations on the international market. If Estonia, for one or the other reason, should prefer switching from oil shale to some other source, serious obstacles would have to be surmounted; first, national self-reliance would have to be sacrificed and second, a new energy source would have to be found and agreed upon.

Total primary energy supply (TPES) in Estonia was 194 PJ in 2002. Of this, 116 PJ or 60 per cent was oil shale. Other domestic supply – 12.5 per cent of the total - consist mainly of wood and peat. In addition to this some three per cent of primary energy supply is fuel oil, which to

⁷⁶⁰ Einari Kisel, personal communication, May 16, 2007.

⁷⁶¹ In this chapter I will refer repeatedly to two reports; the first, which I for the sake of simplicity call "Energy 2004", is the national long-term development plan for fuel and energy economy until 2015 ("*Kütuse- ja energiamajanduse pikaajalise riikliku arengukava aastani 2015*"). The second, which I call "Electricity 2005" is the development plan for the Estonian electricity economics 2005-2015 ("*Eesti elektrimajanduse arengukava 2005-2015*").

a large extent is domestically produced.⁷⁶² Thus, Estonia has a high degree of self-reliance in primary energy supply in addition to being de facto totally self-sufficient in electricity generation. Motor fuels have to be imported, however. An indication of the degree of self-reliance can be estimated for Estonia and some neighboring countries by calculating the share of energy production in relation to TPES as well as the share of imports in relation to TPES.

Table 8.1. Energy production⁷⁶³/ TPES and energy imports/TPES for selected countries in 2004.

Country	<i>Energy production/TPES, in %</i>	<i>Imports/TPES, in %</i>
Estonia	68.6	42.3
Latvia	46.5	85.6
Lithuania	56.9	133.4
Sweden	65.1	61.4
Finland	41.7	72.5

Source: IEA, own calculations.⁷⁶⁴

Notwithstanding the fact that the figures are not totally unambiguous indications of domestic versus imported energy (as some processed forms of imported energy are subsequently exported. Therefore Lithuania, for instance, has imports that are 133 per cent of the total energy supply), the figures in table 6 still clearly demonstrates that Estonia is considerably more self-reliant regarding energy than most other countries in the region. Only Sweden, with its far-reaching reliance on domestic hydro and nuclear power production, comes close to Estonia in this respect.

The presently exploited oil shale deposits are estimated to last until 2025, assuming no changes occur in demand. Still unexploited active deposits of oil shale would allow for using oil shale until at least 2060.⁷⁶⁵ Gross domestic energy consumption in 2002 was 276 PJ, of

⁷⁶² "Estonian Energy 2002", Ministry of Economic Affairs and Communications. Note that these percentages do not match perfectly with the figures in the table below because exports and imports are included in the figures. Thus, Estonia is statistically almost completely self-sufficient in energy, but in reality petroleum, for instance, has to be imported. Part of the Estonian-generated electricity is exported.

⁷⁶³ Energy can of course not be produced in the traditional sense of the word. However, when energy carriers such as shale oil are produced industrially, it becomes reasonable to lump together electricity generation and shale oil production under the concept "energy production".

⁷⁶⁴ Data available on <http://www.iea.org/textbase/stats/index.asp>.

⁷⁶⁵ Energy 2004.

which 107 PJ was final consumption, while 158 PJ was conversion to other forms of energy. From final consumption some 18 per cent consisted of electricity.⁷⁶⁶

The alternative of replacing oil shale with natural gas as an energy source raises some serious concerns for Estonia. First of all, an increase in gas imports from Russia would require new investment in infrastructure. Second, there is some obvious hesitation in Estonia for a far-reaching dependence on Russia – or as Tõnis Meriste of Eesti Energia puts it: “*The valve is on the wrong side of the border*”, with reference to recent friction between Russia and some former Soviet republics.⁷⁶⁷ A solution to this would be to integrate the Estonian gas network with that of rest of Europe or with Finland. An additional measure would be to cooperate with Latvia for underground gas storage. Natural gas for heating has to compete with heating oil and shale oil and this price competition is decisive for the cost development.⁷⁶⁸ At present Estonia imports all of its natural gas from Russia, with a daily purveyance exceeding 5 million cubic meters. The capacity ceiling is however at 8 million cubic meters. Electricity and heat from natural gas is generated at the power stations at Iru (417 GWh in 2003) and the much smaller Sillamäe station (7.3 GWh)⁷⁶⁹

In recently renovated boiler blocks in the Narva power stations, coal could be used parallel with oil shale. Estonia has no coal deposits of its own. Also peat, a domestic fuel in Estonia, could be used together with oil shale. Peat, however, causes high emissions of CO₂ and is often found in areas of nature protection areas.⁷⁷⁰

Ilmar Öpik estimates that the consumption of oil shale could be reduced from the present 10 million tonnes for electricity generation annually to somewhere between 6 and 7 million tonnes. This would require enhanced efficiency both in production and transmission. Only some 20 per cent of the energy in mined oil shale actually reaches the end consumers.⁷⁷¹ Öpik continues:

⁷⁶⁶ “Estonian Energy 2002”, Ministry of Economic Affairs and Communications.

⁷⁶⁷ Tõnis Meriste, Environmental Manager of Eesti Energia, personal communication, Tallinn, January 15, 2007.

⁷⁶⁸ Energy 2004.

⁷⁶⁹ Electricity 2005.

⁷⁷⁰ Energy 2004.

⁷⁷¹ Öpik (2002) arrives at this estimate by multiplying the efficiencies at various stages. The efficiency rate is 85 per cent for enriching, 30 per cent for conversion and 80 per cent for power transmission. Thus, $0.85 \times 0.3 \times 0.8$ equals roughly 0.2 or 20 per cent.

“No wonder, therefore, that one may hear voices not only from Brussels, but from here in Estonia as well, in favor of stopping utilization of oil shale polluting the environment and of liquidating the ineffective and uneconomic oil shale industry”⁷⁷²

He dismisses several alternative energy sources as “fairy tales”. Only in combination with fossil fuels can renewables play a role and then especially wood and ligneous fuel which is a by-product from the forest industry. But perhaps the most important step in reducing environmental hazards would be improving the Narva power plants.

To sum up, replacing oil shale with natural gas, peat or coal would most likely imply even bigger problems than continued reliance on oil shale. Therefore large-scale use of these fuels can be excluded, at least for the time being.

8.2.2. Electricity generation

The Estonian electricity grid has been linked only to Russia and the other Baltic states.⁷⁷³ The transmission capacity is dimensioned to cover total consumption. However, the structure of the Estonian power grid is not particularly suited for the development of dispersed power generation, or renewables. Although the grid is relatively well developed and has adequate capacity, it is basically constructed on the premise that power production takes place in Narva while consumption mainly takes place in Tallinn (with roughly 1/3 of the inhabitants of Estonia).⁷⁷⁴ Losses in the grid have diminished significantly in the past decade. In 1996 the losses were close to 25 per cent, while the figure for 2003 was approximately 13 per cent. The goal is to reduce the share of losses to 8 per cent by 2009 and keep the total lost amount unchanged until 2015, which means that despite more power being transferred, the losses would not be allowed to increase accordingly.⁷⁷⁵

The total installed power generation capacity in Estonia was 2433 MW in 2006 (see table 8.2.below). It is worth mentioning that the total installed capacity was significantly higher in

⁷⁷² Öpik (2002) p. 199.

⁷⁷³ From November 2006, there has been a cable connection to Finland.

⁷⁷⁴ Energy 2004.

⁷⁷⁵ Electricity 2005.

2002, namely 3019 MW. This discrepancy in figures is a result of shutting down units because of the renovation of energy blocks in the Narva power stations.⁷⁷⁶

Table 8.2. Electric power generation in Estonia.

Power station	Installed capacity, MW	Fuel	Owner
Narva power stations (Narva elektri jaama AS), two stations, Eesti and Balti	2142	Oil shale	Eesti Energia AS
Iru	171	Natural gas	Eesti Energia AS
Co-generation stations, all	85	Oil shale, natural gas	Eesti Energia AS, Private capital
Renewables	35	Wind, water, biogas	Private capital
Total	2433		

Source: "Aruanne elektri- ja gaasiturust Eestis" ("Report on the electricity and gas market in Estonia") Energiaturu Inspeksioon, Tallinn 2006.

Table 8.3. Electricity balance of Estonia. In GWh (TWh/1000).

Year	2002	2005
Generation	7634	9114
Final consumption + losses in the grid	6944	7506
Imports	412	345
Exports	1102	1953
Net exports	690	1608

Source: "Aruanne elektri- ja gaasiturust Eestis" ("Report on the electricity and gas market in Estonia") Energiaturu Inspeksioon, Tallinn 2006.

There is a notable discrepancy between various sources available. According to "Estonian Energy 2002" electricity generation of the power stations was 8.5 TWh in 2002⁷⁷⁷ while "Energy 2004" gives the figure of 8.5 TWh as total energy production of the power plants,

⁷⁷⁶ Electricity 2005.

⁷⁷⁷ Estonian Energy 2002 p. 39.

thus likely including heating. Domestic consumption of *energy* constituted 5.3 TWh in 2002. "Estonian energy 2002" puts final consumption of *electricity* at 5.3 TWh.⁷⁷⁸

Operating with figures from "Estonian Energy 2002" the electricity balance for 2002 was as follows: exports 1.1 TWh, own use in plants 1.3 TWh, losses 1.3 TWh. Imports were 0.4 TWh.⁷⁷⁹ It is estimated that total electricity consumption in Estonia will reach 7 to 9 TWh by 2015 and 9 to 15 TWh by 2030. The confusion of figures is increased by "Electricity 2005" which although putting the total generation for 2002 at 8.5 TWh, gives the figure of 10 TWh for 2003, which would imply that the estimated generation for 2030 would have been reached only one year after the previous report. The most significant change in consumption between 2002 and 2003 was the increase in exports by 80 per cent.⁷⁸⁰

Exports of electricity fluctuate in accordance with water reserves in the hydro power stations in Latvia.⁷⁸¹ At present Latvia has a total installed electricity power generation capacity of 2200 MW, of which 71 per cent is hydro power.⁷⁸² Latvia has significantly more inhabitants than Estonia (2.3 million compared to Estonia's 1.4 million) but has a smaller total installed electricity power generation capacity than Estonia. This fact leaves Latvia with no other option at present than to import electricity from neighboring countries. Net imports of electricity have been in the range 2.1 TWh – 2.8 TWh annually between 2000 and 2004.⁷⁸³ Not all of Latvia's imports originate in Estonia, but Lithuania and Russia, too.

The nuclear power plant at Ignalina in Lithuania will be shut down in 2009. The consequences for the entire Baltic electricity system will be far-reaching, but most likely the demand for oil shale-produced electricity will increase. The leading energy companies of the three Baltic states, *Lietuvos Energija* (Lithuania), *Latvenergo* (Latvia) and *Eesti Energia* (Estonia) have agreed to commence with initial studies on a joint nuclear power plant.⁷⁸⁴ Due to Estonia's significant economic growth since the mid-1990s, domestic electricity consumption is estimated to increase. A serious problem arises when this development is

⁷⁷⁸ Estonian Energy 2002 p. 9.

⁷⁷⁹ Estonian Energy 2002 p. 39.

⁷⁸⁰ "Electricity 2005" p. 8, table.

⁷⁸¹ Electricity 2005.

⁷⁸² Eurostat, Electricity Statistics, Provisional data for 2004.

⁷⁸³ Figures vary somewhat depending on the source. For more details on the estimates on Latvia's electricity imports, see www.iaea.org/inis/aws/eeddrb/data/LV-elim.html.

⁷⁸⁴ "Balti riikide energiafirmad sõlmivad tuumaleppe" (*The energy companies of the Baltic States to sign nuclear agreement*), by Aivar Reinap, Postimees, March 7, 2006. www.postimees.ee, accessed on August 3, 2006.

contrasted with the fact that environmental concerns will force existing power generation capacity either to be renovated (as has been done partially in the Narva power stations) or to be shut down altogether. In addition to the renovated parts in the Narva power plants, only the significantly smaller, natural gas-powered, Iru station (near Tallinn) will fulfill the new requirements when the transition period on electricity generation agreed upon in connection with Estonia's accession to the EU runs out in 2015. As a result, the capacity of total Estonian power generation will reach only 25 per cent of the capacity in place, unless new capacity is built. If far-reaching dependence on neighboring countries for the supply of electricity is considered problematic, there is no alternative to constructing new capacity in Estonia.⁷⁸⁵ Estonia wishes to draw on the European Union's cohesion fund for funding environmentally important investments in oil shale power generation. The estimated costs exceed 10 billion Estonian kroon. The investment program requires that equipment to reduce sulphur emissions should be in place in all power plants by 2015, including small local ones. In addition to this, in 2005 also a part of the *Balti* power plant was shut down, namely the TP-17 boilers, which were the most environmentally hazardous.⁷⁸⁶ Thus, the overall installed capacity has actually decreased. But at the same time, as a result of the renovation works, electricity generation capacity can be increased by a total of 80MW, in part resulting from enhanced fuel efficiency (approximately 20 per cent) in the circulating fluidized bed boilers (up from 30 per cent to 36.5 per cent).⁷⁸⁷

Another problem identified in "Energy 2004" is the development of education and research in energy related sectors. Despite a large potential, the development of education and research has been hampered by the high structure of the scientists in parallel with a lack of funding. Research activities have not succeeded in providing enough support for modernization of the energy sector. Thus, there is a need for developing education in energy-technology.

Per capita consumption of electricity remains relatively low in Estonia (Table 8.4.), partly because Estonia has relatively little energy-intensive industry, but also because of a lower GDP/capita or a lower material standard of living, which effectively prevents consumption.⁷⁸⁸

⁷⁸⁵ Energy 2004.

⁷⁸⁶ "Electricity 2005" p. 7. There have been three types of boilers in use – TP-17, TP-67 and TP-101. Emissions of SO₂ from the TP-17 were 3,500 mg/Nm³ in 2001, while the corresponding figures for the other two types were 1,500 and 1,900 respectively. Emissions of NO_x were roughly on the same level for all three boiler types. Source: EBRD (2002).

⁷⁸⁷ EBRD (2002).

⁷⁸⁸ Laur, Soosaar & Tenno (2003).

As a result of Estonia’s rapidly growing economy, consumption of electricity will most likely increase significantly in the near future.

Table 8.4. Table. Electricity consumption per capita in selected countries.

Country	Electricity consumption, kWh/person
Estonia	4434
Sweden	16565
USA	14043
EU-15	7322
OECD total	8625

Source: “Energy in Sweden 2005”, “Electricity 2005”.

The Estonian electricity market has been open for competition for large users only, those with annual demand exceeding 40GWh, since July 1999. This is slightly more than 10 per cent of total demand. According to the accession agreement between Estonia and the EU, the electricity market should be opened up no later than the end of 2008 to an extent of 35 per cent, while the deadline for complete opening is by the end of 2012.⁷⁸⁹ In order to reach this, the following questions have to be adequately addressed:

First, the Estonian electricity market is dominated by one producer and seller, namely *Eesti Energia*. In order to guarantee efficient competition, the entrance of several firms into the market would be required. Second, present generation capacity will not live up to environmental requirements. New investment will be hard to attract in Estonia under free market conditions. Third, as Estonia has the technical capacity to import all the electricity needed, the conditions prevailing outside Estonia will have a major impact, i.e. the oil shale-based production can be seen as a disadvantage.⁷⁹⁰ As was mentioned before, the fact that the electricity grid of Estonia is connected with that of Russia (and the other Baltic states) complicates the overall picture. New production capacity will have to count not only with conditions in the Estonian (or Baltic) market, but the Russian as well.

Electricity prices for consumers have remained significantly lower in Estonia than in most other EU countries. In 2001, the household electricity price was approximately 3 EURcent per

⁷⁸⁹ Energy 2004.

⁷⁹⁰ Ibid.

kWh, while the EU average was 12 EURcent per kWh. Even in comparison with Latvia and Lithuania, the household prices in Estonia were some 50 per cent cheaper.⁷⁹¹ Significant price hikes in 2005 brought the price for electricity in Estonia closer to that of Latvia and Lithuania, but the Estonian prices still remain low in comparison with the rest of the EU. The household prices now vary between 6.4 and 8.7 EURcent per kWh. This situation is unlikely to prevail, because bringing Estonian environmental standards in power generation to an all-EU level will result in closing some power production units. Moreover, in the future there might be large investments in new power generation capacity either specifically in Estonia or as a joint Baltic enterprise. In addition to this, the gradual opening of the Estonian electricity market between 2010 and 2013 will result in higher excise duties on electricity. Upward pressure on electricity prices is mitigated by the significant revenues *Eesti Energia* makes on selling carbon dioxide emission quotas (some 50 per cent of the company's annual profits are reported to originate from this trade). In the long-run, though, electricity prices are expected to increase as much as 50 – 60 per cent.⁷⁹²

8.2.3. Oil and chemical products

Profitability in the shale oil industry is a function of the world market price for oil. With today's technology, which is basically the same as in Soviet times, profitability is reached when oil prices in the world market exceed USD 30 per barrel.⁷⁹³ *Viru Keemia Grupp (VKG)* in Kohtla-Järve, one of the two producers of shale oil, saw profits (before taxes) jump more than 14-fold between 2001 and 2005.⁷⁹⁴ At the end of 2005, *VKG* expanded its oil production capacity by 15 per cent and is presently planning to build a new production unit by 2008, which would enable production of oil from fine grained oil shale. Two more similar units are planned to be constructed in 2010 and 2011. The technology would basically be the UTT-3000, i.e. using a solid heat carrier as described in a previous chapter (the present technology used by *VKG* is based on the Kiviter-process). Being dependent on the world market price for oil, i.e. an external factor the company totally lacks control over, is a cause for uncertainty, though. In order to reduce this dependence, *VKG* aims at increasing the role of other chemical

⁷⁹¹ Streimikiene (2007).

⁷⁹² "Monetary Developments & Policy Survey March 2006", published by Eesti Pank. Available at www.eestipank.info/pub/en/dokumendid/publikatsioonid/seeriad/ylevaade/-2006-03taust3.pdf, accessed on February 7, 2007. See also Tenno & Laur (2003).

⁷⁹³ Einari Kisel, director of the energy department of the Ministry of Economic Affairs, personal communication May 16, 2007.

⁷⁹⁴ Net profits in 2005 were 133.7 million Estonian kroon, compared to 9.3 million in 2001. Source: Viru Keemia Grupp, yearbook 2005.

products such as phenols and, later, industrial adhesive resins. A step in this direction was taken with the purchase of 100 per cent of the shares in *Viru Liimid AS* in 2005. This company is specialized in resins used in wood or rubber production.⁷⁹⁵ In addition to this, various other chemicals are produced. For instance, clean phenols can be separated for the production of hair dye. In 2007, this was tried for the first time on an industrial scale.⁷⁹⁶

The present higher world market price for shale oil and the ensuing higher profits for *VKG* have also made it possible for *VKG* to increase its R&D spending. The focus is on making it possible to utilize the whole potential of oil shale, thus differing from electricity generation, which only uses oil shale as combustion fuel. In the field of environmental protection, there are plans to add limestone, CaCO_3 , to the boiler of the electrical power plant. At 800°C the limestone becomes calcium oxide CaO and carbon dioxide CO_2 . CaO is then further mixed with water, H_2O , becoming $\text{Ca}(\text{OH})_2$ i.e. calcium hydroxide, to which sulphur dioxide is added. This in turn binds sulphur resulting in CaSO_3 , which is plaster (gypsum) ash, which can be used as a raw material for cement. Emissions of sulphur dioxide in particular have been a problem for the oil shale industry.⁷⁹⁷ Estonia was allowed a transitional period until 2016 in its accession agreement with the EU.⁷⁹⁸

It should be mentioned that also *Eesti Energia* is experimenting with tying carbon dioxide to calcium hydroxide (or perhaps some other reagent), i.e. a similar process to the one *VKG* may use in reducing emissions of sulphur dioxide. Additional gains are made when the processing temperature is lowered from 1000°C to 700°C , because at the lower temperature only 75 per cent of the limestone will decompose. The chemical composition of limestone is the prime reason why oil shale creates emissions of carbon dioxide. Raw material for such processes exists in abundance in the giant ash heaps in the industrial landscape of *Ida-Virumaa*.⁷⁹⁹

⁷⁹⁵ Viru Keemia Grupp, yearbook 2005.

⁷⁹⁶ Meelika Nõmme, R&D Project Manager, Viru Keemia Grupp, personal communication, January 17, 2007, Kohtla-Järve. During our conversation Ms Nõmme mentioned a curious detail, namely that in Austria local shale oil is used at health spas. A quick search on the Internet reveals that the phenomenon is not restricted to Austria only, but shale oil as an ingredient in health and cosmetic products is widespread. Actually, Tirolean shale oil was first mentioned as early as 1350, and already by then it was used as a medical substance. (Source: Kattai (2003). The Estonian oil shale industry has not gone into the wellness business, yet.

⁷⁹⁷ The UTT-3000 technology used in Narva emits less sulphur and this is one of the reasons *VKG* will introduce the technology.

⁷⁹⁸ Meelika Nõmme, R&D Project Manager, Viru Keemia Grupp, personal communication, January 17, 2007, Kohtla-Järve.

⁷⁹⁹ Tõnis Meriste, Environmental Manager of *Eesti Energia*, personal communication, Tallinn, January 15, 2007

VKG has to dispose of the semi-coke according to EU directives. The semi-coke is cemented and used as a basis for the waste disposal. The gases are lead to the electric power plant, but this process produces SO₂, which now is cleaned in cooperation with *Alstom Sweden*. The emissions of SO₂ used to be 6,000 – 7,000 mg /m³, but now they can be reduced to some 800 mg /m³, while the emissions of CO₂ are technically speaking no particular problem for VKG, because the emission quota has not been reached and accordingly VKG sells emission rights.⁸⁰⁰

Another factory producing shale oil is located in Narva, founded in 1980, and owned by *Eesti Energia*. The factory produces a liquid fuel with low sulphur content, the main market for which is boiler houses in the Baltic States.⁸⁰¹ Because of the regulated electricity prices, most of the profit of the Narva power stations actually stems from shale oil production.⁸⁰²

Mining concessions for a total of more than half a billion tonnes have been granted, most of which to the state owned *Eesti Põlevkivi* mining company, but also 38 million tonnes to VKG and 20 million tonnes to the construction company *Merko* as well as smaller concessions to *Kunda Nordic Tsement* and *Tamme auto*, which in 1999 bought *Kiviõli keemiatööstus* (which once was *Estländische Steinöl* or *Eesti Kiviõli*) from VKG. At that time production at Kiviõli had been halted, but was restarted with the change of ownership.⁸⁰³ The latter produces 65,000 tonnes of shale oil annually and employs 700 persons. The shale oil produced is used mainly in boiler houses in Estonia and the other Baltic states. Other products are impregnation oil, phenols and peat briquettes.⁸⁰⁴

8.2.4. Summary

The Estonian oil shale industry is presently a relatively well functioning conglomeration of industry, on which Estonia is totally dependent. In addition to this, the oil shale industry forms the backbone of the regional economy in the north-eastern parts of the country. Furthermore, Estonian know-how of shale oil production is, according to Einari Kisel of the

⁸⁰⁰ Meelika Nõmme, R&D Project Manager, Viru Keemia Grupp, personal communication, January 17,2007, Kohtla-Järve.

⁸⁰¹ "Narva Elektriijaamad" .

⁸⁰² "Kas põlevkivi on meie õnn või õnnetus?" ("Is oil shale our blessing or curse?", in Estonian) by Edgar Savisaar. *Põhjarannik* 17. jaanuar 2007.

⁸⁰³ "Energiatööstusest" (*On the energy industry*, in Estonian) by Väino Laanoja, *Õli ja Kivi*, internal newsletter of OÜ Kiviõli Keemiatööstus, Nr 1, Veebruar 2003.

⁸⁰⁴ www.keemiatööstus.ee (home page of Kiviõli keemiatööstus, accessed on March 6, 2007) See also the home page of the parent company Tamme auto, www.tammeauto.ee, a construction and transport company.

energy department at the Estonian ministry of Economic Affairs, becoming increasingly in demand internationally. Particular interest has been showed by Jordan, but also by Russia, China, Australia and Egypt.⁸⁰⁵

Against this background, with the addition of the closure of Lithuania's Ignalina nuclear power plant, it is obvious that in the short term there is no obvious option to sticking to the oil shale-based energy system. The most urgent environmental hazards are rather a matter of finding funding for piecemeal improvement than about replacing the existing system, which generates electricity, jobs, income, national security (to some extent even for Latvia and Lithuania), and perhaps even nationally prestigious projects abroad. Any challenging energy system will have to compete somehow with this wide range of qualities. The dependence on the oil shale sector is further entrenched by the fact that Estonian electricity (and energy in general) consumption is estimated to increase in the near future, not least as a consequence of the more or less spectacular economic growth recorded in recent years.⁸⁰⁶

In a highly critical article about excessive private sector utilization of the oil shale deposits, the then minister of economy and communication, Edgar Savisaar estimated that the total value of the Estonian oil shale at world market prices for oil in January 2007 would equal 30 billion dollars. When the world market price for crude oil exceeds 30 USD, production of Estonian shale oil production becomes profitable. He suggests a Norwegian model, which means that the state would be a monopoly concession holder and producer and that incomes generated from oil shale would remain in state hands. He even contemplates the possibility of buying back previously granted concessions.

“Let us finally realize that Estonia with its oil shale deposits could one day turn out to be as rich as the oil states of the Middle-East. This is no fairy tale, this is real money there inside the earth, which will be more valuable as time goes by.

Is this our blessing or curse? In the same way it could be asked whether two trillion kroons is big or small money, which Virumaa stands on./.../ One day we ourselves or our

⁸⁰⁵ Einari Kisel, personal communication, May 16, 2007.

⁸⁰⁶ According to EBRD, real GDP growth was 10.5 per cent in 2005 and 11.4 per cent in 2006. See www.ebrd.com/pubs/facts/country/estonia.pdf. In its newest Estonian commitments, the bank focuses on energy efficiency and renewables.

descendants will realize how well this money could have been used in the interests of all society, but by then these oil shale deposits will no longer in our hands.”⁸⁰⁷

These words coming from a cabinet minister in the highly market-oriented Estonia are noteworthy, even if Mr. Savisaar’s Center party is considered moderately left-leaning. In fact, he returns to the very same discussion that took place several decades ago, when the young oil shale industry was just beginning. Savisaar continues in the footsteps of Märt Raud, voicing criticism against private engagement in the oil shale industry but still allowing it. A satisfactory answer to the question who should exploit the oil shale has never been found.

8.3. Environmental hazards

Claiming that the Estonian oil shale industry is environmentally hazardous will probably go unchallenged. The correctness of such a claim is widely recognized both within Estonia and abroad. In this context it should be pointed out that the Estonian independence movement against Soviet power, which gained momentum in the mid 1980s had a very strong environmental flavor resulting from the environmental damage inflicted on Estonia by the Communist system. The oil shale industry was regarded as a major, though by no means the sole culprit.⁸⁰⁸ The environmental damage caused by the oil shale industry could roughly be divided into three categories, namely landscape transformation, hazardous waste and atmospheric emissions.

Some of the transformations of the landscape lie totally open for the layman’s eye. The rural scenery of the flat Ida-Virumaa county is interrupted by giant heaps of black ash, visible from a distance of tens of kilometres. It has to be admitted that this lends a particular dramatic twist to the landscape and prompts a sense of awe in the occasional visitor. These heaps are the

⁸⁰⁷ “Kas põlevkivi on meie õnn või õnnetus?” (*Is oil shale our blessing or curse?*) by Edgar Savisaar. *Põhjarannik* 17. jaanuar 2007.

⁸⁰⁸ After the collapse of the Soviet Union, one of the most urgent environmental protection measures Estonia had to take was to secure the giant waste deposit on the coast near Sillamäe. The waste consisted of materials stemming from a uranium enriching factory, which for a long time was the biggest in Europe, enriching uranium from several countries in the Soviet bloc. Due to poor safety standards, there was a serious risk that radioactive materials would leak into the Gulf of Finland. In cooperation with the European Commission and the Scandinavian countries, the deposit was covered and strengthened, partially with oil shale ash, and it is at present deemed as safe (Source: Kaasik (2006). This deposit used to be a strange sight indeed, looking like an inviting turquoise blue lagoon only narrowly separated from the grayish waters of the Gulf of Finland.

highest relative surface formations in Estonia.⁸⁰⁹ But while some of the heaps tower more than 100 meters over the lowland, the ground in many places is actually being depressed as a result of underground mining. This area undergoing such a topographic transformation has a length of 70 kilometres and a width of between 10 and 30 kilometres.⁸¹⁰ Moreover, the groundwater level has been dropped in order to operate mines and quarries and this has caused pollution of the water. A cessation of mining activities will likely result in a rapid elevation of the groundwater level with unpredictable consequences.⁸¹¹ On the other hand, the 200-250 million tones of water that have been removed is not only clean water. Some 70 per cent is actually rainwater and the remaining 30 per cent could in any case not be used as drinking water. The water is harsh, but not poisonous.⁸¹² This view is not shared unequivocally. Many wells have run dry when the level of ground water has been dropped by mining and there are concerns that in the future the ground water level will drop below the sea level, with an influx of salt water as a result.⁸¹³



Heap of oil shale-ash towering over the landscape near Kiviõli. (Photograph by the author)

These heaps consist mainly of semi-coke, which in itself is less problematic. Processed oil shale is to 66 per cent made up of semi-coke. The actual hazard stems from chemical substances which are embedded in the semi-coke, such as oil, gudron and especially pitch. In addition to this, phenol-polluted water causes concern. Until recently and especially during the Soviet rule, hazardous waste was let into small rivers and streams. Several river-beds are

⁸⁰⁹ One such heap in the vicinity of Kiviõli is open to visitors. There are stairs all the way up. The heap is gradually becoming greener, with grass, bushes and even trees. But ash is still ever-present and anyone visiting the heap should be aware that there is a risk of clothes being stained with a greasy black substance.

⁸¹⁰ Liblik & Punning (2005) p. 14.

⁸¹¹ Liblik & Punning (2005) p. 16.

⁸¹² Tõnis Meriste, Environmental Manager of Eesti Energia, personal communication, Tallinn, January 15, 2007

⁸¹³ Gavrilova, Randla, Vallner, Strandberg & Vilu (2006).

still today covered with tar-like residuals from the oil shale industry. Recent samples show, however, that present pollution of hazardous waste falls within the legal limits.⁸¹⁴ Despite recent positive developments, the amount of hazardous waste has increased in Estonia in recent years and the country remains at the very top of producers of hazardous waste in Europe relative to its size and population.⁸¹⁵ Approximately 97 per cent of all hazardous wastes stem from the oil shale industry and related activities.⁸¹⁶ The single largest source for hazardous waste is, however, not directly the oil shale industry, but the cement producer *AS Kunda Nordic Tsement*. Still 15 years ago, the factory did not clean its emissions at all.⁸¹⁷

The atmospheric emissions from the oil shale industry comprise roughly 70 per cent of the Estonian total. In particular, CO₂ is not likely to cause concern in the sense stipulated by the Kyoto protocol. The reason behind this is that the base line agreed for Estonia was based on emissions in 1990, which were significantly higher than today. The cause of this dramatic fall in emissions was the collapse of the planned economy in connection with the demise of the Soviet Union. Estonia signed the Kyoto protocol in 1998 and ratified it in 2002. The obligations concerning Estonia require a reduction in emissions of greenhouse gases (GHG) by 8 per cent in comparison with 1990. As the Estonian emissions at present are some 50 per cent below the level in 1990, there are definitely no technical problems in reaching this goal, while the present emissions of CO₂ are almost half of the national quota of an annual 34,494 thousand tons.⁸¹⁸ However, the Estonian government's national program adopted in 2004 foresees a reduction of CO₂ emissions by 20 per cent, methane by 28 per cent and NO₂ by 9 per cent in comparison with the 1999-levels, which is a more challenging task.⁸¹⁹ The fact that several former socialist countries got a target for emission reductions based on the year 1990 is oftentimes referred to as "hot air", implying that no real change needs to take place, because the collapse of the socialist system led to a simultaneous economic collapse, which in turn significantly reduced emissions. The very large cuts in emissions that followed from this collapse have their origin in the fact that industry under socialism in Eastern Europe was

⁸¹⁴ Otsa & Vili (2003) pp. 92-3.

⁸¹⁵ Maivel (2003) p. 83.

⁸¹⁶ Keskkonnauilevaade 2005.

⁸¹⁷ Maivel (2003). In the mid-1990s, I visited the small town of Kunda, where the factory is located. The whole town was covered with a film of white ash creating a feeling of winter in the middle of summer. Trees and grass were all white and the air was thick with particles. Fortunately, those days are long gone.

⁸¹⁸ Energy 2004.

⁸¹⁹ Estonia's Fourth National Communication under the UN Framework Convention on Climate Change, November 2005, pp. 18-9.

approximately 6 or 7 times more energy intensive than in Western Europe.⁸²⁰ Hopes are put to financing a part of the much-needed modernization of the Estonian power generation industry by selling the exceeding emission rights.⁸²¹ The flip side is that the figure for emissions of CO₂ in producing 1 kWh electricity in Estonia is 1.18 kg, while the corresponding figure for the EU average is 0.34 kg and in Sweden as low as 0.03 kg.⁸²² The ongoing renovation of the Narva power stations is estimated to bring down the figure for Estonia to a level similar to that of Poland, namely 0.96kg.⁸²³ On the other hand, the emissions of CO₂ relative to GDP (PPP) are more than four times higher than in Sweden and three times higher than in Latvia, Lithuania and Finland. The reason for this is not only the CO₂ intensity of oil shale, but also the very large changes in the Estonian GDP in the past two decades.⁸²⁴ The Estonian GDP fell dramatically with the collapse of the Soviet Union, but has been on a track bouncing back in the last ten years. Household consumption of electricity started increasing in Estonia already in 1998 with rising living standards.⁸²⁵

In 1993 Estonia and Finland agreed jointly to reduce the emissions of SO₂ by 1997 of both countries to 50 per cent of the levels in 1980, an objective Estonia succeeded in fulfilling. The Estonian Environmental strategy from 1997 called for a further decrease of SO₂ emissions by 80 per cent by 2005 compared with the level in 1980. Moreover, dust and ash emissions were to be reduced by 25 per cent from 1995 to 2005, and the oil with a high sulphur content (exceeding 2 per cent) was to be replaced by other fuels by 2005.⁸²⁶

The Estonian government's Energy Conservation Programme from 2000 calls for increased energy efficiency by decoupling the growth in GDP from the growth of energy consumption. Thus, the growth rate in energy consumption should stay at 50 per cent of the growth rate of GDP.⁸²⁷ There are strong indications of success, as consumption of primary energy in 2003

⁸²⁰ Midttun & Chander (1998).

⁸²¹ Energy 2004. The reason for Estonia having significantly smaller emissions than the national quota stems from the wording of the Kyoto protocol, according to which reductions are counted against emission in 1990. After the collapse of the Soviet Union in 1991 and the ensuing economic downturn, both industrial production and consumption and therefore emissions were significantly reduced.

⁸²² It should be stressed that Sweden produces most of its electricity from hydro and nuclear power.

⁸²³ Electricity 2005.

⁸²⁴ Tenno & Laur (2003).

⁸²⁵ Tenno & Laur (2003).

⁸²⁶ EBRD (2002).

⁸²⁷ Estonia's Fourth National Communication under the UN Framework Convention on Climate Change, November 2005, pp. 18-9.



The EU has participated in reducing environmental hazards (Photograph by the author).

was just below the 1995-level, while GDP had jumped by almost 300 per cent in the same time.⁸²⁸ However, in the year 2000, relative emissions of CO₂ per unit of GDP in Estonia were still some 4.5 times higher than in Sweden and 3 times higher than the EU-15 average.⁸²⁹ One highly complex issue is the fact that because of the location of the bulk of Estonian power production in the north-eastern corner of the country, enormous amounts of heat generated in the process have not found any suitable use. Annually some 10 TWh heat is led directly into the Narva River – an amount exceeding the energy delivered to users by 150 per cent.⁸³⁰ Despite being the location of almost all of Estonia’s electricity power generation, the city of Narva has repeatedly refused to buy heating from the *Balti* power plant, because natural gas from Russia is cheaper. One idea worth considering for the city of Narva would be to buy oil shale from Russia for heating purposes, because this would be cheaper than buying Estonian oil shale for the same purpose. The reason for this is that oil shale in the nearby Russian deposits is of lower quality and has few alternative uses, while the Estonian oil shale is better suited for oil production.⁸³¹ Whatever the outcome will be, these facts are presented to

⁸²⁸ Keskkonnaulevaade 2005.

⁸²⁹ Tenno & Laur (2003).

⁸³⁰ Gavrilova, Randla, Vallner, Strandberg & Vilu (2006).

⁸³¹ Ants Liimets, city secretary of Narva, personal communication, Narva, October 14, 2005.

demonstrate that trade between Estonia and Russia in the border region is not necessarily affected by the sometimes harsh words between the governments of Estonia and Russia.

In July 2006, the Estonian government commissioned the Ministry of Environment to produce a national development plan for oil shale for the period 2007-2015.⁸³² The task for the development plan is to integrate environmental, economic, security, social and regional aspects of the oil shale industry, i.e. to analyze the oil shale complex as a whole. The aim is also to secure that resources are not wasted for short term aims. The need for a national development plan is further stressed by the large number of concession applications for mining oil shale (altogether 15) and the ensuing number of legal processes that have resulted from the lack of overall strategy for the future of oil shale. The largest issue looming ahead is unequivocally that of environmental protection. This issue can in turn, be divided into the following aspects: the use of renewable and non-renewable natural resources, land use, natural diversity, emissions into the atmosphere (including impact on Natura 2000 areas), contamination of water and land, waste, human health, and regional differences.

One technology to which hopes of reaching an acceptable level of emissions have been attached is the circulating fluidized bed (CFB), which basically is an application of technology used abroad in coal fired power stations.⁸³³ Solid oil shale is burned while being circulated in a particular aerodynamic system, which shares some characteristics with a fluid (sometimes called a pseudo fluid). The solids are thus resting on gas which is poured into the boiler with a pressure that is equal to gravitation, which creates an impact that is similar to floating. This method allows for the combustion at lower temperatures, which reduces the emissions of sulphurous gases, in particular, but also other GHG.⁸³⁴ The European Bank for Reconstruction and Development, EBRD, estimates the reduction in emissions by switching from pulverized combustion to CFB to be 95 per cent in SO₂, (because the sulphur is captured by ash) 55 per cent in NO_x, 23 per cent in CO₂, and 97 per cent in particulates.⁸³⁵ In addition to this, using CFB is estimated to lead to a 25 per cent reduction in fuel consumption.⁸³⁶ In absolute figures, in the renovated blocks of the Narva power plants, CFB technology has led

⁸³² ""Põlevkivi kasutamise riikliku arengukava 2007-2015"" keskkonnamõju strateegilise hindamise programm"

⁸³³ This technology was developed in the USA at the time of WWII. Later it was widely used in experiments with oil shale. Its applicability on Estonian oil shale first drew attention in the early 1960s. Source: Jürisma (1961).

⁸³⁴ Ots (2004) p.117 & p. 136.

⁸³⁵ "Narva Elektriijaamad".

⁸³⁶ "Cleaner Energy from Oil Shale", April 2004.

to reductions in emissions of SO₂ from 800 mg/m³ to 10 mg/ m³, while the EU requirement is 200 mg/ m³. According to present plans, total efficiency of the CFB boilers would reach 1000 MW by 2012.⁸³⁷

Installment of CFB boilers started in 2002 with a 200 MW power unit at *Eesti* power plant and an equally large unit at *Balti* power plant. These measures were part of a 300 million euro renovation package at the power plants for the years 2002-2005.⁸³⁸ In order to safeguard the investment, electricity from the new CFB boilers is guaranteed a market until 2013. This course of action was chosen because of the technological risks involved. However, in the next phase investment will be made according to market principles. On the other hand, further development in this sector is tightly connected with how much electricity will be generated by the *Ignalina* nuclear power station in Lithuania.⁸³⁹

Ash from the heaps has already for a long time been used in cement production. The problem in Estonia is, however, that there is no domestic demand of such a size that would cause a notable reduction of the ash. Previously some ash was used to build concrete roads in Siberia, where the local sand mixes well with oil shale ash. This method reduced costs per kilometer road to one-third. Similar sand cannot be found in Estonia. Exports to Russia have not developed positively in recent times for political reasons, while exports to Scandinavia of either ash or cement produced from it have not taken off because of different technologies in use.⁸⁴⁰

⁸³⁷ Einari Kisel, personal communication, May 16, 2007.

⁸³⁸ "Narva Elektriijaamad".

⁸³⁹ Einari Kisel, personal communication, May 16, 2007.

⁸⁴⁰ Villu Vares, personal communication, April 5, 2005.



Waste disposal area, a so-called “ash field”, outside the Eesti power plant (photograph by the author).

8.4. Alternatives and renewables

According to the Estonian long-term national development plan for fuel and energy economy until 2015 (referred to as “Energy 2004”) the overall aims are, among others, to increase the share of renewable energy to 5 per cent of total consumption, to increase the share of cogeneration of electricity and heat to 20 per cent of total consumption, to renew the electricity grid every 30 years, to guarantee the competitiveness of oil shale energy while reducing environmentally hazardous impacts by installing new technology, to keep consumption of primary energy up to 2010 at the 2003-level and to build new power transfer capacity with the Nordic countries and Central Europe.

In 2003 the share of renewables in total *electricity* generation was less than 1 per cent, although a significant (270 per cent) increase took place that year due to the installment of wind- and hydro generation. The hydro power station on the Narva River in the vicinity of the city of Narva actually lies on the Russian side of the border, but Estonia has the right to 1/3 of the power generated.⁸⁴¹ This station has a total capacity of 125 MW. The Narva River is by far the river with the biggest flux in Estonia, 400 m³ per second, but because the border between Russia and Estonia runs in the middle of the river throughout its entire length, any utilization would have to be done in cooperation with Russia. Other Estonians rivers are significantly smaller and the whole country is overwhelmingly flat, which allows for only highly limited utilization of hydro power. Total technically feasible hydro potential in Estonia is estimated to be somewhere in the range 30 – 60 MW⁸⁴², which could satisfy between 2 and 5 per cent of total consumption. There is one niche for hydro power, though, namely small scale generation. At present 20 small plants operate in the country, in addition to which there are several micro hydro stations with a capacity below 10 kW.⁸⁴³ The biggest hydro station today is 1,2 MW, while for example a single block (i.e. production unit) at Narva oil shale power plants is 215 MW.⁸⁴⁴ Total new hydro power capacity is approximately 5.4 MW. An additional 5.6 MW could be added by restoring a number older hydro stations, which became obsolete when the oil shale based electricity generation expanded. The small hydro power stations (those currently operational as well as those assigned as renovation targets) are located closer to the population centers and reflect the dispersed characteristic of the population density of Estonia. Thus, using hydro power would probably result in reduced transfer losses.⁸⁴⁵

In the years following the birth of the Estonian republic in the early 1920s, hydropower was perceived as being the most promising method for electricity generation – Estonia attempted to emulating Sweden.⁸⁴⁶ However, the plans to construct a larger hydro power station on the Narva river, which from a power production point of view would have been one of the most suitable locations in Estonia (although in the North-Easternmost corner) never took off, because of a lingering conflict between industries and the government on the rights to utilize

⁸⁴¹ Electricity (2005). There were plans to construct such a power plant in the early 1920s, but the plans were shelved because of high costs (Mägi (2004) p. 75.

⁸⁴² Tõnis Meriste of Eesti Energia estimated the real potential to be 20 MW. Personal communication, Tallinn, January 15, 2007.

⁸⁴³ Raesaar (2005).

⁸⁴⁴ Tõnis Meriste, Environmental manager, Eesti Energia, personal communication, Tallinn January 15, 2007

⁸⁴⁵ Raesaar (2005).

⁸⁴⁶ Mägi p. 74.

the water resources. From a transmission point of view this location is far from optimal, but in the early 1920s a unified electricity grid was still far off in the future. In 1920 the government had made it clear that it lacked the resources to construct a hydro power plant on the Narva River. The future of any such plans was to be left in the hands of private capital, domestic or foreign.⁸⁴⁷ Nevertheless, the government remained involved in the question. In 1921 the first plan to build hydro power at this location was presented, but it was opposed by the industry and never realized.⁸⁴⁸ Throughout the rest of the 1920s the issue would lie dormant, until in early 1931, when the textile manufacturer *Kreenholm* in Narva began constructing a small power station on the Narva River, backed by capital of German origin. This step excluded a competing larger investment, supposed to be financed by British capital. These developments led only to the resignation of the government, but to no power generation.⁸⁴⁹ In the mid-1930s the issue of electrification of Estonia became a government priority and the question of a power station on the Narva River was raised anew. The ultimate aim was to provide 56 per cent of the population with electricity.⁸⁵⁰ These plans were interrupted by WWII. Only in 1955 was a power station erected on the Narva River, but by then the area in question had been ceded to Russia.⁸⁵¹

Renewable energy sources for Estonia consist mainly of biofuels for cogeneration and wind power. The introduction of wind power is made more complicated in Estonia by the fact that the country is dependent on the two large oil shale-fuelled power plants, which do not allow for enough flexibility in the adjustment of power production.

“The Narva stations go on like big trucks and cannot quickly be started if there is no wind.”⁸⁵²

This problem is to some extent mitigated by the grid links to Latvia and Russia, which would allow for electricity transmission, that is, acting as a sort of reserve. The Latvian grid is, however, tightly connected with the Russian one, which makes this issue one of security of supply. Other sources for back-up generation would also be needed.

⁸⁴⁷ Karma (1999) p. 20.

⁸⁴⁸ Mägi (2004) pp. 74-5.

⁸⁴⁹ Karma (1999) pp. 106 –7. The German capital was the private oil shale enterprise *Eesti Kiviõli*, which aimed at having access to relatively cheap electricity for its shale oil plant about fifty kilometres to the west.

⁸⁵⁰ Karma (1999) p. 144.

⁸⁵¹ Kaelas (1958) p. 62.

⁸⁵² Tõnis Meriste, Environmental manager, Eesti Energia, personal communication, Tallinn January 15, 2007.

As of today, the Estonian electricity system would allow for 90-150 MW wind power, while the technical maximum is between 400 and 500 MW.⁸⁵³ Installing wind power is complicated by the fact that the Estonian electric grid is weak at the coasts, where the wind power potential is big. Thus a large scale investment in wind power would require simultaneous capacity enhancement of the electric grid.⁸⁵⁴ In addition to this, some sort of back-up power would be required, such as hydro power.

Biomass has been developed in recent years in Estonia. In co-generation the potential is 400 MW, but then all settlements would need a co-generation station. At present only big stations are produced in the world, while Estonia would need small stations of 1-2 MW and heating of 20 MW, because of the low population density of Estonia, with several small settlements spread around the country. Developments of small-scale co-generation plants are at present only in a trial phase. One additional problem that could arise is that when farmers produce biomass for heating, it is difficult to require them to keep up the grid balance obligations. Such energy production would be very local and spread and therefore complicated. The newly installed fluidized bed combustion technology at the oil shale power plants allows for mixing 10 % of biofuels in the boilers. Peat could also be useful and new blocks could be reconstructed to some extent.⁸⁵⁵

The scope for energy saving measures remains significant. Losses in the electricity grid are high and consumption of heating is 25-30 per cent higher per unit of building space in Tallinn than in the nearby Finnish capital of Helsinki. Heating in Estonia has diminished significantly in recent years and production in 2002 was 10.5 TWh. Of this, 7.5 TWh was consumed in district heating.⁸⁵⁶ Forty-five per cent of heating is produced from domestic fuels, i.e. oil shale and peat, while natural gas accounts for 38 per cent.⁸⁵⁷ The losses in the district heating system are 18 per cent.⁸⁵⁸ This is mainly due to poor insulation of pipes. Moreover, consumption of heating is inefficient and there is scope for major improvement.⁸⁵⁹

⁸⁵³ Energy 2004.

⁸⁵⁴ Tõnis Meriste, Environmental manager, Eesti Energia, personal communication, Tallinn January 15, 2007

⁸⁵⁵ Tõnis Meriste, Environmental manager, Eesti Energia, personal communication, Tallinn January 15, 2007

⁸⁵⁶ Estonian Energy 2002. For the sake of comparison, in Sweden total production of district heating was 51.8 TWh in 2002. (Source: Energy in Sweden 2005).

⁸⁵⁷ It should be pointed out that mainly shale oil is used. The share of oil shale, i.e. with no prior processing, is minimal. (Source: Estonian Energy 2002).

⁸⁵⁸ The corresponding figure for Sweden was 12 per cent in 2002 (Energy in Sweden 2005).

⁸⁵⁹ The Swedish Energy Agency financed a pilot project for the reduction of emissions of CO₂ with focus on reducing losses in district heating and buildings in the Baltic States and Russia in 1999-2001. The results showed

To sum up, with the present outlook, there is scope for the enhanced use of renewables together with energy saving measures, but even if all possibilities were made use of, oil shale would still remain the biggest single source for electricity production. Calculating with the highest figures presented for technically feasible electricity generation in this chapter, total capacity would be in the vicinity of 1000 MW.⁸⁶⁰ Present total capacity of the Narva oil shale power plants exceeds 2000 MW. In addition to this, one has to include the likely increase in consumption as a result of rapid economic growth in any estimate. From these figures follows that any competitor to oil shale faces an uphill struggle, to say the least.

8.5. Social challenges

The region of Ida-Virumaa, where the entire Estonian oil shale sector is located, show some demographical peculiarities, which must be addressed whenever the oil shale sector is discussed. Today the region is only marginally Estonian-speaking while the most widely spread language in the region is Russian. Estonian is the official language, as in the rest of Estonia, though. This demographic situation is mainly a result of Soviet Russification efforts, when migrants from all over the former Soviet Union were encouraged to settle in Estonia, especially in those areas which were undergoing rapid industrialization⁸⁶¹. The exile-Estonian Kaelas (1958) sets out to estimate the share of Estonians and non-Estonians in various sectors of the economy in 1955 by counting names mentioned in the Estonian-language Communist party daily *Rahva Hääli* in various contexts and arrives at a figure of 41 per cent Estonian and 59 per cent Russian. This method is certainly not thoroughly accurate, but illustrates at least that a process of Russification of the oil shale industry was under way. In other sectors the corresponding figures were (still) strongly in favor of the Estonians.⁸⁶²

Thus the towns in Ida-Virumaa are overwhelmingly Russian-speaking, while the countryside is predominantly Estonian-speaking. There is, however, also a historical Russian minority in the countryside in the southern parts of the region.

that there was scope for significant cost-efficient improvement, especially compared to if corresponding reductions had been made in Sweden. (Source: Internationella klimatprojekt).

⁸⁶⁰ Hydro 100 MW, wind 500 MW and biomass 400 MW.

⁸⁶¹ Kaelas (1958) pp.16 – 21. For an analysis of this development in the Baltic states, see Idzelis (1984).

⁸⁶² Why should one doubt the figures? First, a name does not necessarily correspond with ethnicity and even less with identity. Second, there might have been other reasons for Russian names to be more frequent than Estonian ones. The Soviet policy of promoting everything Russian would be one such reason. Third, the sample is small (83 names within one month). It is however a well-established fact that russification took place. Today's situation in the region is evidence enough.

Official statistics show that the total number of inhabitants of Ida-Virumaa was 179,702 on March 31, 2001, when a census was carried out (this figure had decreased to 174,809 on January 1, 2004). A total of 80,504 persons were Estonian citizens - almost 45% of all inhabitants - and 61,921 were without any clearly defined citizenship (technically “Soviet citizens”) while 34,577 persons were citizens of the Russian Federation. Out of the 179,702 inhabitants, 35,917 claimed to be “ethnic Estonians”, or 20% of the total population. Thus even among Estonian citizens a minority were “ethnic Estonians” in 2001.⁸⁶³

Should such topics be addressed at all in a research focusing on the oil shale sector? My assumption is that the entire complexity of the present situation can not wholly be understood without a closer look at questions of citizenship and ethnicity. The society is to some degree divided along ethnical lines, to some degree along citizenship lines (most ethnic Estonians are Estonian citizens, though). It might even go without saying that any major changes in the oil shale sector are likely to be registered somehow along these fault lines in society – whatever the actual facts are. For example, a reduction in the labor force would most likely affect fewer “ethnic Estonians” than Russian-speakers – simply because there are fewer Estonians in general. One might even speculate whether employers who have to lay off labor will value Estonian citizens higher than others. It should be pointed out that there is a risk that non-Estonians will develop a strengthened sense of being disadvantaged.

The social role of the oil shale sector is very important in the region of Ida-Virumaa. One can say that the oil shale industry forms the backbone of the regional economy, and as a consequence any dramatic decrease in its employing function would have a serious impact on the region. This was also recognized in the national development plan for the oil shale industry.

“In Ida-Virumaa, bordering with Russia and having a mainly Russian-speaking population, a critical socio-economic situation has developed. The oil shale sector is the biggest employer in the region and thus it has a significant social role. At the same time, the need to maintain a competitive price for energy requires a decreased social role and a increased efficiency by reducing the number of employees.”⁸⁶⁴

⁸⁶³ Figures from the Estonian statistical office, www.pub.stat.ee/px-web.2001/Dialog/saveshow.asp ,(accessed on September 15, 2005).

⁸⁶⁴ “*Eesti põlevkivienergeetika restruktureerimise tegevuskava 2001 – 2006*”, EV Majandusministeerium 2001.

In 1999, the chairman of the board of the Estonian state-owned energy supplier *Eesti Energia*, Gunnar Okk, was explicit about the social role of his company:

“Eesti Energia has an increased responsibility for balancing the social environment of Ida-Virumaa, because out of 7,500 employees 4,500 are connected with Ida-Virumaa”⁸⁶⁵

The difficulties in creating new jobs outside the oil shale sector are also addressed by the development plan for the oil shale industry, which points out that entrepreneurial activities in the region are only half of what they are in the rest of the country. In addition to this, until recently, foreign direct investment in the region had not reached levels where it would have alleviated unemployment or even brought in new technologies and skills in other sectors. Despite these factors, further redundancies seemed to be required in the oil shale sector.⁸⁶⁶ The restructuring process seen ahead for the oil shale industry caused the business monthly “*Ärielu*” in January 1999 to call for a national plan to solve the seemingly ever deepening social and economic slump in the region. Doubting the will and capacity of the companies to properly address the situation, it was reasoned that a regional social plan would be needed, perhaps with the support of the European Union or the World Bank. Were such measures not to be taken, “extremely unpleasant” consequences could be expected, which could “destabilize the whole Estonian society”.⁸⁶⁷ In the period 1990 – 2000 the number of jobs within the industry in Ida-Virumaa decreased by 10,200.⁸⁶⁸ At the same time there was no significant increase in the number of new jobs in other sectors. As a result the region has faced one of the highest unemployment rates in Estonia.

Table 8.5. Unemployment rates in 1997, 2000 and 2004 for the region of Ida-Virumaa, Tallinn and Estonia total.

	1997	2000	2004
Ida-Virumaa	13.3	21.1	17.9
Tallinn	8.5	12.2	10.0
Estonia	9.6	13.6	9.7

Source: Estonian Statistical Office.⁸⁶⁹

⁸⁶⁵ *Energeetika Uudiskiri*, Eesti Energia Nr. 2 1999.

⁸⁶⁶ “*Eesti põlevkivienergeetika restruktureerimise tegevuskava 2001 - 2006*” EV Majandusministerruum 2001

⁸⁶⁷ “Põlevkivi: Ida-Virumaa õnn või õnnetus” (*Oil shale: Ida-Virumaa’s blessing or curse*) by Juhan Sillaste, *Ärielu*, January 1999.

⁸⁶⁸ Note that of course not all industry in the region is connected with oil shale.

⁸⁶⁹ www.pub.stat.ee/px-web.2001/Database/sotsiaalelu/15Tooturg/10Tootus/10Tootus.asp (accessed on September 16, 2005).

From table 8.5. it can be clearly seen that the unemployment rate in Ida-Virumaa has been significantly higher than the average for Estonia. On the other hand, it should be added that even higher unemployment rates have been registered in the south-eastern, small, overwhelmingly Estonian-speaking region of Põlva. There seems to be a slight tendency towards higher unemployment in the eastern parts of the country regardless of degree of industrialization or demographic factors.

A dramatic turn for the better took place in Ida-Virumaa in 2006. Unemployment dropped to 8.5 per cent. In an article with the headline “*The event of the year in Ida-Virumaa is the sharp decline in unemployment*”, the regional newspaper *Põhjarannik*⁸⁷⁰ lists the likely reasons behind the change: The overall economic growth in Estonia, increased migration of people from the region (partly as a result of the Estonian EU-membership), the development of the local service sector and tourism, retraining programmes for the unemployed and improved standards in locally available education. The years of rampant unemployment are described in the following words:

“The decline in unemployment is an extremely significant development for Ida-Virumaa. From the beginning of the 1990s, when many previously large enterprises turned out to be weak competitors under the new capitalist circumstances and shut down or sharply reduced their production, unemployment began to rise and remained at around 20 per cent. High unemployment has been one of the profound problems of the region for more than 10 years, from which other tribulations have developed: the social helplessness of many inhabitants, increased crime, low purchasing power and difficulties to pay for municipal services as well as many others.”⁸⁷¹

The positive signs were noted already in 2005 by Ants Liimets, city secretary of Narva municipal government. This city of almost 70,000, located in the very north-eastern corner of both Ida-Virumaa and all of Estonia, is almost completely Russian-speaking (over 90 per cent). Both large oil shale –fuelled power stations are located here, as well as one shale oil factory.

⁸⁷⁰ This newspaper is published in an Estonian and in a Russian edition. The Russian-language version “Severnoye Poberezhe” can be found at www.rus.pohjarannik.ee. The two editions are more or less the same. It should perhaps be mentioned that this paper is the successor to the paper “Rohkem Põlevkivi!” that was published in the Stalin period and referred to at length elsewhere in this work.

⁸⁷¹ Gamzejev, Erik “Ida-Viru aastasündmus on tööpuuduse järsk vähenemine”, *Põhjarannik* 30.12.2006.

“Earlier the city had no money. Now we have the resources to redistribute. Both social benefits and pensions are now stable. The situation has improved for all of the population. I can’t imagine that there can be anyone without proper food any longer. This is because the level of social security has developed.”⁸⁷²

But despite the improvements in social security, unemployment has been a problem. The official unemployment rate remained steadily somewhere between 6 and 8 per cent for a number of years. Real unemployment may have been almost twice as high. New jobs have emerged, but also old ones have been lost. In 2004 the *Kreenholm* textile manufacturer cut 500 jobs.⁸⁷³ On the positive side it can be said that no large company has gone bankrupt in recent years. The population is still falling, but the trend is close to being broken, as nativity has picked up and emigration has dropped.⁸⁷⁴

In December 2006 the human rights organization Amnesty International criticised Estonia for, *inter alia*, discrimination in the labour market against people who do not speak Estonian. According to Amnesty International

“...significant differences remain in the levels of employment between ethnic Estonians and persons belonging to the Russian-speaking linguistic minority. According to official statistics, 5.3 per cent of ethnic Estonians were unemployed while 12.8 per cent of persons belonging to the Russian-speaking linguistic minority were unemployed in 2005. Persons belonging to the Russian-speaking minority are disproportionately affected by long-term unemployment”⁸⁷⁵

The report continues:

“...the economic situation in the north-eastern region of Ida-Virumaa which is densely populated by persons belonging to the Russian-speaking linguistic minority remains considerably worse than the national average, as does the employment situation”⁸⁷⁶

⁸⁷² Ants Liimets, city secretary of Narva, personal communication, Narva, October 14, 2005.

⁸⁷³ The *Kreenholm* textile manufacturer is completely owned by the Swedish textile company *Borås Wäfveri*.

⁸⁷⁴ Ants Liimets, city secretary of Narva, personal communication, Narva, October 14, 2005.

⁸⁷⁵ “Estonia. Linguistic minorities in Estonia: Discrimination must end” Amnesty International, AI Index EUR 51/002/2006 p. 25.

⁸⁷⁶ *Ibid.*

Notwithstanding the ill-timed moment for this criticism (the situation had already taken a sharp turn for the better at the time when Amnesty's report was published), Amnesty's allegations of having identified structural injustice probably contain a nucleus of truth. However, throughout the report Amnesty totally misses the fact that the high unemployment rate in Ida-Virumaa was a consequence of three factors beyond the control of the Estonian authorities, namely the low oil price in the world market throughout the 1990s, the reduced demand for oil shale as a result of the break-up of the Soviet Union and finally the lack of entrepreneurial attitudes among the population of the traditionally heavy-industry-reliant Ida-Virumaa.⁸⁷⁷ Instead, Amnesty International identifies proficiency requirements of the Estonian language as the main obstacle for a more dynamic labour market. Anyone who has visited the region could probably confirm that knowledge of Estonian is usually non-existent among those employed in whatever sphere of the society, including many officials in municipal and government institutions. Although knowledge of Estonian would definitely be an asset for anyone applying for a job, this is clearly not a prerequisite. The problem has instead been the general lack of jobs, which in turn has little to do with Estonian language policy.⁸⁷⁸ As has been shown earlier, the critical situation in the regional labour market was well known for a long time and caused serious concerns. In March 2000, the then Minister of the economy, Mihkel Pärnoja, wrote:

“Also the social situation in Ida-Virumaa speaks for the continuing of oil shale energy production, especially for employment, from which the incomes of a large number of families in the region are dependent. The possibility that miners or energy employees who have lost their jobs will find new employment corresponding to their qualifications in their home region is very small.”⁸⁷⁹

⁸⁷⁷ This latter claim is based on my own experiences from the region. For a long time, the most striking difference between Ida-Virumaa and the rest of Estonia was the absence of a thriving small-scale businesses sector in Ida-Virumaa. Roughly speaking, there was a time lag of more than a decade in the development of even such everyday businesses as supermarkets where the customer did not have to ask for the products at the counter. The situation has been rapidly improving in recent years.

⁸⁷⁸ Amnesty unfortunately loses its judgment in addressing the language training situation. One can agree that the Estonian authorities should do much more to promote the skills of Estonian among non-Estonians. On the other hand, Amnesty criticizes basically all attempts at doing this. The following extract is from the report quoted above: “*The Estonian authorities also organize summer camps where children from various communities get together and where Russian-speaking children have a chance to practice their Estonian language skills. However, according to international psychological studies, children who learn a foreign language through this approach are several times more likely to develop learning difficulties, which are often associated with more profound psychological disturbances.*” (p. 21) Amnesty bases this claim on one article from 1984 by one Canadian psychologist. Also other factual claims in the report are misleading. Whatever good intentions Amnesty might have had, something clearly went wrong in preparing this report.

⁸⁷⁹ Energeetika Uudiskiri, Eesti Energia Nr. 1 2000.

The episode with Amnesty International's report is worth analysing, because it so clearly illustrates the dilemma Estonia is facing with its oil shale industry. Amnesty is definitely not the first organization criticising Estonia for its laws on citizenship and language, just the most recent. For the sake of clarity, it should be pointed out that the Estonian laws have not been seen as contradictory to standards set by the European Union or the Council of Europe, which Estonia is a member of. The strained social situation that developed in Ida-Virumaa in the 1990s as a result of problems especially in the oil shale industry has often been interpreted in ethnic or linguistic terms, especially by people from outside Estonia. For many observers there seems to be a correlation between being Russian and being unemployed. This is, nevertheless, basically a false correlation for reasons mentioned before. If the world market price for oil is set to fall dramatically again, the employment situation in Ida-Virumaa will most likely worsen, although the local economy has diversified and it is therefore less vulnerable today. Thus, to simplify, Estonia should expect outside criticism if the world market price for oil falls. Such criticism would not be too harmful, and probably even helpful, were it not for the policies pursued by Russia, which often aim at accusing Estonia of violations of the rights of the Russian-speaking population. Accusations coming from a world power have a tendency to go unchallenged in media around the world. Assume now that Estonia would entirely close down the oil shale industry in order to, say, opt for developing a sustainable energy system based on renewable sources (whether this is realistic at present will be discussed later). Such a move would likely have serious repercussions internationally, as this would be perceived as a measure directed against the Russian-speaking population. In itself, this would of course be nothing different from any other country deciding to replace its polluting energy industry, but in the case of Estonia the fear for strong international reactions effectively helps to maintain the present dependence on oil shale. Now there are no serious proposals for closing down the oil shale industry (maybe with the exception of the Estonian Green Party), but the fact remains that the present state of the lock-in situation into a fossil fuel in Estonia is of a different magnitude than elsewhere. When the cable for electricity transmission between Finland and Estonia was taken into use on November 29, 2006, Swedish media reported in an upset voice that electricity from "Europe's perhaps most polluting power plants" might soon be sold in Sweden.⁸⁸⁰ In this context, Estonian electricity

⁸⁸⁰ "Smutsig el snart på väg till Sverige" Svenska Dagbladet 17 oktober 2006. www.svd.se, see also "Svenskar skyr skifferel", Hufvudstadsbladet, 20/10/06 www.hbl.fi, "Norden kommer att importera smutsig el från Estland" Dagens Nyheter 29 december 2006. Einari Kisel of the energy department of the Estonian Ministry of Economic Affairs pointed out that Europe's probably dirtiest electricity comes from Russia and is transmitted through the Finnish electricity grid (Personal communication, May 16, 2007).

production is seen as a serious environmental problem. But as was discussed before, were Estonia not to generate electricity at “Europe’s perhaps most polluting power plants” there would have been if possible an even sharper reaction.

The restructuring of the oil shale industry and the job cuts was actually a process that took place simultaneously with a similar process in the Central and East European coal production. In total, coal production was cut by 41 per cent between 1990 and 1999, while labour was reduced by 49 per cent. An estimated one million East European miners lost their jobs in this period. In Estonia, the workforce was cut by 40 per cent. The effects of these redundancies in Central and Eastern Europe was an increase in productivity by an average of 8 per cent (in central Europe the figure was 22 per cent, in the former Soviet Union –2 per cent). In Estonia productivity rose by 8 per cent.⁸⁸¹ The Narva power stations have had a more or less constant workforce of 2,500 persons for the past three years and no changes seem to be in sight.⁸⁸²

The restructuring process of the energy industry was not even typical for Estonia only, but for the whole of ex-socialist Europe. Against this background, international criticism of Estonia for the strained labour and social conditions in Ida-Virumaa in the 1990s becomes even more hollow. In a survey made in August and September 2005, the Narva-based sociologist Sergey Gorokhov asked a sample of inhabitants of Narva to spontaneously list their current concerns as well as things that have turned for the better and things that have turned for the worse in the past year. The results are worth taking a closer look at. The current concern most often mentioned by the respondents was problems with employment, searching for a job and keeping the present job. In second place came problems in personal life, while the third and fourth concerns were low wages and price hikes, respectively. The relation between Russians and Estonians was only mentioned in 16th place (although problems connected with insufficient knowledge of the Estonian language came in 14th place). Things that were considered to have taken a turn for the better were the general appearance of the city, new shopping malls and supermarkets, the construction of new sports facilities and other buildings. Improvement in the social sphere was in 7th place. Among negative changes, the top four concerns were as follows: general price hikes, increased unemployment, the functioning of municipal organs and the condition of the streets.⁸⁸³

⁸⁸¹ Brendow (2003).

⁸⁸² Ants Liimets, city secretary of Narva, personal communication, Narva, October 14, 2005.

⁸⁸³ Gorokhov (2005).

The survey clearly indicates the existence of a significant social problem, but there is very little evidence of friction along ethnical lines.⁸⁸⁴

8.6. Attitudes toward the oil shale industry

Attitudes towards the oil shale industry in Estonia can be difficult to pinpoint without doing a proper survey on the topic, which is beyond the scope of this work. This issue should nevertheless be addressed, because general attitudes among the population will always be reflected – at least to some extent – in political decision making and thus in shaping the future conditions for the oil shale industry.

It is of course only to be expected that the population of Ida-Virumaa is strongly in favor of continuing oil shale excavation and processing. According to a poll in October 2006, 85 per cent of the respondents considered this industry to be important. Two-thirds were in favor of expanding the oil shale industry on condition that environmental damage is reduced with state-of-the-art methods, while only 5 per cent supported the idea of reducing production.⁸⁸⁵ But further development of the oil shale industry is not always welcome in Ida-Virumaa either. The rural municipality of Maidla is reported to oppose increased mining in its territory. According to newspaper reports, the chairman of the municipal council is concerned about the effects increased mining would have, because 30 years ago the opening of the Aidu quarry led to a population reduction by half in the municipality.⁸⁸⁶ This action by the municipality was supported by the then minister of economy and communication, Edgar Savisaar, who was strongly critical to privatization in general of the oil shale deposits:

“The application presented to the Ministry of the Environment for founding a new mine for excavating an additional 200 thousand tonnes of oil shale at the Uus-Kiviõli deposit is by no means justified. The municipality of Maidla did the right thing when disputing this in the court. To me it was said that the state would have no legal possibility to deny

⁸⁸⁴ This is completely in line with my own observations as an observer for the OSCE in Narva between 1995 and 1997. The social situation, especially concerning unemployment, was indeed worrying, while signs of inter-ethnic conflict were more or less absent. In my personal opinion, this capacity to separate social problems from inter-ethnic relations is strong evidence of noteworthy political maturity among the inhabitants of Narva.

⁸⁸⁵ “Uuring: idavirumaalased toetavad põlevkivikaevanduse laiendamist”(Survey:the people of Ida-Virumaa support extension of oil shale mining), by Peeter Kuimet, *Postimees* 31.10.2006, available on www.postimees.ee/311006/esileht/siseuudised/226162_print.php, accessed on February 9, 2007.

⁸⁸⁶ “Vallarahvas seisab vastu uutele kaevandustele”(The people of a municipality oppose new mines), by Eva Kübar & Sandra Maasalu, *Postimees* 25.08.2006, available on www.postimees.ee/250806/esileht/siseuudised/214794.php?r.

entrepreneurs mining concessions. If it really is that way, then the law has to be changed rapidly to give the state that possibility.”⁸⁸⁷

The attitudes outside Ida-Virumaa are more complex to analyze, but it can safely be claimed that the attitudes are far from unambiguously positive. In 2005, an educational program called “oil shale land” was launched, the aim of which was to make students from schools in the capital Tallinn familiar with the oil shale industry and the county of Ida-Virumaa. One of the motives behind this project was to challenge the negative attitudes towards the region and its industry among both Estonian and Russian-speaking students in the capital and instead create an interest for a possible future profession in the oil shale industry.⁸⁸⁸ A study among Estonian-speaking students in Tallinn indicates rather negative views. Asked to list what they associate Ida-Virumaa with, the most prevalent answers were basically as follows: many Russians, HIV, drug addiction, oil shale mining, environmental damage, and crime.⁸⁸⁹

Such answers given by students in their mid- or late teens should perhaps not be taken too seriously, but they still point in one direction, namely that the region has a bad reputation, especially among Estonians. In this context it simply serves as an illustration of the claim that there is an attitude question in Estonia vis-à-vis the county of Ida-Virumaa and the oil shale industry, which has to be taken into consideration when discussing the present developments.

The energy system based on oil shale was no important political topic on the eve of the parliamentary elections on March 4, 2007. The programmes of the main political parties do not reflect any serious concerns about oil shale. The biggest party after the election, the liberal *Reform Party* states simply that energy production from non-renewables has to be secured until renewables can be used on a large scale.⁸⁹⁰ The slightly left-leaning *Centre Party* (which came narrowly behind the *Reform Party* in the elections) does not mention oil shale specifically.⁸⁹¹ One might assume that this question is difficult to handle for the *Centre Party* with a large Russian-speaking electorate. The third biggest party, the conservative-leaning *Union of Fatherland and Res Publica*, wants to stop further concessions for oil shale mining

⁸⁸⁷ “Kas põlevkivi on meie õnn või õnnetus?” (*Is oil shale our bless or curse?*) by Edgar Savisaar. *Põhjarannik* 17. jaanuar 2007.

⁸⁸⁸ “Krai slantsev zhdjet gostei”, (*The oil shale land is expecting visitors*, in Russian) by Josef Kats, *Molodjezh Estonii*, February 5, 2005, available at www.moles.ee/05/Feb/15/8-2.php, accessed on March 18, 2005.

⁸⁸⁹ “Põlevkivimaa. Kevad 2005”, available at <http://deepthought.ttu.ee/ajaleht/tp2005/polevkivimaa.pdf>, (a page from Tallinn Technical University) accessed on February 9, 2007.

⁸⁹⁰ www.reform.ee, accessed on March 22, 2007.

⁸⁹¹ www.keskerakond.ee, accessed on March 22, 2007.

until present deposits are exhausted. Moreover, the party favors decentralized electricity production in Estonia and a reduction of oil shale-based electricity generation in favor of renewables and energy saving. One aim is to gain independence from Russian electricity. In the near future, however, Estonia's power generation mix should be based on renewables together with oil shale.⁸⁹² The *Estonian Social Democratic Party* has no particular standpoint on oil shale, but like most other parties, it claims adherence to ecological values.⁸⁹³ The predominantly rural *Estonian People's Union* also lacks a specific opinion on oil shale, at least in its political programme.⁸⁹⁴ The *Green Party*, which re-entered the parliament in the elections, favors innovative approaches, both domestic and foreign, to solve the energy situation. It would also like to see the Estonian power grid disconnected from Russia and to minimize oil shale utilization in the coming 10 years, but at the same time take responsibility for the employment situation.⁸⁹⁵

As this brief summary of the opinions of the Estonian political field represented in the parliament shows, the oil shale-based electricity generation system does not seem to provoke strong political passions. Basically all parties are in favor of ecological solutions, but oil shale should be maintained until it is possible to switch to something else. Even the *Green Party*, foreign ideological partners of which tend to call for radical solutions, is rather cautious in its calls for a change of the present system. From this it can be concluded that no major political party in Estonia can identify any clear-cut, viable alternative to oil shale.

Oil shale may have a rather tarnished reputation, especially from an ecological viewpoint, but with no obvious alternatives, it is likely to remain unchallenged both among the general population and the political system. One could even speculate whether there is a mood of resignation prevalent in this issue in today's Estonia. Few people are happy about the present situation and there is relatively little evidence of pride taken of this particular Estonian technology, but it is accepted. The oil shale industry which was a national gem in the thirties and a waterhole for Estonian scientists during the Soviet years has more or less lost its attraction and become a necessity, albeit a problematic one.

8.7. Summary and comments – the anatomy of a lock-in

When studying the present structure of the Estonian oil shale industry, two well-known concepts from the literature are close at hand. However, both concepts differ from the

⁸⁹² www.irl.ee accessed on March 22, 2007.

⁸⁹³ www.sotsdem.ee accessed on March 22, 2007.

⁸⁹⁴ www.erl.ee, accessed on March 22, 2007.

⁸⁹⁵ www.roheline.erakond.ee, accessed on March 22, 2007.

observed characteristics in important ways. In spite of this, I find it appropriate to comment briefly on both.

Would it be correct to speak about an oil shale cluster in the sense Michael Porter uses the concept, that is, the joint impact of domestic competition, sophisticated domestic demand, supporting industries, and certain specific factor conditions such as skilled labor and appropriate infrastructure?⁸⁹⁶ At a first glance, Estonia might appear to have developed a cluster, but at second glance one can see that only a few of the conditions as defined by Porter are actually present. There is domestic demand, but it cannot be claimed to be particularly sophisticated. It is, by and large, a typical demand for energy for other purposes. So far, energy consumption is rarely anything but bulk consumption (with the exception of the occasional customer demanding environmentally friendly energy). There is also little domestic competition. In electricity, the market is dominated by one single seller, *Eesti Energia*. In shale oil, there is a de facto oligopoly with *VKG*, *Kiviõli Keemiatööstus*, and *Eesti Energia*. There are few supporting industries in the sense identified by Porter, which through their activities would improve the performance of the oil shale industry. On the other hand, there is the chemical industry, which at least to some extent uses products derived from oil shale, both energy and intermediate products. Moreover, Estonia has a uniquely skilled oil shale workforce, both blue and white collar. In the town of Sillamäe, located in the oil shale district, a modern harbor has been constructed in the last few years, with the capacity to handle chemicals and oil.⁸⁹⁷ All in all, it is difficult to describe the Estonian oil shale industry as a cluster in Porter's notion, despite the fact that several similarities can be found.

Approaching the Estonian oil shale industry with the perspective of Thomas Hughes' Large Technical System (LTS) will not suffice to encompass the whole structure. The oil shale industry is not one, but many systems. Based on a particular raw material, it is rather built into other LTS. The electricity generation is logically a key component of the electricity LTS, while the oil production makes use of other LTS, such as the road network or district heating. Thus, it is difficult to treat Estonian oil shale industry as an LTS in its own right. But nonetheless being an energy-technological system, it constitutes the very basis of modern society. At present it stands not only for electricity generation and the production of energy and chemicals, but also for increased national independence and social stability. It is therefore

⁸⁹⁶ Porter (1990).

⁸⁹⁷ For details, see www.silport.ee.

a superstructure embracing the very fundamentals of society. But the Estonian oil shale industry shares without doubt characteristics with Hughes' LTS. Usually the components of an LTS tend to support each other and become more and more intertwined. Over time, vast investment is made in the system while research institutions are created to support it. Thus the socio-technical system gradually becomes conservative and is prone to resist changes. Or in Hughes' words:

“Inventors, engineers, scientists, managers, owners, investors, financiers, civil servants, and politicians often have vested interests in the growth and durability of a system”⁸⁹⁸

This phenomenon can be observed throughout the history of the Estonian oil shale industry, and its contribution to the survival of the industry cannot be underestimated.

It has repeatedly been claimed that any major changes in the present situation of the Estonian oil shale-based energy system will be complicated to carry out and therefore it is reasonable to treat the present situation as a lock-in. The question of whether the system can be altered depends on the characteristics of the interplay of those forces maintaining it. First, these forces could be divided into *positive* and *negative*. A positive force would be one that in itself pushes or pulls the present system further on its path. Such forces are for instance new innovations related to oil shale utilization and export earnings. Negative forces would be those that prevent changes because of unwanted consequences, such as increased unemployment if radical changes were to be carried out. Also the question of maintaining national self-reliance in power generation can be counted as a negative force. The negative forces do not in themselves push the system further, they just counteract radical change of the system.

Second, the forces maintaining the system could also be seen as either *endogenous* or *exogenous*. Endogenous forces are those that directly stem from the oil shale industry itself, such as innovation, export earnings or scientific progress in relevant fields, while exogenous forces are international politics, government actions, environmental concerns, EU legislation, and popular attitudes. A particular exogenous force worth highlighting is the development of alternative energy sources. However, it should be stressed that for exogenous forces it is not

⁸⁹⁸ Hughes (1997) p. 77.

necessarily oil shale as such that is of importance, but rather the existence of any reliable energy system. It happens to be oil shale, but in theory it could be anything else.

Third, a distinction can be made between forces of *nature* and *human* created forces. The former would then be environmental issues, the existing reserves of oil shale and the calorific value of oil shale. Human created forces are on the other hand everything connected with society at large.

Starting from the distinction between forces of nature and human created forces, it is obvious that the outer limits of the system, that is the Estonian oil shale industry, are defined by the very existence of oil shale. At the present pace of excavation, the active resource will last for an estimated 60 years.⁸⁹⁹ Of course, passive resources might be exploited which in turn opens up the perspective for a longer duration of the present system, but at this point, this topic remains speculative. Furthermore, it can with certainty be established that in Estonia there will be no domestic fossil fuel more efficient than kukersite oil shale.⁹⁰⁰ The calorific value of oil shale can not increase even if technological development might increase the total energy extracted to some limited extent. These facts clearly establish the outer boundaries for the possibilities within the present system. All other actions, i.e. human created forces, will operate within these limits as long as oil shale remains the primary energy source. Within the human created system, a particular layer is constituted by the realities of international order. In its simplest sense, this would mean that each country is left to its own devices in meeting its energy needs. The boundaries of such a system are, however, increasingly porous. In the chapter on the early developments of the Estonian oil shale industry, it was claimed that national self-reliance on energy has been a primary objective of nations. Such a viewpoint is still valid today, but as a result of increasing international cooperation, energy policy worldwide has undergone dramatic changes. Energy flows across borders are more of a rule than an exception. The common market of the European Union is an important step in this direction. The issue at hand becomes what security policy concerns are attached to international cooperation. In the case of Estonia, the question is double-edged. On the one hand, Russia, with its giant energy resources, is perceived as a potential threat, while on the other hand there remains some suspicion as to whether the European structures are to be

⁸⁹⁹ Energy 2004.

⁹⁰⁰ This question is not as far-fetched as it might sound. There are enormous deposits of low calorific *dichtyonema* oil shale in Estonia, which theoretically could be used for the same purposes as kukersite oil shale used at present.

trusted in a tense situation. Therefore there is plenty of motivation for the continued existence of the Estonian oil shale industry. In brief, the realities of international politics provide enough reason for Estonia to stick to oil shale. In this context Estonia's geographic location plays a role. Until recently, Estonia together with Latvia and Lithuania were cut off from the European electricity network. The connection of the Baltic electricity grid to the Russian one makes Russian electricity production a factor to count with when new generation capacity in Estonia is planned. This might seriously hamper the willingness of investors, especially if environmental requirements are less tight in Russia, or if nuclear safety standards do not match with those of the EU. This dominant Russian connection with the Baltic electricity grid can be reduced by technological means, such as cables. This process has already begun with the cable between Estonia and Finland as a first step. More connections are probably needed, such as increased transfer capacity between Poland and Lithuania and a cable connecting the Baltic States directly with Sweden.

The positive and negative forces, as defined above, together constitute what Hughes calls "momentum".⁹⁰¹ While the positive forces pull or push the system in a certain direction or along its trajectory, the negative forces prevent any radical or abrupt change. In the case of the Estonian oil shale industry it has been shown how the social conditions together with the question of ethnicity/citizenship in the region of Ida-Virumaa effectively block thorough changes of the present structure. The downsizing of the oil shale industry in the 1990s led to notable concern both within and especially outside Estonia, where production cuts sometimes were perceived as being targeted against the non-Estonians in the region. For the past decade Estonia has enjoyed significant economic growth, resulting in increasing standards of living. It can be assumed that this gives rise to two simultaneous effects on the electricity branch of the oil shale industry. On the one hand, low electricity prices provide incentives for more energy-intensive industrial production in the country, but on the other hand emerging prosperity creates room for price hikes.

Among the positive forces, the following ones have been identified: new investment in cleaner oil shale technology, increasing profits due to the high world-market price for oil, and the high degree of technical specialisation in oil shale within the scientific and engineering communities in Estonia. On the other hand, the fact that CO₂ emissions are counted against a

⁹⁰¹ Hughes (1998).

baseline defined as the emission level in 1990 allows for relatively large emissions. Among negative forces, preventing change, should be counted the fact that the electricity monopoly *Eesti Energia* has been able to make significant profits on selling emission rights while at the same time operating a CO₂-intensive industry. Another negative force is the ultimate reliance on Russian electricity in the Baltic States, which might have a restraining impact on the willingness to invest in new methods of generating electricity.

Making a distinction between endogenous and exogenous forces is by no means straightforward. Nevertheless, making this distinction is still relevant, because it defines the boundaries of the system while allowing for its evolution. One could claim that the direction of exogenous forces is more decisive for the future than that of the endogenous forces, although a weakening of the latter probably will affect the former as well, while a severe weakening of the exogenous forces would most likely bring the system to a standstill and lead to erosion. This reasoning is quite straightforward. The exogenous forces react to what the system produces and how, for instance, the production of electricity is made at affordable prices not creating too much environmental damage. Therefore it is up to the oil shale industry to constantly provide proof of success in this respect in order to maintain support. As has been shown, at present the oil shale industry enjoys only a little goodwill as such, but it is tolerated because it is the key supplier of electricity (and other forms of energy). It was previously mentioned that nuclear power, which could be seen as a potential competitor to oil shale, has a bad reputation stemming from the aftermath of the Chernobyl accident when many Estonians were mobilized by the Soviet authorities for the cleaning-up. This was a singularity, a particular event not foreseen, but nonetheless it probably had a profound impact on popular attitudes in Estonia towards nuclear power as such, weakening its attraction and indirectly supporting the oil shale industry. The effect of this sort of event cannot be neglected when attempting to analyse the future direction of the energy system. Furthermore, nuclear power fits poorly in Estonia with its small population and low population density.

Another dimension is a distinction between forces that maintain lock-in and forces eroding it. The latter forces often mirror the former, but also entirely others can be identified, such as environmental hazards. However, the eroding forces can by definition neither be positive nor negative, because they counteract the path that creates the lock-in (but they can of course be either endogenous or exogenous).

Table 8.6. Major elements constituting lock-in into oil shale in contemporary Estonia

	Created by humans		Caused by nature	
	<i>Endogenous</i>	<i>Exogenous</i>	<i>Endogenous</i>	<i>Exogenous</i>
Positive	1)Technological development 2)Accumulated know-how, tacit knowledge	1)World market price for oil 2)International cooperation 3)Demand for electricity and energy	1)Existence of high-calorific oil shale	
Negative	1)Lack of technological development due to limited resources 2)Sunk costs 3) Profits from selling emission rights as a result of the choice of baseline 4) Lock-out of new technology because of market conditions	1)Ethnic concerns, 2)Unemployment and social concerns 3)International politics, 4)Popular attitudes 5)National self-reliance, security of supply 6) Government actions		1) Lack of other obvious energy sources

Eroding forces	1)Slow technological development in the oil shale industry 2)Changes in the knowledge base in Estonia	1)Changes in the knowledge base in Estonia 2) Development of competing technologies 3)International cooperation, increased trust 4)Societal attitudes	1)Depletion of oil shale resources	1)Environmental hazards 2)Population structure and geography favour dispersed electricity generation
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Research and development on oil shale, often ascribed a major engine behind the growth of technological systems, has been strong in Estonia but weak worldwide. In today's Estonia the picture is no longer clear. The average age of especially researchers in the oil shale chemistry is alarmingly high. This development is also reflected in the difficulty to attract young scientists to the oil shale sector and in particular oil shale chemistry. Helle Martinson comments on this development, not without lamentation:

“We are the last ones alive. Are there any young and bright people in this at all? In power production, yes, but not in chemistry. There is a lot of data, a lot of work done, but with no meaning. Everybody is either dead or in some small business. Oil shale chemistry is not profitable. Nowadays one looks at increasingly small details, not highly complicated matters like oil shale.”⁹⁰²

A further aspect on lock-in is the distinction between perceived and real lock-in. Could it be assumed that at least partially the strength of the present lock-in is a result of a particular notion? This would imply that in reality there are ways out from the present state, but that the perceptions of those involved in the decision-making at all levels cause such alternatives to be overlooked.⁹⁰³ Such an assumption would correspond with the ideas put forward by Douglass North on incorrect interpretations of the surrounding world.⁹⁰⁴ Under such conditions actors

⁹⁰² Helle Martinson, personal communication October 11, 2005.

⁹⁰³ Mats Söderström of Program Energisystem pointed out the relevance of this question.

⁹⁰⁴ See North (2005) p. 5.

would perceive their actions as rational, but they would act according to a set of rules that correspond with their own beliefs and not reality itself.

As has been shown above there is no obvious competitor to oil shale in Estonia. At present, renewables can only compensate for a smaller share of total electricity generation. The only serious alternatives in the short run are imports and nuclear power, which to some extent coincide. Enhanced energy efficiency together with environmentally sounder technology at the production facilities is the perhaps the best short-term option for Estonia for mitigating the negative externalities resulting from the large-scale use of oil shale.

9. An outline of a failed industry - the case of oil shale in Sweden

9.1. Counterfactual history or an alternative path

A highly interesting, but also controversial, approach is counterfactual history. What would have happened, if...? Robin Cowan and Dominique Foray discuss the criteria that should be applied on any counterfactual analysis of economic history. If one assumes that the neoclassical assumption of a single equilibrium holds, using counterfactual history writing poses no major problem, supposing that the premises are known. The issue becomes more complicated as soon as we look upon economic development from an evolutionary perspective. Cowan and Foray claim that by establishing some causal relations, one can give a fairly good answer to the question “what if?”⁹⁰⁵ A similar argument has been formulated by Andrea Bassanini and Giovanni Dosi. Studying path-dependent processes opens up the possibility of having something to say about “possible worlds” by assessing the importance of the initial factors underlying the process.⁹⁰⁶

In this chapter, I will make an attempt to approach this thinking. By studying the Swedish oil shale industry, which existed until 1966, perhaps something can be said about the possible development that at different times lay open for the Estonian oil shale industry. This comparison makes it possible to draw conclusions that would otherwise have been impossible, or too speculative. With a real-world example of a different path, well-founded arguments about possible paths should be possible to present.

In the first half of the 20th century Sweden developed an oil shale industry, which, in the end, never became viable and was gradually perceived more of a problem than an asset, despite numerous efforts to save it. When the shale oil industry eventually was shut down in 1966 it had become synonymous with economic failure and environmental disaster.

⁹⁰⁵ Cowan & Foray (2002).

⁹⁰⁶ Bassanini & Dosi (2000) p. 63.

The purpose of this chapter is to analyze the developments that led to the establishment of a shale oil industry in Sweden and, in particular, why it was eventually shut down. Moreover, this chapter also discusses the process of technology choice in Sweden and the role played by experiences gained in Estonia in this process. Most people would agree that a polluting, non-profitable industry should be closed as soon as possible, unless there are extraordinary reasons for maintaining it. The issue at hand is, however, not this, but rather to analyze the question what circumstances set the development in motion and later aborted it in Sweden. What particular factors lay behind the decisions both to create, to maintain and to shut down the industry? This development can be contrasted with the development of the Estonian oil shale industry in order to identify similarities and differences. It could be argued that this issue could be turned down straight away by referring to the very different political and economic history of these two countries, as well as the differing chemical characteristics of the oil shales in Sweden and Estonia. The Estonian oil shale sector also gained from more research and development from its very start than its Swedish counterpart. But despite these and other obvious differences, there are parallels to be drawn from the development of these industries, which should be of interest for the studies on why and how industries adapt to changing political and economic environments, how they find new niches and how they in the end either survive or go extinct.

This chapter aims only at a study of the directly energy-related and chemical production based on oil shale. In addition to this, also radioactive substances can be extracted from oil shales – and this has been done in both Sweden and Estonia⁹⁰⁷ – but this issue remains beyond the scope of this work.

9.2. The beginning of an industry

In Sweden there are relatively large reserves of oil shale, 20 billion tonnes of known reserves, which in theory could yield 800 million tonnes of oil.⁹⁰⁸ These reserves are located in several places in Sweden, but the richest deposits can be found on the island of Öland and the districts of Närke and Östergötland, to the west and south-west of Stockholm, respectively. Potential

⁹⁰⁷ In Estonia attempts to extract uranium and possibly other radioactive materials from dictionema oil shale in the 1950s and 1960s turned out to be a failure. Instead, imported radioactive materials were processed. See Lippmaa & Maremäe (2003).

⁹⁰⁸ SOU 1974:64. [Swedish Government Official Report]. In SOU 1956:58 the reserves of oil shale are estimated at 49 million tonnes, but the potential oil yield remains almost the same or 880 million tonnes.

oil yield from the richest Swedish oil shales (in Närke) is between 5 and 6 per cent, while for example the oil shale from the large deposit in Östergötland contains only 3.5 per cent oil.⁹⁰⁹ (In contrast, Estonian kukersite oil shale contains between 11 and 16 per cent oil). However, the exploitable oil shale for oil production in Sweden is 13 billion tonnes.

In the late 1800s the first attempts in Sweden were made to produce oil from oil shale⁹¹⁰. Already in 1913 a governmental committee was established with the task to analyze the possibilities to use oil shale in oil production. After WWI the question of oil supply for the navy was perceived as increasingly urgent, because Sweden, though neutral during the war, faced difficulties in importing oil-based fuels. Adding to the urgency was the fact that the navy increasingly used oil-based fuels instead of coal. A privately-established small scale shale oil factory⁹¹¹ at Kinne-Kleva (in the vicinity of lake Vänern) received financial support from the government more or less from its very start in 1923. This small scale production never became financially viable, and in 1932 the factory was bought by the government. At this time the Royal Swedish Academy of Engineering Sciences⁹¹² suggested that the resources for buying the plant should instead be invested in experimenting with a technology developed in Estonia, the tunnel oven, but did not succeed in persuading the parliament.⁹¹³ Instead, the factory at Kinne-Kleva continued operations with its so-called Bergh ovens, which would later develop into the main technology in Swedish shale oil production.⁹¹⁴ A detailed description of the technologies used in Sweden follows later in this text.

In conjunction with the government take-over of the plant, even the name of the factory was changed to the “naval shale oil plant”.⁹¹⁵ The production remained of a mainly experimental character, with an annual output of 500 tonnes of oil. However, in 1939 the factory was rapidly enlarged to produce 7,000 tonnes of oil annually for the navy.⁹¹⁶

⁹⁰⁹ SOU 1956:58. It should be kept in mind that the yield of kerogen, which is the organic component of oil shale, is a different thing from oil yield. Oil is produced from kerogen, but far from all kerogen can be turned into oil.

⁹¹⁰ The Swedish oil shale is closely related to the Estonian dichtungema oil shale (Kattai 2003 p. 29), which is not used in Estonia because of its lower oil content.

⁹¹¹ The factory was run by AB Svensk Oljeindustri.

⁹¹² In Swedish “*Kungliga Ingenjörsvetenskapsakademien*”.

⁹¹³ Bergh (1996)p. 151. See also SOU 1956:58 .

⁹¹⁴ SOU 1956:58.

⁹¹⁵ In Swedish “*Flottans Skifferoljeverk*”.

⁹¹⁶ Bergh (1996).

On October 25, 1940, the Government Fuels Commission recommended that the annual production of the Swedish oil shale industry should match the minimum domestic demand of liquid fuels.⁹¹⁷ One major problem was the lack of experience of various technologies for oil production and therefore picking any technology for the new factory was almost a gamble. Only the Bergh oven had previously been used in Sweden.

In January 1941 the government-owned Swedish shale oil company *Svenska Skifferolje AB* (SSAB) was established, with the primary task to provide oil to certain crucial sectors in the Swedish society - especially the navy, because imports from the West were cut off after Denmark and Norway had been occupied by Germany in April 1940. From the beginning, the Government Fuels Commission realized that imports of oil would be cheaper than shale oil production, but as this was no longer an option, commercial feasibility was hoped to be achieved from various by-products – such as gasoline, gases, sulphur, and aluminum oxide.⁹¹⁸ But despite this possibility, it was obvious from the very start that no private capital could be expected to be raised for such a risky enterprise. The production capacity that was about to be built was big, previous experience of the production scarce and commercial opportunities theoretical at best. Therefore the influential Royal Swedish Academy of Engineering Sciences recommended the establishment of a government-owned company, SSAB.⁹¹⁹

It should be pointed out that similarly to Estonia, government intervention was crucial for the emergence of an oil shale industry in Sweden, even if the very first attempts were private initiatives. But also in that case, government funding was required from the very start.

The deposit of the richest Swedish oil shale, in the mid-Swedish district of Närke, was predestined to attract the biggest interest. Consequently, SSAB's shale oil factory was put into operation at Kvarntorp near the city of Örebro, in 1942. Despite the fact that the oil shale of Närke is the richest (in organic content) in Sweden, the relatively low calorific value of the oil shale was perceived as problematic from the beginning.⁹²⁰ In 1943 the factory at Kinne-Kleva was merged with SSAB.⁹²¹ In 1946 the parliament decided to shut down the factory at Kinne-

⁹¹⁷ SOU 1956:58.

⁹¹⁸ Byttner p.9.

⁹¹⁹ SOU 1956:58 p. 86.

⁹²⁰ Ljungdahl (1951).

⁹²¹ Bergh (1996).

Kleva and concentrate production to the bigger factory at Kvarntorp.⁹²² In a highly critical article about the developments in the Swedish oil shale industry, the inventor of the Bergh oven, Sven V. Bergh claims that the closing down of the Kinne-Kleva factory was decisive for the further problems for the Swedish oil shale sector.⁹²³ Without Kinne-Kleva, a monopolistic industry emerged with little or no insight:

“The shareholders, the Swedish people, have learnt very little about the activities of the company. At the shareholders’ meeting the Swedish people have been represented by a secretary of state. There are no inquisitive shareholders who demand clarity in detail and who mercilessly condemn any wastefulness.”⁹²⁴

Bergh champions the viewpoint that the Kinne-Kleva factory could easily have been turned into a producer of gas and building materials, while the monopoly of SSAB should have been restricted to the sale of the side products from the industry, oil and sulphur. Thus production would have remained diversified. Whatever justification there might be for Bergh’s views, the fact remains that Bergh was the prime mover behind the Kinne-Kleva factory and definitely had his very own interests in the success of it. In Estonia oil shale rose to eminence through the combination of government and private initiatives and it is understandable that a similar approach would have been welcomed by Swedish entrepreneurs in the field. However, two crucial factors were different; first, the lower calorific value of Swedish oil shale left less scope for profits, which would weaken the interest for private sector investment. Second, the large-scale Swedish build-up of the oil shale industry took place during wartime conditions, which probably restricted the interest of domestic investors, while making it impossible to attract foreign capital. On the other hand, Sweden had a much bigger domestic market than Estonia - both in size and prosperity. This would have reduced the need to find foreign financing.

Eventually, four different technologies for producing shale oil were taken into use at Kvarntorp, because there was no precise experience of the efficiency of each technology. Initially only two technologies were considered - the Bergh oven and the IM oven (described below) - both having the same capacity of processing 500 tonnes of oil shale in a day. When the Fuels Commission in April 1941 recommended an increase of total annual production

⁹²² SOU 1956:58 p. 91, see also Bergh (1957).

⁹²³ Bergh (1957).

⁹²⁴ Ibid p. 49.

from 15,000 cubic meters of oil to 28,000 cubic meters, an additional Bergh oven and an HG-oven (described below) were added. This was perceived a suitable mix, each technology complementing the others. In addition to these ovens, the Ljungström-method, which is not an oven (described in detail further below) was also used. In April 1942 the Fuels Commission asked for a subsequent enlargement of the factory with one and a half Bergh oven, one IM oven and half a HG oven, funding for which was granted by the parliament.⁹²⁵

9.3. Finding the Right Technology Mix

9.3.1. Technology transfer to and from Estonia

Only one of these technologies, the tunnel oven from which the IM oven would emerge, had been tested on an industrial scale before, in Estonia. The foundations for the IM oven were developed in 1928 when a tunnel oven was constructed by the Swedish-owned consortium at Sillamäe in Estonia and a second, bigger oven in 1938.⁹²⁶ These ovens had been developed by the inventor Gustaf Gröndal, whose company *Patentaktiebolaget Gröndal-Ramén* was the holder of the patent.⁹²⁷ After the founders Gröndal and Ramén had died, the company was taken over by Gröndal's son-in-law, Fredrik Carlsson,⁹²⁸ whose company *AB Industrimetoder*, (later renamed as the engineering bureau *Fredca*), became the principal developer of the IM oven.

The first oven at Sillamäe produced 270 tonnes of oil a day, while the second produced 500 tonnes. These two ovens produced a total of 140 thousand tonnes of shale oil before WWII. In brief, in a horizontal tunnel oven, the oil shale is transported on wagons through a tunnel heated by gasses emitted by the oil shale itself, which in turn require an external source for their heating. During this slow process, oil is extracted from the oil shale.⁹²⁹ The IM oven that was about to be taken into use in Sweden was a modification of the ovens that had been in use in Estonia. The tunnel ovens in Estonia had been designed for processing enriched kukersite

⁹²⁵ SOU 1956:58.

⁹²⁶ It should be pointed out that tunnel ovens were also simultaneously developed by the German-owned consortium *A/S Eesti Kiviõli* in Estonia. Source: Kattai (2003) p. 45.

⁹²⁷ Patents no 58777 and 60119 in Sweden (1923), no 329 and 426 in Estonia (1923 and 1924). The technology was patented also in England, Germany, France, Norway, Yugoslavia, Italy, USA, Canada, Australia and South-Africa.

⁹²⁸ Kreüger (1933).

⁹²⁹ Sundius (1941).

(i.e. the particular oil shale found in Estonia), with an organic content of 40-45 per cent, in lumps.⁹³⁰ Therefore, technological developments in Estonia had an important influence on technology developed in Sweden. This diffusion of technology was abruptly halted by WWII and never resumed. Even if it might be far-fetched to ascribe the demise of the Swedish oil shale industry to the lack of diffusion of technology, this fact should nevertheless be mentioned.

9.3.2. The IM oven

Trials in Estonia had shown that because of the specific chemical composition of kukersite, it has a specific behavior during thermal decomposition. The organic material in kukersite melts instead of emitting oil fumes when heated too slowly. Because the raw material led into the oven held a low temperature, it had a cooling effect within the oven, resulting precisely in a slower heating. To avoid this, Carlsson designed and patented the IM oven where heating was quicker, because the oven was divided into three sections, each with its separate heating thereby allowing for pre-heating. This way it was possible to avoid falling temperatures within the oven between the entrance and the exit, which was the case in the tunnel ovens used in Estonia.⁹³¹

The son of the inventor Sven V. Bergh, Sigge Bergh, claims that the Royal Swedish Academy of Engineering Sciences went too far in promoting the IM oven and argues that the consequences of using this technology could easily have been tested in Estonia before the war at the Swedish-owned factory.⁹³² However, when WWII broke out, there was no possibility for experimenting and obviously the fact that the IM oven had been in large-scale use before spoke in its favor. But even despite this, other types of ovens were also included in the total set of ovens at Kvarntorp from the beginning. After all, it was a well-known fact that the Swedish oil shale is poorer and that it has a different chemical composition from the Estonian one.⁹³³ The Academy wanted to take no risks when it came to the security of the supply of oil during the war and thus long-term development potential was a subordinated issue. Moreover, tests had shown that from 1 tonne of oil shale, 12 kg raw petroleum and 48 kg oils could be

⁹³⁰ Dr Helle Martinson, e-mail communication 2006-03-15.

⁹³¹ "Patent No 99249. Sverige. Beviljat den 30 april 1940".

⁹³² Bergh (1996).

⁹³³ This fact had already been established for the Swedish public by Cyrén (1924).

extracted with the IM oven, while the corresponding figures for the Bergh oven were 4 kg and 46 kg, respectively.⁹³⁴

The Academy reacted to the occupation of Denmark and Norway on April 9, 1940 and recommended immediate action, which meant construction of a full-scale IM oven, instead of starting by building an experimental one, which the Academy had proposed as late as April 1, 1940 for the purpose of resolving some technical problems caused by the different characteristics of Swedish and Estonian oil shale⁹³⁵. Consequently, the first oil produced at the new Kvarntorp factory came from an IM oven in April 1942.⁹³⁶

Moreover, the IM oven was the most efficient oven when the overall aim is to produce motor fuel. Similarly, the Ljungström field (described in detail below) was efficient in times of crisis, because it allowed the swap of abundant hydropower for rare oil and petroleum. When times of peace returned, both methods were gradually regarded as obsolete for economic reasons. The IM-oven, though producing more oil than the others, however, consumed all the gas it produced. After the war, gas gradually became one of the principal products of Kvarntorp, because it was regarded as having commercial potential. As a consequence the IM ovens were taken out of use in 1958-59. At the same time the Ljungström-field was shut down and the surviving method for production was the improved Bergh-Kvarntorp oven seconded by an HG oven.⁹³⁷ Sigge Bergh assumes that had the initial decision been based on commercial feasibility, i.e. the production been focused on both oil and gas using more or less exclusively Bergh ovens, the entire factory could perhaps have withstood the new economic realities after the war, but because of actions taken by the Academy of Engineering Sciences, the fate of Kvarntorp was sealed from the onset.⁹³⁸

⁹³⁴ "Anteckningar från samtal med Dir. Fr. Carlsson. A/B Industrimetoder den 28.1.1941". Arkivcentrum Örebro A 151. This memorandum from a meeting between representatives of SSAB and Fredrik Carlsson does not state who had carried out the tests, but judging from the text, these figures were provided by Carlsson himself, who had personal interests in selling his invention. Consequently, there are some words of precaution written in the memorandum. Furthermore, it should be pointed out that the condensation device attached to the oven was constructed by *Deutsche Koller Generatoren- und Ofenbau Gesellschaft, Bergfeld & Co.*, Berlin.

⁹³⁵ SOU 1956:58 pp. 86-7.

⁹³⁶ Runering (2005) p. 298.

⁹³⁷ "Skifferskriften" (1961).

⁹³⁸ Bergh (1996) pp. 157-8. It is worth noticing that one of the leading Estonian experts on oil shale, Agu Aarna, writes in 1965 that there are no perspectives for further development of tunnel ovens in Estonia. The existing six tunnel ovens should in his opinion be used as long as they function, but afterwards be replaced with some new system. Aarna (1965).

On the other hand, there is no doubt that the Kvarntorp factory was built as a response to the German occupation of Denmark and Norway and the deteriorating geopolitical situation in the vicinity of Sweden and in all of Europe. There is no evidence to be found anywhere that reasons other than the security of the supply for Sweden would have played any role in the establishment of Kvarntorp. As a side-effect, however, Sweden developed technological know-how in the oil shale sector, part of which could still have turned out to be of importance in the future, but this was never either the explicit or the implicit purpose of Kvarntorp.

It cannot entirely be ruled out that non-technical arguments played a role in the decision how to design Kvarntorp. It should be mentioned that the creator of the IM oven, Gustaf Gröndal (d. 1932), had been a member of the Academy of Engineering Sciences.⁹³⁹ This fact definitely gives Bergh's claims some credibility.

9.3.3. The Bergh-oven

The Bergh oven, which later in a modified version became known as the Kvarntorp oven, was basically a set of five smaller retorts (2.5 m in length) with a common heat source. This allowed the shale to go through increasing temperatures from 100°C to 500°C, with moisture being the first to be removed, while gradually other substances are distilled from the shale. Gases were led away through a tube common for the five retorts. When the coke finally reached the lower end of the retort with a temperature of 500°C, it simply dropped beneath the retorts and ignited when it came into contact with air. Steam circulated the entire aggregate on the outside, heated by the coke. The idea of replacing one big retort with several smaller ones allowed replacement of one defect retort without interrupting the entire process. The oil yield could thus reach 80% of laboratory conditions.⁹⁴⁰

Another oven, HG, was also taken into use at Kvarntorp in order to gain experience for the evaluation of each technology.⁹⁴¹ The HG oven, named after its developers Hultman and Gustafsson, was a modified version of the Scottish Pumpherson retort. It was initially used at Rockesholm, not far from Kvarntorp, in 1917. This attempt was not particularly successful, and it was obvious that without increased capacity to produce other chemicals, the oven would not be economically feasible. However, the HG oven was given a second chance at

⁹³⁹ Bergh (1996) and Kreüger (1933).

⁹⁴⁰ Sundius (1941).

⁹⁴¹ Bytner (1960) p. 15.

Kvarntorp.⁹⁴² This type of oven is basically a vertical generator, several meters high, heated from the outside by either gas or oil.⁹⁴³ These particular circumstances – the size allowing for heating big chunks of shale, without further processing, and the possibility to switch between two fuels was the prime motivation of keeping the HG oven at Kvarntorp, despite its relatively low efficiency. The reason for a switch between fuels being perceived as important was that shifts in the composition of output of the factory did not significantly alter the production possibilities, i.e. more oil in the output could simply be achieved by heating the HG retort with gas and vice versa.⁹⁴⁴

9.4. A Totally New Method

An entirely new method for producing shale oil was developed by the inventor Fredrik Ljungström. Instead of mining the oil shale, method requires the heating of the oil shale in its deposit, *in situ*. When the underground deposit is heated to 380 degrees Celsius, oil vapours and gases pour through fractures in the shale toward vertical holes dug in the ground. From these holes the gases can be captured and condensed into liquid state. The shale coke remains in the ground. With limestone on top of the shale, this method becomes more efficient, as the gases find fewer cracks to pour out in the open, but instead they find their way toward the holes dug in the ground for this purpose. Moreover, the method becomes more energy efficient. The fundamental drawback with this method is the high demand for electricity for heating .⁹⁴⁵

With the Ljungström method, each gas-hole (for capturing the oil) is surrounded by six heating holes (into which a heating element is applied) in the shape of a hexagon. The oil gases then pour toward the gas-hole in the middle of the hexagon. This pattern is then repeated into a continuous field, i.e. combining all hexagons for the obvious reason that one separate hexagon loses energy to the area outside of it, while several hexagons reinforce each other⁹⁴⁶.

⁹⁴² Bergh (1996).

⁹⁴³ It can be added that vertical generators became dominant in Estonia.

⁹⁴⁴ SOU 1956:58.

⁹⁴⁵ Runering (2005).

⁹⁴⁶ Ljungström (1999) pp. 281-2.

In October 1941 the first Ljungström-field was started, Norrortorp I. At this location the thickness of the oil shale layer was 15 m, which lay under a layer of limestone of 5m. It consisted of 36 heating holes in each row, 2.2 m between them in a hexagon and thus giving the field a width of approximately 68 m. The field could be moved forward – the first row of heating holes was called “the front”, which could be moved at a speed of 3.3 m in a fortnight, which meant that a new row of hexagons was added. Norrortorp I was active until 1945 and had by then covered an area of 68m times 280 m and produced oil at a rate of 8.3kWh/liter The field employed a total of 45 persons.⁹⁴⁷

A bigger field, Norrortorp II, was opened in April 1944, which basically had the same characteristics as Norrortorp I, but was 185 m wide. This field produced oil at a rate of 6.5 kWh/liter. The oil had thermal value of 10.5 kWh/liter. In the years 1947-49, shortage of electricity caused Norrortorp II to shut down, and when it was reopened in 1953, only a part of it was used under the name Norrortorp III. This field was finally closed in 1958 because of high electricity prices and the lack of demand for the production of shale oil in Sweden. A much larger field, LINS-250, never left the planning stage in Sweden, but was used experimentally in the USA and in Canada.⁹⁴⁸ It should also be mentioned that between 1948 and 1954 a similar technology was used in Kiviõli in Estonia, but the results were discouraging, especially because of unfavorable geological conditions and subsequent major loss of gases.⁹⁴⁹

A more critical picture of the Ljungström field is presented by the Swedish Government official report. Under normal conditions, when imports of oil are not threatened, the Ljungström field shows negative efficiency. For a yield of 21 cal. in oil and gas from 100 cal. in the ground, an energy addition of 41 cal. from the outside is required. The only motivations for using a Ljungström field would be the emergence of a situation with simultaneous excess electricity supply and drastically reduced imports of oil.⁹⁵⁰ Thus the Ljungström method, at least in Sweden, is clearly to be identified as a method only for exceptional circumstances. On the other hand, there are signs that there is a renewed interest in a modified version of the Ljungström-method in the USA with its enormous oil shale deposits. Experiments have been

⁹⁴⁷ Ljungström (1999) p. 295.

⁹⁴⁸ Ljungström (1999) pp. 295-305.

⁹⁴⁹ Kattai (2003) p. 72.

⁹⁵⁰ SOU 1956:58 p. 99.

carried out by Shell Oil Company, but it is too early to judge what the real costs for oil extracted this way will be.⁹⁵¹

9.5. A quest for survival

After the war, the Kvarntorp factory had to embark on a transformation process to turn itself from a producer of crisis-time fuel to a chemical multi-product enterprise. This need is clearly manifested in a memorandum in February 1948 from SSAB, signed CEO Claes Gejrot.⁹⁵² The Swedish government had expressed its wish to transform *SSAB* into a “normal long-term enterprise”. In order to achieve this, it was recognized that the company would make losses in the beginning of this transformation period, because of significant new investment, including ovens for chalk and a device for burning shale coke. At this time it was suggested that profitability could be achieved by producing liquefied petroleum gas (“gasol”, LPG), in addition to which enhanced oven capacity would increase the output of oil by 50 per cent and power production by 160 per cent. Still the losses turned out to be bigger than expected. The reasons mentioned by Gejrot include increased prices and reduced delivery of electricity, delayed deliveries of equipment because of the difficult supply situation, increased wages due to collective labor union agreements, the extremely cold winter of 1947 and unexpected costly damage from the production to vegetation and the fishery. Moreover, because the distribution network for petrol produced at Kvarntorp was not sufficiently developed, an agreement was reached with the companies *Shell* and *Standard*, according to which these companies would buy 40 per cent of the planned production at a price so much lower than market prices that the entire profit from *SSAB*’s petroleum was eliminated. This agreement was terminated in the summer of 1947. It was recognized by Gejrot that the crucial question for *SSAB* was the overall development of costs both within Sweden and in the surrounding world. In this respect hopes were tied to LPG, of which there was little competing import. A general increase of costs in Sweden loomed as the largest single threat to the future of *SSAB*.⁹⁵³

In its first annual report in peacetime, *SSAB* states the need to develop a profitable industry, which should focus on increased production of oil, gas, electrical energy and liquefied

⁹⁵¹ Bartis et. al. ”Reconsidering Oil Shale” *Energy* (Stamford) 30(2005):4, p. 21-24.

⁹⁵² ”Konfidentiell redogörelse av verkställande direktören rörande dels verksamheten vid Svenska Skifferoljeaktiebolagets anläggningar i Kvarntorp räkenskapsåret 1/7 1946-30/6 1947 och dels förutsättningarna för driften under pågående utbyggnadsperiod” Arkivcentrum Örebro F1D:150B.

⁹⁵³ *Ibid.*

petroleum gas for households and industries.⁹⁵⁴ The following year the production was divided into two categories – main products and side products. The first category consisted of petroleum, paraffin oil and heavy oil, while the second category was composed of sulphur (a key component for the chemical industry), ammonium sulphate (from which nitrate for fertilizers can be produced), chalk, LPG and gas.⁹⁵⁵

The demand for LPG clearly exceeded expectations not only in Sweden, but LPG was also exported to Denmark and, on a smaller scale, to Norway.⁹⁵⁶ This development raised hopes for economic viability for Kvarntorp, which had been making losses every year after WWII. Eventually, not even the launch of this successful product could make the enterprise profitable. Throughout the annual reports a large number of explanations are served as to why the loss-making continues, each of which is reasonable, but taken together give the picture of an enterprise not in tune with its environment.⁹⁵⁷

The factory at Kvarntorp never produced any profit, but its existence had been motivated by the exceptional demand for security of oil supply during WWII.⁹⁵⁸ The production lasted until 1966⁹⁵⁹ and Sweden did not develop the oil shale industry further⁹⁶⁰. The production at Kvarntorp was regarded as acceptable as long as immediate national security was a question, but in a world of free trade flows, the very *raison d'être* for a loss-making Kvarntorp was eroded. A number of supportive measures were taken by the Swedish government, such as direct subsidies, the right to keep a part of collected petroleum taxes, reduced interest payments on government loans and some other measures, but the books steadfastly remained in the red, for every single year.⁹⁶¹ Clearly, time was running out for Kvarntorp.

In his generally highly critical study on the shale oil factory at Kvarntorp, the journalist Anders Bytner states that there were three main groups of reasons for this production to continue even after the flow of imported oil picked up again after WWII. First, Kvarntorp was

⁹⁵⁴ Svenska Skifferolje Aktiebolaget. Förvaltnings- och Revisionsberättelse 1/7 1945-30/6 1946.

⁹⁵⁵ SSAB. Förvaltnings- och Revisionsberättelse 1/7 1946 – 30/6 1947. See also Skifferskriften (1961).

⁹⁵⁶ SSAB. Årsredovisning och Revisionsberättelse 1/7 1950-30/6 1951.

⁹⁵⁷ The annual report 1952-53 for instance mentions the devaluation of the Swedish crown in 1949 as a significant reason for the problems, because imports of certain technical devices from the USA became much more expensive. SSAB. Årsredovisning och Revisionsberättelse 1/7 152 – 30/6 1953.

⁹⁵⁸ SOU 1961:27.

⁹⁵⁹ SOU 1978:17.

⁹⁶⁰ To be precise – Sweden produced uranium from oil shale at Ranstad until 1969, i.e. after the Kvarntorp factory was closed down.

⁹⁶¹ SOU 1961:27 p. 75. See also annual reports from SSAB.

perceived as an important component of the security of supply for the country, because if Sweden were once again to be sealed off from the world market of fuels, the Kvarntorp factory could still produce valuable liquid fuels that could otherwise not be supplied. Second, there was a widespread notion that the Kvarntorp factory could somehow be made profitable through new investment. Third, the emergence of “created interests” during the years of operation of the Kvarntorp factory effectively stopped attempts at shutting down the production. Byttner identifies among these “created interests” local, political, business related and purely personal interests, but does not name any particular actor.⁹⁶² The Swedish Government official report in 1961 on the shale oil question comes to the conclusion that it would be cheaper to store imported oil for several years’ consumption than to maintain the Kvarntorp factory. Furthermore, the report adds that storage of this magnitude would give Sweden enough time to restart shale oil production were the crisis to be prolonged. An additional gain would be that the oil shale fields would not be depleted in the meantime, as long as import routes were accessible⁹⁶³.

9.6. Not the Right Quality?

One critical problem of the Swedish oil shales is that they have an unfavorable ratio between carbon and hydrogen and a high sulphur content. While 65 per cent of the fossil energy content in the Estonian oil shales can be extracted as oil, the corresponding figure for the Närke shales is 25 per cent. On the other hand, the Swedish oil shales exist in sufficiently large quantities. Oil shale deposits with a kerogen content of more than 10% are estimated to 74 billion tonnes, containing a total of 9.1 billions of tonnes of kerogen.⁹⁶⁴

It can be seen from the table 9.1. below that the active resources of Estonia not only clearly exceed those in Närke,⁹⁶⁵ but as already mentioned they also have significantly higher oil content. A certain precaution should, however, be taken when comparing these figures, as those for Sweden are four decades older than those for Estonia. The Estonian reserves were probably significantly higher in 1960 than they are today, as some resources have been exhausted, while the methods for assessment have developed in the past decades and the figures for Sweden might change if newer methods were to be applied

⁹⁶² Byttner (1960).

⁹⁶³ SOU 1961:27 pp. 71-2.

⁹⁶⁴ DsI 1983:20 p. 68.

⁹⁶⁵ As has been mentioned before, the resources of Närke are not the only ones in Sweden. There are large deposits elsewhere, but they are more difficult to excavate.

Table 9.1. A comparison between Estonian and Swedish oil shale.

Location <i>(Note that only locations with industrial activity are listed)</i>	Oil content <i>(Note that oil shale as such does not contain oil, but kerogen, which when heated yields oil)</i>	Reserves of oil shale
East-Närke (around Kvarntorp), Sweden	4.8 – 6.0 %	Total: 762 million t At the surface: 213 million t
Estonia deposit, (Ida-Virumaa) Estonia	Fine grained: 11.5 – 13 % Chunks: 15 - 17 %	Total: 5 billion t Economical: 1.5 billion t

Source: SOU 1961: 27 and Veiderma (2003).

Whatever the sources for uncertainty of these figures, it remains obvious that the natural preconditions for developing the oil shale industry in Estonia were without doubt better than in Sweden. As has been mentioned before, the Swedish oil shale is similar to the Estonian dictyonema shale, which is not used for energy production due to its lower energy contents.

On the other hand, it seems reasonable to assume that the different developments of the oil shale industry in Sweden and Estonia can also to some extent be explained by the very different political history of both countries. Sweden managed to remain outside WWII while Estonia was repeatedly occupied and finally remained under Soviet control after the war - until 1991. Basically, the Estonians were not capable of directing the destiny of Estonia for decades after WWII. It was under such circumstances the Estonian oil shale industry was developed further, or transformed.

Even under the Soviet regime, some uneconomical aspects of the oil shale industry were recognized, at least when there was a clear-cut substitute. Between the 1950s and 1970s the Estonian oil shale industry was gradually transformed into a multi-product conglomerate,⁹⁶⁶ and again in the 1960s and 1970s into the main source of electrical power generation in Estonia. In Sweden the factory at Kvarntorp also aimed at diversifying its products, but never succeeded in becoming economically viable. However, it should be stressed that these developments were initially parallel – during a time span of two decades, in both Sweden and

⁹⁶⁶ It is sufficient to mention that a brochure produced by the Kohtla-Järve oil shale industry in 1979 lists a great number of products, from heating oil to glue and from lacquer to conservation substance for the agriculture. Source: “Produktsiya kohtla-jarveskogo ordena oktyabrskoy revoljutsii slantse-khimicheskogo proizvodstvennogo objedineniya imenii V.I.Lenina. Reklamnyj prospekt” Eksperimentalnyj kombinat Bit, Tallin 1979. In Russian.

Estonia the oil shale industry changed from being the producer of fuels in a war or war-like situation into a chemical conglomerate.

What remains to be addressed is the question of whether the relative size of the oil shale industries had any impact on their fate. It is tempting to claim that the relatively small size of the Swedish oil shale industry (within Sweden) made it of less general interest. The oil shale industry had developed into a more integrated part of Estonia; there were more “created interests” around, that could defend the existence of the oil shale industry. Due to characteristics of the political system in the Soviet Union, there would also be less public criticism of the kind expressed by for example Byttner. Moreover, Sweden was dependent on the oil shale industry only during WWII. After the war, there was simply no niche left for the industry – a fact which brands the oil shale industry as a second-class option.

The Swedish Government official report in 1961 unequivocally states that continuous losses leave no room for any other solution than closing the factory at Kvarntorp.⁹⁶⁷ Even continued production for the sake of security of supply was ruled out because storage of imported oil was deemed less expensive.⁹⁶⁸ The report also pays attention to environmental problems caused by emissions of smoke and sulphur oxide in particular, which does significant damage to forests, gardens and growing plants. In addition to this, corrosion appeared on metal parts of buildings and on machinery. The local population was also reported to have made complaints about “sanitary inconveniences”.⁹⁶⁹ As was mentioned above, the main reason for shutting down the Kvarntorp factory was economic, but it is worth noticing that also environmental questions and the local opinion were at least paid attention to. Already in the annual report for 1945-1946 the existence of environmental hazards are recognized by SSAB.⁹⁷⁰ Burning shale coke damaged vegetation in the surroundings, while polluted water had to be filtered from oil before it was led into lake Hjälmaren. After filtering, however, the report states *there should no longer be any justified reason prevailing for complaints*. The issue of burning shale coke is supposed to be solved with a new oven. But the problems remained and the annual report for 1949-1950 of SSAB addressed the topic again, claiming

⁹⁶⁷ SOU 1961:27.

⁹⁶⁸ Ibid. pp. 74 – 81.

⁹⁶⁹ SOU 1961:27 p 78.

⁹⁷⁰ Svenska Skifferolje Aktiebolaget. Förvaltnings- och Revisionsberättelse för räkenskapsåret 1/7 1945 – 30/6. 1946. Arkivcentrum Örebro B2:21.

that the waste water was of “good quality”.⁹⁷¹ The following year the flue gases were still reported as a problem. The register of compensation paid to people in the vicinity of Kvarntorp, however, suggests comprehensive environmental damage to forests, corrosion of property, damage to gardens, damage to fishery and other damage to water in the area.⁹⁷²

9.7. A forgotten technology?

After shutting down production at Kvarntorp and a few years later at Ranstad (where uranium was produced, not oil)⁹⁷³, oil shale has not been an issue of any significance in Sweden. Oil shale as a potential energy source was still mentioned in Swedish Government official reports on energy in the 1970s, but for instance in the survey from 1980 on solid fuels, there is only a brief mentioning of oil shale, casting doubts on the prospect of utilization of oil shale because of environmental, technical and economic reasons. There is no mentioning of oil shale at all either in the final report of the parliamentary commission on energy in 1995⁹⁷⁴ or in the report by the Commission on Energy Research, Development and Demonstration from 2003.⁹⁷⁵

Present Swedish energy policy is committed to reducing the role of fossil fuels, especially in order to reduce emissions of greenhouse gases and nowadays only some 30% of Sweden’s total energy supply originates from fossil fuels, which makes Sweden one of the OECD member states least reliant on fossil fuels. Transport is the only sector still heavily reliant on fossil fuels.⁹⁷⁶ Thus the possibility for a rebirth of the oil shale industry in Sweden looks extremely unlikely, despite occasional calls for utilizing the reserves.⁹⁷⁷

To conclude, the Swedish oil shale industry, despite receiving substantial government support, could never break even economically and therefore it failed to establish itself as

⁹⁷¹ Svenska Skifferolje Aktiebolaget. Årsredovisning och Revisionsberättelse 1/7 1949 – 30/6 1950.

⁹⁷² Svenska Skifferolje Aktiebolaget. Arkivcentrum Örebro. D5:103.

⁹⁷³ For a lengthier discussion on this topic, see Anshelm (2000).

⁹⁷⁴ SOU 1995:139.

⁹⁷⁵ SOU 2003:80 “EFUD – en del i omställningen av energisystemet”. Betänkande av LångEn-utredningen. The Commission on Energy Research, Development and Demonstration describes its task in the following way (in English): *The Commission’s task is to examine and evaluate measures included in this programme* [i.e. the Swedish government’s programme on ecologically and economically sustainable energy system], *and analyse the need for changes. The Commission is also to submit draft guidelines for long-term energy policy for the planning period that commences in 2003, and to advise on action to bring about an energy supply that is sustainable in the long term.* SOU 2003:80 p. 31.

⁹⁷⁶ Silveira (2001).

⁹⁷⁷ See for instance Ny Teknik 1985:36. In an article covering 3 pages it is claimed that Swedish oil shale could meet domestic demand for oil for 100 years.

financially independent in the market. It was created as an import substitution industry for times of crisis, but despite efforts to broaden its production, it never took off in peacetime. In the first years after WWII, peace was fragile and there were concerns about a war between the Western powers and the Soviet Union. Against this background it was reasonable for Sweden to maintain its oil shale industry, but as peace gradually became perceived more or less secured – at least in the short run – the role of the oil shale industry was eroded. Thus, with all likelihood, oil shale industry will remain a parenthesis in Swedish industrial development. It is worth highlighting that albeit government intervention was important for the emergence of the oil shale industry in both Sweden and Estonia, there were significant differences from the beginning. First, the Estonian oil shale industry comprised of several independent actors, while the Swedish oil shale industry was basically centered around one government-owned enterprise and private initiative was squeezed out. Second, the aim of the Estonian oil shale industry was broad (i.e. energy), while in Sweden the rather narrow purpose of the oil shale industry was to guarantee the supply of oil during WWII. These initial differences had a profound impact on the later developments. Contrary to Sweden, the variety thus created in Estonia was enough to guarantee the survival of the oil shale industry. In this respect, Sven V. Bergh's claim that the monopolistic structure of the Swedish oil shale industry contained the seeds to its demise definitely deserves credit.

An interesting parallel between the Estonian and Swedish oil shale industries is the process of transformation from oil producers to a multi-product chemical conglomerate at more or less the same time. There is an overwhelming impression of an industry searching for its niche in both Sweden and Estonia in the 1960s.⁹⁷⁸ This similarity becomes even more striking when taking into consideration that there were practically no direct contacts between Sweden and Estonia between 1945 and the late 1980s.⁹⁷⁹ Here a comparison with Thomas Hughes' account of developments in the German hydrogenation industry before 1933 becomes interesting. According to Hughes, the technologically challenging process of producing synthetic fuels at a factory at Leuna (in Germany) created its own momentum after WWI, although its output was not in demand due to high costs. In Hughes' words:

⁹⁷⁸ An overview of the situation in Estonia in the late 50s and early 60s was published in Swedish by Umblija (1961).

⁹⁷⁹ There is at least one exception. In 1956 a group of representatives of *SSAB* were allowed to visit the oil shale industries in Estonia. Their report from the trip contains rather detailed descriptions of the technology in use in Estonia. Arkivcentrum Örebro D2:139.

“/.../ a technology stimulated by war gathering a momentum carrying over into peacetime. The commitment of engineers, chemists, and managers experienced in the process, and of the corporation heavily invested in it, contributed to this momentum. The product of the wartime hydrogenation process was applied to peaceful purposes, but this did not entirely absorb the creativity of the engineers and chemists looking for new applications of the challenging technology they had mastered.”⁹⁸⁰

In Sweden such a wartime industry tried to establish itself during peacetime, but did not succeed in the long run. One could say that the momentum was too weak. On the other hand, the technology created could be said to have been of less challenge to the Swedish engineering community in comparison to other technologies in use at the time. In Estonia, on the contrary, there existed at the time no more challenging technology, which could have drawn the engineering community’s attention away from oil shale. But the picture is blurred by the fact that in both the Swedish and the German case, the issue was concentrated to one single industrial plant, while in Estonia there was an entire industry, thereby allowing for greater flexibility and variety. Another significant aspect was that the Swedish society did not experience any institutional upheaval during and after WWII. In the German case, the society went through at least two major institutional shifts in the period examined by Hughes, i.e. between 1898 and 1933. This aspect should perhaps be added to the causes behind the momentum of the German industry.

In Estonia the industry gradually underwent one more transformation into electrical power generation, while this way was closed for the Swedish oil shale industry, because of the significant hydro-power capacity and the emerging nuclear power. A transformation similar to the one in Estonia was therefore not a realistic option in Sweden, where the total dominance of hydro and nuclear power left very little scope for other modes of electricity generation. It can be speculated under what conditions oil shale could have become an important energy resource in Sweden. Assume that nuclear power would not have been built up (as was the case for instance in Denmark). Sweden would in that case have been forced to find some other energy source, which could have been coal. But due to the lack of domestic coal deposits, it would not have been entirely unlikely that oil shale would have been labeled domestic coal and become an important fuel for electricity generation.

⁹⁸⁰ Hughes (1969).

Nuclear power was perceived as a threat to Estonian oil shale industry, too.⁹⁸¹ This was certainly no coincidence, but instead evidence of the fact that the shift in technological paradigm in favor of nuclear energy had left oil shale behind. Similarly, developments in chemical technology left only little scope for a large oil shale-based chemical industry. The very reason for utilizing oil shale, i.e. to meet the urgent demands of the more or less isolated nation state, had ceased to exist. What saved the Estonian oil shale industry once more was the breakup of the Soviet Union, from which the nation state Estonia re-emerged with urgent energy demands.

Finally, a few speculative words have to be said about the conditions under which the oil shale industry existed in the 1950s and 60s. In Sweden this industry, despite well-developed know-how, was never perceived as being at the core of Swedish industry. It was a second-best option, valuable only in times of crisis, and unless it could justify its existence, there was no reason to keep it. In Estonia, on the other hand, the oil shale industry had developed into a major part of the industrial structure, partially because of the higher quality of Estonian oil shale, but partially also because there were fewer competitors. The nuclear build-up in the Soviet Union took place later than in Sweden.

Moreover, one has to take into account the explanation that the Estonian oil shale industry was perceived among Estonians as an outstanding piece of Estonian engineering, which under the Soviet occupation had an emotional dimension totally absent in the Swedish case. Thus the wish to preserve the oil shale industry in Estonia was therefore of another magnitude than in Sweden. Interestingly, the probably most accurate words on this comparison were written as early as 1956 in a book by the Soviet historian D. Kuznetsov:

“Such a development of the oil shale industry can not take place in capitalist countries in peacetime. This is caused by the fact that in those countries the excavation and processing of oil shale is made with the aim of maximizing profits./.../ Under conditions of peace, the processing of oil shale is significantly decreased. Synthetic liquid fuels cannot compete with crude oil.”⁹⁸²

⁹⁸¹ Aarna (1959).

⁹⁸² Kuznetsov (1956) p. 56.

10. Summary and Conclusions

10.1. Path Dependence

The development of the Estonian oil shale industry raises a number of interesting questions about what forces and processes led to the emergence and survival of this unique industry. How could an industry afflicted with numerous seemingly insurmountable problems survive? Was this a result of domestic, conscious choices or was it a path, once embarked upon, that could not be deviated from due to various constraints of an institutional and cognitive character? In brief, were the seeds of a trajectory sown in the very beginning, which could then be altered only at huge costs?

Estonian oil shale experts used to say that oil shale is a highly complex substance, referring to the chemical composition of the substance.⁹⁸³ But oil shale has become highly complex in many other aspects as well – political, economic, social, environmental, and technological. If oil shale had never been processed, but remained a fuel for boilers and locomotives instead, it would most likely never have caused a lock-in. True, equipment would have been constructed to suit the characteristics of oil shale, but the deviation from the global mainstream would have remained minor, indeed. With increasing knowledge of this complex substance, and with increasingly sophisticated technology developed, oil shale-based products proliferated and soon oil shale formed the very basis of the Estonian energy system. This is still the case today, even if the technological emphasis has undergone changes. It can therefore be claimed that the more knowledge was gained and implemented in technological development, the further away the Estonian energy system drifted from the global mainstream. It can therefore be argued that a bifurcation in the technological evolution occurred in the early 1920s, the direction of which has ever since been maintained and reinforced by increasing knowledge. This process could, nevertheless, have come to an end if the institutional set-up had remained unchanged, because it is highly likely that oil shale would, sooner or later, have been challenged. Fluctuating institutions, on the other hand, are more likely to leave functioning technology in place,

⁹⁸³ See for example Ots (2006) p. 1 “*Estonian oil shale as power fuel undoubtedly belongs in the fuel class with the most complicated organic and mineral matter composition in the world. The composition of oil shale creates numerous complicated and mutually related problems that can influence operations and reliability of power plant equipment*”.

simply because new institutional arrangements initially lack the power and willingness to challenge entrenched interest groups that do not stand in their way.

In the 1920s, Estonia ended up with an energy system based on oil shale due to numerous small developments, i.e. Estonia was definitely not predestined to utilize oil shale. This initial success for oil shale attracted both innovators and investors, thus strengthening the industry, or creating variety. When Germany looked for oil supplies for its navy in the latter part of the 1930s, both Estonia and the oil shale industry found it extremely difficult to reject their advances. The prospects of further development of the oil shale industry combined with the German presence in it had caused a lock-in.

After WWII, the oil shale industry was quickly rebuilt despite enormous destruction of both human and material resources. Nevertheless, significant know-how and engineering skills remained within the decimated labor force, which was now left without a clear purpose. To continue developing a technology so closely connected to the now non-existent state was a highly sensitive issue under the new regime. Supplying the city of Leningrad with gas was technologically a unique development, but this method also suited the new ruling structures, which did not have to emphasize that even this technology originated in pre-WWII Estonia. This probably provided the engineers with a sort of surrogate for the loss of purpose.

When the extreme forms of political coercion were relaxed in the 1950s, the oil shale community saw alignment with Soviet political goals to enhance the chemical industry as a way to promote their own professional interests and indirectly to reduce Soviet influence over Estonia's scientific and technological development. The paradox lies in the fact that in order to gain more freedom, the oil shale community had to align itself with the very structure it actually wanted to break away from. But in doing so, it also tacitly accepted the Russification of the industry that until then had been perceived as the "Estonian national technology". A small-scale oil shale industry was simply not a possibility, it had to be large-scale. In brief, short-term gains were given preference above long-term threats.

When compared to the developments of the oil shale industry in Sweden, it is important to point out the similarities in development until the 1960s. At this point the paths diverged, when oil shale had become a problem instead of a promise in Sweden and other technologies were perceived as more challenging and promising. In Estonia this did not happen. Can it be

claimed that developing other technologies in Estonia *could* have been a possibility? In Sweden it was nuclear power, in particular, that seemed to have the greatest potential. Assume that the Estonian engineering community had drawn the same conclusion. Two observations contradict such an assumption. First, nuclear power was then, as well as today, too big for Estonia. Second, nuclear power was a technology developed throughout the Soviet Union, and it could therefore hardly have been developed separately in Estonia. In this case, the Estonian engineering and scientific community would have become even more subordinated to Soviet structures than was the case with oil shale. Sticking to the declining oil shale was a way to maintain some freedom of movement, especially because there were hopes that oil shale would gain momentum internationally. The Soviet Union shunned radical new ideas in general, which made it even more reasonable for the Estonian oil shale community to stay with oil shale instead of trying to replace it with something else. Any attempt to “rock the boat” could have led to unforeseeable consequences for the entire Estonian scientific and engineering community. After the collapse of the Soviet Union, oil shale-based power generation and other oil shale-related industries soon found a new niche by adjusting to the changed circumstances, which were basically the rationale of the nation state safeguarding electricity generation. As has been pointed out, the oil shale industry today carries several reminders of its initial condition(s).

10.2. Developments in the 1920s and 1930s

The Estonian oil shale industry, being of the same age as the country, started from scratch in the very end of the second decade of the 20th century. There were only few outside experiences to emulate; there was basically no skilled labor force, no scientific or technological know-how. But by the mid-1920s, oil shale had become a major source of energy in Estonia. This development is remarkable in the sense that in a few years’ time a hitherto more or less unknown fuel gained a dominant position in the Estonian national energy system. As a consequence of dramatic institutional change caused by WWI, Estonia found itself without an obvious fuel supply. Under these circumstances, oil shale emerged from relative obscurity and within a very short period of time it became established as the leading source for energy. There was, however, hardly anything natural in this process; there were competing energy sources, such as domestic wood and peat and imported coal. But due to some quite minor initial advantages, oil shale soon forced other fuels into the background. One particular advantage was that oil shale stimulated a number of engineers to carry out

experiments, which supported the utilization of oil shale instead of other fuels. Moreover, after having alleviated doubts held by many people in the railway system, the promoters of oil shale had found an important customer of oil shale with a stable demand. Gradually the initially hesitant heavy industry followed suit.

In the early 1920s, a window of opportunity opened for oil shale because imports of coal were threatened as a consequence of international turmoil in the aftermath of WWI. The initial rise of the oil shale industry was without doubt accommodated by government support and it is unlikely that private initiative alone could have led to the same outcome. But having said this, it should be stressed that the Estonian government of the early 1920s was relatively weak, and could probably not have forced its will upon heavy industry without evidence of the suitability of oil shale. Achievements by engineers in mapping the properties of oil shale as a fuel were of crucial importance as well as the decision to use the railway system as a showcase.

By the time imports of coal were resumed, oil shale had made deep inroads into the energy system and would not easily be phased out any longer. Depicting alternative scenarios is always risky, but it is highly plausible that if oil shale had not gained momentum in these formative years, Estonia would have stayed with imported coal as its main source of fuel and relied on peat as a domestic back-up. Furthermore, Estonia would have developed hydropower as the basis for its small electricity network at the time. In sum, oil shale as a fuel was initially an unlikely candidate for becoming Estonia's main source of energy, but as a result of active promotion from a small group of people during the few years when a radical change was possible, oil shale came to dominate Estonia's energy agenda. This development was the crucial initial advantage needed to tilt the energy system in oil shale's favor and this is, by and large, where Estonia still stands today, almost 90 years later. What can be observed here is that relatively small steps in the beginning set the stage for the further development. However, these steps were not totally random, only partially.

Once this oil shale-based energy system had gained momentum, it soon took a leading, even dominant position, becoming one of the major industries in pre-WWII Estonia. But Estonia would probably not have been able to develop the oil shale industry on its own due to shortage of domestic capital. Therefore foreign investors were let in, which led to the creation of technological variety, which in turn prevented stagnation that could have been the outcome

had only the Estonian government been active in the oil shale sector. On the other hand, domestic Estonian interests also voiced concern over having a state-owned monopoly. It is likely that without the mix of government and private enterprises (both domestic and foreign), the oil shale industry would have remained basically a producer of oil shale for direct combustion, without value-adding processing.

Oil shale thus prevailed, but can it be claimed that oil shale would have been an inferior option to other alternatives with respect to the existing knowledge of the early 1920s? It was feared that Estonia would lack the capacity to fully develop the new industry, but in the end such fears were alleviated due to openness to foreign investment. Moreover, oil shale turned out to be a perfect match with the contemporary ideologies, according to which nation states were supposed to be as self-reliant as possible. In other words, oil shale happened to fit well into the prevailing political paradigm at the time. Embracing oil shale as the main source of energy was a bold move – and initially a successful one. Only with hindsight can it be claimed that other options might have rendered a more beneficial long-term outcome. The large amount of ash resulting from burning oil shale was then – and is still today – a major drawback. Had oil shale remained a local non-processed fuel, it is possible that it would, in the end, have lost its attraction, not least due to decreasing prices on alternatives in the world market.

Gradually, oil shale processing technology also developed and production began to switch from direct burning of oil shale to processing, thereby giving rise to more sophisticated production. As a result of the depression in the early 1930s, Estonia, like so many other countries, introduced a wide range of high import tariffs, fuels included. As a consequence of the protected domestic market, shale oil (i.e. processed oil shale) became competitive. The oil shale producers adjusted to the new circumstances and soon focus in production was shifted towards shale oil and gasoline. This shift would have been impossible if there had been no technology to utilize and to develop. As a result of the multitude of actors and technological methods that had emerged in the 1920s, the technology required already existed, albeit initially only on a smaller scale. Of course, not all technologies would survive, but the mixture of government and private, domestic and foreign, and large and small investment had produced a vibrant industry, from which there were experiences to draw upon. This remarkable variety would prove crucial also in the future for the survival of the oil shale industry.

The increased production of a refined end-product, in turn, allowed for exports. Non-processed oil shale, directly from mines and quarries is bulky (due to the high content of non-organic material) and is therefore suitable for use only in the geographical vicinity of the deposits. In this particular case, Estonia was probably the optimal area for such use, because distances are small and there are virtually no natural barriers to transportation. With increasing experience, knowledge, and technological capacity to process oil shale into refined products, especially shale oil, an export market opened up. The ability to produce large quantities of shale oil was a prerequisite for exports. This ability in turn was a result of the early decision to allow for competition in the oil shale sector. Several technologies were taken into use, with different inclinations with respect to the range of end-products. When Germany emerged as a big buyer, however, short-term pecuniary gains were put ahead of long-term political concerns. There existed an uneasy awareness of these facts in Estonia, but it was hoped that somehow it would be possible to combine the best of both worlds, i.e. exporting to Germany for the sake of promoting the expansion of the oil shale industry, while at the same time avoiding being caught in the German sphere of interest. At this time, the oil shale industry had developed a momentum which would effectively have pre-empted attempts to change its course. Estonia found itself caught in an awkward situation, but lacked enough political will and means to change the course of events. The role of the oil shale industry should, nonetheless, not be overestimated. There is little evidence that the oil shale industry would have been a focal issue for the big powers in the late 1930s, but still the capacity of the oil shale industry to produce shale oil, which was valuable for military purposes in particular, had at least momentarily put Estonia in the international spotlight in an undesirable way. In the end, however, it was not Germany that eliminated the Estonian state, but the Soviet Union, which without doubt was well aware of the capacity of the oil shale industry.

10.3. WWII and its aftermath

After havoc had been inflicted upon the oil shale industry by the warring powers of Nazi-Germany and the Soviet Union during WWII, the oil shale industry was harnessed for the immediate needs in the nearby Russian metropolis of Leningrad, which was suffering not only from fuel shortage caused by the war but also poor availability of energy in general due to its location. The development of the Estonian oil shale industry close to the city had not gone unnoticed and thus the role of the industry was radically altered. Now household gas was to be produced, which in a technological sense was a unique development. Even if the Estonian

capital Tallinn was later also supplied with household gas, there is no doubt that this outcome was unfortunate for Estonia, whose major energy resource was now being consumed *de facto* abroad without any real compensation being paid. In spite of such concerns, Estonian engineers continued their everyday work, using their skills and knowledge for the benefit of the new masters, some out of fear, others out of complacency or professional interests, and some perhaps even out of ideological convictions. The rapid reconstruction of the oil shale industry in the immediate post WWII-years indicate that knowledge and routines had not been completely lost during the war, but instead they bridged the gap caused by the destruction of physical capital during the war, and political terror. The Sweden-based exile-Estonian Aleksander Kaelas claimed in 1953 that the experienced and skilled (Estonian) workforce had been shattered and that reconstruction was carried out by German prisoners of war and later immigrants from other parts of the Soviet Union.⁹⁸⁴ This statement is too simplified to reflect the whole picture. Several Estonian sources, in particular personal memoirs, contain enough evidence that in the aftermath of WWII numerous Estonian engineers and other specialists remained within the industry, while manual work was, no doubt, increasingly carried out by others than Estonian workers.⁹⁸⁵ Without the contribution of skilled Estonian engineers, it would have been less likely that the oil shale industry would have started production only a few years after its destruction. Furthermore, there is one aspect that should not be left unaccounted for, namely American equipment which had been sent to the Soviet Union during the war and which was now used to jump-start the Estonian oil shale industry. American-built compressors and turbines played a role never recognized by Soviet sources, but it is highly likely that the pace of reconstruction would have been much slower without such equipment – both in the sense that it was ready to be used as such, but also because it was used as a basis for further technical development.

Also oil shale-related science soon picked up after the war, despite significant losses of personnel in that sector, too. Available sources claim that the scientists worked in an atmosphere of fear, but nevertheless they worked, which is the crucial point in this context. But time was an important element of reconstruction. Even Aleksander Kaelas' highly critical account observes the rapid pace of reconstruction of the oil shale industry.⁹⁸⁶ This was not only a consequence of the infamously limited patience of the Soviet leadership, but probably

⁹⁸⁴ Kaelas (1953). According to Kaelas, some 10,000 German POWs rebuilt mines and even opened a couple of new ones, constructed the gas pipeline to Leningrad and the adjacent oil shale gas plant.

⁹⁸⁵ See for example Rooks (2004), Tomberg (2002), Öpik (1999).

⁹⁸⁶ Kaelas (1953).

equally much a result stemming from the presence of Estonian know-how. This is only to say that the longer reconstruction is postponed, the bigger the loss of knowledge, because, as pointed out by Dominique Foray, knowledge is reproduced in interpersonal connections.

“These means of reproducing knowledge may remain at the heart of many professions and traditions, but they can easily fail to operate when social ties unravel, when contact is broken between older and younger generations, and when professional communities lose their capability to act in stabilizing, preserving, and transmitting knowledge. In such cases, reproduction grinds to a halt and the knowledge in question is in imminent danger of being lost and forgotten”⁹⁸⁷

A similar argument is made by Nelson and Winter: *Basically, we claim that organizations remember by doing*[emphasis in original]⁹⁸⁸

Perhaps sensing the risk of complete loss of knowledge and skills developed in the previous two decades, Estonian engineers participated in the Soviet-directed reconstruction works. In recent times, it has become almost axiomatic in Estonia to label the developments in the oil shale industry of this period as colonialism from the side of the Soviet Union. These claims are far from unjustified. Nevertheless, as was argued earlier, reconstruction of the oil shale industry was made possible by the active participation of Estonian engineers.

When the remaining Estonian engineers, workers and scientists carried on with their everyday tasks after WWII, they did not encounter such an enormous break with the past in their professional duties as did the entire surrounding society. The fundamentals of the industry remained stable despite the enormous institutional change. Under such circumstances they probably manifested a totally rational reaction, which to a large degree explains the further development of the oil shale industry. Here it might be elucidating to juxtapose these developments with those of the German engineering community in hydrogenation as recapitulated by Thomas Hughes.⁹⁸⁹ In Germany before and after WWI, the engineers engaged in the hydrogenation of coal (which shares technological similarities with the production of shale oil) created a momentum partially based on the engineering community's drive to enhance their problem-solving capabilities, which had been much in demand during

⁹⁸⁷ Foray (2004) p. 4.

⁹⁸⁸ Nelson & Winter (1982) p. 99.

⁹⁸⁹ Hughes (1969).

WWI, but which failed to find a niche in post-WWI Germany. This became one reason for the engineering community's alliance with the totalitarian ideology in the 1930s. In Estonia, developments took a different turn. While both the German hydrogenation and the Estonian shale oil technologies emerged as answers to immediate needs, the Estonian shale oil production served no one particular single interest except for the rather abstract national well-being (contrary to the German industry's war-time efforts), and was made up of various and sometimes conflicting interests. When this industry was taken over by the Soviet Union, the Estonian engineers simply continued performing their tasks, perhaps because quitting was not perceived as an option. It is possible that the very idea behind the gas industry was of Estonian origin, but the industry was comprised of other sectors, too, where commitment to Soviet aims was only a way to pay lip service. In Germany, on the contrary, as Hughes points out, the engineering community actively sought out and joined the totalitarian forces, albeit perhaps out of political ignorance. More profound similarities are, however, to be found in the concept of momentum (or path dependence); in both cases it was a force strong enough to bridge an interruptive gap - in Germany the depression of the early 1930s, in Estonia WWII with its enormous destruction. In both cases the engineering community had invested heavily in their skills and took pride in promoting their technology. This momentum guaranteed continuation regardless of regime and the engineers accepted whatever opportunity available to continue.

10.4. The chemical industry

Only with increased access to distant Soviet energy resources, did the demand for oil shale-based household gas decline and the Estonian oil shale industry was left to look for a new role. But due to a fortunate twist in history (from the oil shale industry's perspective), the development of the chemical industry became a major project in the Soviet Union in the late 1950s. This was made possible by the strong development of the Soviet oil and gas industries, allowing for the production of detergents, plastics and synthetic fibers.⁹⁹⁰ This change in industrial preferences was a consequence of shifts both in the global situation and the increasingly relaxed interior policy in the Soviet Union. The perspective of a chemical cluster in Estonia based on oil shale was far from new. Such ideas had been toyed with already

⁹⁹⁰ Lyndolph & Shabad (1960).

before WWII, but also in the first post-WWII-years.⁹⁹¹ The change of direction in Soviet industrial preferences happened to coincide with the long-term interests of the Estonian oil shale community, which could now develop the oil shale industry in a more science-based direction, instead of being a mere supplier of energy to, in principle, Russia. This would make it possible to tacitly support the struggle of Estonia's scientific community to maintain some independence, and perhaps even nurture international contacts, especially if oil shale abroad should experience a rise to prominence (as was for instance predicted by John Kenneth Galbraith, see chapter 4.1.). A strong oil shale-based chemical industry raised hopes of renewed self-consciousness among Estonian scientist. Doing the best under the prevailing circumstances meant being in line with overall Soviet aims. In the end, a chemical industry was established, but it never developed the muscles that were hoped for. Instead, a new development took place, when the Soviet authorities once again turned their attention to the Estonian oil shale because of the increasing demand for electricity. This was before the launch of the Soviet nuclear power program.

In a somewhat paradoxical way, the actions of the Estonian oil shale community were actually in line with the policy of the Soviet leadership in developing the chemical industry. In most cases, it can almost certainly be excluded that this would have been due to ideological sympathies. Instead, at least the short-term interests of both parties coincided, while the long-term interests must have diverged as the Soviet authorities had no real intention to particularly promote Estonian science and technology. However, developing a strong chemical industry was in their long-term explicitly expressed interests, both domestic and international (in order to cope with the surrounding world). The Estonian scientific community, on the other hand, had no wish to see the Soviet state even stronger, but the immediate benefits gained from the development of the chemical industry – in terms of national aspirations, professional challenges and research opportunities – were enough for participation. Thus, it has been assumed that striving to maintain what could be called the “Estonian national technology” coincided with acute needs of the Soviet Union. Therefore, it can be argued that a kind of symbiosis emerged, albeit under strain. A situation of this kind is what Bruce Benson refers to in his study on competing institutions:

⁹⁹¹ For example P. Lindvere's article in *Rohkem Põlevkivi!* 20.11.1946, where he proposes production of plastics, anti-corrosion substances, insecticides and even in artificial scents.

“If the agreement stems from an initial situation involving either partial co-operation or asymmetric conflict the dominant power will demand a relatively large share of the wealth arising from clarified property rights, but he is likely to have to maintain his position of dominance in order to assure credibility on the part of the weaker party. The institutions that evolve to support credible commitments to respect the property rights arrangements will be those of coercion and command. After all, the incentives for a weak party to accept this contract are relatively ‘negative’ - subjugation is expected to be better than the alternative high probability of losing everything through violent confrontation”⁹⁹²

In sum, the steps taken by the Estonian engineering and scientific communities were against Estonia’s long-term interests in at least two ways. First, the strengthening of the oil shale industry had a reinforcing effect on the Soviet power. Second, the expansion of the oil shale industry led to further influx of immigrants from other parts of the Soviet Union, in full accordance with the implicit Russification strategy of the Soviet leadership.

Certain rationality can nonetheless be traced behind the Estonian attempts at developing the chemical strand of the oil shale industry. In the 1950s and 1960s the demise of the Soviet Union was hardly regarded as imminent. It was reasonably assumed that Soviet power would last for the foreseeable future. Hence, learning to live with it was a rather constructive approach. According to the exile-Estonian historian Rein Taagepera, many Estonians joined their forces with the ruling structures in the hope of achieving at least some leeway in exchange.⁹⁹³

“Around 1956 many young Estonians began to join the Communist party – an act that had previously been widely considered to constitute national treason. They hoped to achieve something by agreeing to play the game according to the Russian rules. They partly believed Marxist ideals and hoped to implement true federalism./.../Talking to Moscow about true federalism within the Soviet Union was like talking to a wall. But a political return to the Western world seemed unrealistic and, in view of the West’s recent problems, perhaps less attractive than it once did. There remained another alternative: a Communist Estonia *outside* the Soviet Union.”[Italics in original]⁹⁹⁴

⁹⁹² Benson (1995) p. 157.

⁹⁹³ Taagepera (1978).

⁹⁹⁴ Taagepera (1978) p. 81. See also Pennar (1978: p. 117), according to whom Estonians became a majority in the Estonian Communist Party only in the mid-1960s. What triggered Estonians to join the ranks of the Communist Party was the crushing of the Hungarian uprising by the Soviets in 1956, which also crushed any hopes of resistance in Estonia.

Moreover, developing the science-based chemical industry could perhaps pre-empt Soviet attempts at harnessing oil shale for other purposes and especially for purposes of no value for Estonia, as to a large degree had been the case with the production of household gas. In addition to this, the knowledge-intensive chemical industry could, perhaps, also mitigate the Russification attempts, or at least be perceived as the best among poor options. In this context it should be recalled that Mark Roe defines strong path dependence (see chapter 3.2.1) as a situation where a certain group has its own interests involved in the process and therefore effectively resists change, or even the conceptualization of alternatives.⁹⁹⁵ Estonian sources from the 1950s and 1960s give plenty of evidence of a rather free debate on technological issues, but nowhere is there to be found an opinion calling for a drastic reduction or outright closure of the oil shale industry. This argument might be countered by claiming such an opinion would have been too bold even during the interregnum of relatively free debate which took place in those decades, but one might equally well suspect that such an opinion was not voiced because it would have been perceived as a violation of the conformity of the oil shale community. The debate in Estonia in the late 1950s and throughout the 1960s was focused on the issue of how to save the oil shale industry and how to promote (however tacitly) Estonian national ends – but neither on the fundamentals nor the need for such an industry.

Having said this, there remains the particular question as to how such more or less far-reaching alterations in the industry were possible in the first place. In my view, the potential for the dynamic development of the Estonian oil shale industry during the Soviet period should be sought in the industry's inherent capabilities. The Estonian oil shale industry, seen as an entity, had inherited such capabilities from experience of both state intervention and market-based operations in the 1920s and 1930s. At least a part of the labor force had grown used to a dynamic environment during that period. By sticking to ordinary routines, the Estonian oil shale industry therefore contained enough dynamic capabilities to adjust. But where did the industry find room to make use of these capabilities? Following Steven Solnick, the situation can be interpreted as a principal-agent situation, where the oil shale industry (in this case the agent) withheld "hidden information" on its capacity from the authorities higher up the chain of command (the principal). By withholding information or by distorting actual figures of output capacity, the agent could achieve some freedom to maneuver – it created, so to speak, excess capacity for purposes not outlined by those higher up in the hierarchy.⁹⁹⁶ This

⁹⁹⁵ Roe (1996).

⁹⁹⁶ Solnick (1998) chapter 2.

should not be perceived as a question of the amount of physical output solely, but instead as the capacity to promote other ends, for instance through enhancing value-added production. This capacity in turn, allowed for greater flexibility or freedom to pursue the covert goal of an Estonian science and technology. In other words, by satisfying the officially proclaimed societal goals of the Soviet Union in appearance, a niche was left for the pursuit of goals that would not have been possible to do openly.

10.5. Electricity

When the two oil shale-fuelled power plants were started in Narva between 1959 and 1973, they were not without precedent. Power generation on a much smaller scale had taken place already before WWII and on a somewhat larger scale in the late 1940s and the early 1950s. Thus, when the Communist Party of the Soviet Union in 1955 made the decision to construct the first big oil shale-fuelled power plant, *Balti*, to some extent it had to count on local know-how in Estonia, not only in terms of the technical matters related to the power plant itself, but on the collective know-how of the properties of oil shale as a fuel, which existed in Estonia only. Moreover, a prerequisite for the successful establishment of the power station was also the existence of technological expertise in Estonia, which carried out the experimental work on boilers. So in spite of the fact that most of the physical construction of the power plant was designed and even completed in Russia, the crucial knowledge on the fuel was by and large drawn from Estonia. Although the emergence of large-scale electricity generation was initiated by the Soviet authorities, in principle the entire project was based on a strand of Estonian know-how that until then had been of less significance. But nevertheless, it had existed, which is the crucial point here. Following this line, once again it can be argued that variety created in an earlier period allowed for continuation at a later stage.

In the Soviet system there existed what the historian of technology, Nathan Rosenberg, calls Soviet central planning “gigantism”, which is defined as *uncritical commitment to a belief in the existence of indefinitely continuing economies of large-scale production*.⁹⁹⁷ According to Rosenberg, this can be seen in relation to Karl Marx’ interest in British large-scale industrial production in the nineteenth century, while another object for Soviet emulation could have been large companies in the USA in the first half of the 20th century. As a consequence, the characteristic size of Soviet industry carried this heritage, i.e. a line from British 19th century

⁹⁹⁷ Rosenberg (1994) p. 103.

industry via Marx to Lenin and the Soviet system. Therefore a basic condition for the Estonian oil shale industry, were it to develop at all during the Soviet rule, was to operate on a scale that fitted with the prevalent ideology. The gargantuan size was simply a part of the deal.

The massive build-up of power generation was perceived as further evidence of Soviet colonialism by many Estonians. However, when the Soviet institutional structure collapsed, this very same technology not only survived, but turned out to be of the utmost importance in terms of security of supply for the re-established Estonian state. It was a truly ironic twist in history that as a result of the Soviet-induced build-up of power generation capacity prevailing over the attempts at developing the technically and scientifically more sophisticated chemical industry, Estonia was left with stable, domestic power generation capacity. From the Soviet point of view, oil shale-based power generation was only a means, not an end in itself. Its role was only to guarantee electricity supply, while developing the chemical industry, from the point of view of the oil shale community, was a means to improve its collective standing through increased “scientification” of the industry and in the end, it was though, to promote the cause of Estonian interests.

With hindsight, one can argue that had developments gone in the oil shale community’s direction, the outcome seen from today’s perspective would probably have been an inferior one. Estonia would be reliant on electricity imports from Russia, with which it has political relations which at best can be labeled highly complicated and far from amicable. However, this could not have been known in advance. In many respects, electricity generation based on oil shale was considered an inferior technology, or at least a second-rank technology, also by the Soviet Union and thus it was soon overshadowed by nuclear power. Oil shale-based power generation remained in place mainly in order to mitigate peak loads in the electricity supply network and as a sort of back-up capacity. Assume now that the Estonian oil shale community would have had the final say on which technology to develop. It is highly likely that it would have concentrated most resources on the chemical strand for reasons discussed before (and, *nota bene*, counted on Russian-generated electricity). Had this been the case, it is possible that Estonia today would have faced an even more complicated situation, not only because of a shortage of power generation capacity, but also by being stuck with an industrial complex, parts of which might have had been outdated already. The Estonian oil shale chemist Helle Martinson claims that development in the chemical industry worldwide has gone in the

direction of using synthetic substances, away from many traditional raw materials.⁹⁹⁸ It is likely that a chemical industry relying on oil shale would have lost its role very soon, in a similar fashion to the Swedish experience. With some exaggeration in order to sharpen the argument, one could claim that the Estonian oil shale community favoring chemical industry for national reasons actually would have allowed for an increased reliance on Russia with respect to the supply of electricity. This, in turn, is understandable, because at the time there seemed to be no form of exit from Soviet rule and it was perceived a constructive approach to promote whatever niches of national interest that still remained. With a sudden change in the institutional framework all this was turned on its head and Estonia needed first of all what the Soviet Union had also needed, namely an uninterrupted and reliable supply of electricity. Under stable institutional conditions, it is possible that the history of the Estonian oil shale industry would have ended somewhere in the 1970s, had it not been for electricity generation. Electricity generation in turn would perhaps have continued in the shadow of nuclear power for some time, but gradually losing its relevance had the Soviet system survived. Thus, profound changes in the institutional framework made most of the difference between survival and cessation for the Estonian oil shale industry. In one particular sense one might therefore claim that the Soviet Union and today's Estonia with its liberal market economy do not differ; both demand the smooth generation of electricity. There was no "communist mode" of electricity generation as little as there is no particular "liberal free market mode" of electricity generation today. This is not as self-evident as it might appear at a first glance. The Soviet Union claimed to be superior to other societies, but in a technological sense it belonged to the very same paradigm as the rest of the world. It is of particular interest to note that today's pro-market Estonia has steadfastly kept electricity generation under government control. An attempt to privatize electricity generation with the American company *NRG Energy* in the late 1990s failed, despite support from the government and a prominent specialist on oil shale-based power generation, Ilmar Õpik,⁹⁹⁹ and despite arguments which normally would have been met with sympathy, such as attracting significant American investment to the complicated north-eastern region of Estonia, while at the same time enhancing the outlook for a common Nordic-Baltic energy market.¹⁰⁰⁰ In his work on the development of electricity generation in the USA, Germany and England, Thomas P. Hughes observes that each system inherited particular features from the society they stemmed from.

⁹⁹⁸ Helle Martinsson, personal communication, October 11, 2005.

⁹⁹⁹ Mõtus (2002).

¹⁰⁰⁰ Smith (2001) p. 141.

But as a common denominator, they all shared the characteristics embedded in the capitalistic civilization.¹⁰⁰¹ The history of the Estonian oil shale industry reveals surprising concordance with this observation. The power generating branch of the oil shale industry was created under Soviet power and has remained a state-controlled industry, while the shale oil branch is today both private and government-owned, as it was in its early days, despite an interruption lasting for almost 50 years.

10.6. Immigration and environment

As was earlier described, the rapid growth of the oil shale industry in the decades following WWII led to an influx of immigrant workers from elsewhere in the Soviet Union, radically altering the demographic map of not only North-Eastern Estonia, but even Estonia as a whole.¹⁰⁰² In the closing years of the existence of the Soviet Union, there were concerns that the Estonians would soon be outnumbered in their own country by the immigrant, mainly Russian-speaking population. The policy of Russification was probably supported by the authorities in Moscow, although not always openly. As a result, the oil shale industry, which had been a source of national pride, came to be associated with a foreign power structure, the ultimate goal of which was perceived to reduce the Estonian culture to folklore. Writing in 1978, the exile-Estonian historian Rein Taagepera, is skeptical to the claims that this would have been the outright policy, though:

“It does not seem that the Soviet regime actively organized this immigration, with its overtones of cultural genocide. It has simply allowed it to happen, as it allows Estonia to have its Estonian-language universities, press, television, and theaters. But Moscow has also insisted on economic centralization, even if this runs counter to local interests, cultural or ecological. By all accounts, Estonia is already overindustrialized. But the fake “progress” represented by ever-proliferating factory smokestacks and immigrant workers continues, despite popular resentment and timid remonstrations from the few Estonian-born party leaders”¹⁰⁰³

In the 1970s and especially in the early 1980s, concerns about pollution of the environment made inroads on the political agenda even in the Soviet Union. In this respect, popular

¹⁰⁰¹ Hughes (1983) p. 462.

¹⁰⁰² The share of Estonians of the total population of Estonia dropped from 88 per cent before WWII to 64 per cent in 1980. Misiunas & Taagepera (1993) p. 353.

¹⁰⁰³ Taagepera (1978) p. 81.

opinion in Estonia was ahead of that in most other parts of the Soviet Union. The oil shale industry soon became the main target of environmental concerns. Parallel with this development, also previously only discreetly voiced national sentiments became increasingly felt throughout Estonian society. Therefore, growing national resistance against further Sovietization in the mid-1980s developed a strong environmental flavor. Estonian statehood and the Estonian environment were often perceived as indivisible, while the oil shale industry, which still in the 1960s had been the pride of Estonian engineering, had become almost synonymous with everything non-Estonian.¹⁰⁰⁴

When discussing the ethnic perspective it should nevertheless be recalled that immigration was always attached to the development of the oil shale industry. This issue was recognized already in the 1920s. Furthermore, as Tooming reported in the 1930s, ethnic tensions were present already at that time with German-speaking managers, Russian-speaking foremen, and poverty-stricken Poles working for low salaries in the oil shale industry. Thus, it is not immigration as such that was a new phenomenon during the Soviet years, but rather the scale of immigration. In the 1930s, politics all over Europe stressed lingual and cultural conformity of the citizens of a state. In this perspective, immigration was seen as a challenge to maintaining the rather utopian goal of ethnic purity, and so in Estonia too. During the Soviet occupation, the enormous immigration of non-Estonians radically altered the ethnic map of large parts of Estonia, especially that of the oil shale producing areas, reducing Estonians there to a tiny fraction of the total population. Having said this, it still seems clear that in population terms, the very large size of the oil shale industry in otherwise quite small Estonia would probably not have been possible without immigration as such.¹⁰⁰⁵ In this respect, the reserved attitudes of the 1930s towards immigration did not go well together with the aim at developing a large-scale domestic industry. But during the Soviet occupation, the Estonian oil shale community actually struck a Faustian deal with the occupation power. In order to allow for the survival of the oil shale industry, it was to be built according to Soviet ideology, which in the end simply meant enormous size. This resulted in the mass immigration of non-Estonians. It should be stressed that one does not have to have any particular ambiguity towards immigration as such in order to understand that massive immigration from a much bigger occupying power to a small subdued country with the ultimate aim of perhaps even

¹⁰⁰⁴ See Smurr (2004) for a discussion on this topic.

¹⁰⁰⁵ As was mentioned earlier, according to the Estonian historian Jaak Valge the agrarian worldview of the Estonian leadership in the 1930s actually preempted urbanization of the rural Estonian population.

wiping out the native population is an entirely different issue than the immigration policy in stable, democratic and peaceful societies. But, in brief, the oil shale industry could not have developed without some form of migration – domestic or foreign.

10.7. A matter of size

The question of large-scale Soviet-induced immigration is just one element of a broader picture. In the late 1930s, Estonia did not take measures to counteract the German interest in shale oil and was consequently more or less obliged to accept a trade that in the end was harmful for the fundamental interests of the country. The reason for Estonia ending up in such awkward situations should be sought in the fact that there was a discrepancy between the proportions in the size of Estonia and the oil shale industry. Estonia, despite a well-educated population and skilful engineers, repeatedly faced enormous difficulties in coping with the consequences of the technology it had developed. This reasoning can also be transferred to the present situation. Although no urgent external threat is directed against Estonia or its people on a political level, an entirely new threat has emerged, namely that of environmental hazards, especially climate change. Once again Estonia's own resources are probably too small to cope with changes in the surrounding world directly affecting the oil shale industry. At present, Estonia struggles with finding a method to reduce emissions of greenhouse gases. In some respects, the transfer of technology developed elsewhere might suffice, but in other respects Estonia will have to try new methods (such as tying CO₂ to limestone). This is likely to put an extra strain on the limited resources of Estonia. Having taken a path of its own, Estonia has to confront a challenge it might once again lack the resources to handle. There exists a notion in Estonia that the total emissions caused by the oil shale industry are so small on a global scale that Estonia's responsibility is highly limited and it should therefore discreetly be allowed lower reductions than others.¹⁰⁰⁶ This is, however, not the official policy, but instead perhaps a sort of notion of compensation for a tragic history.¹⁰⁰⁷ There are several factors maintaining the present situation in the oil shale industry, one important factor being the social situation of the mainly Russian-speaking population of Ida-Virumaa. High CO₂ emissions will not

¹⁰⁰⁶ This view has been expressed on a couple of occasions in the personal communications I have had in Estonia, but always off the record. Therefore I have chosen not to name any informant in this context.

¹⁰⁰⁷ This particular notion could be put in the broader perspective of victimization prevalent in former socialist countries, as described by Tismaneanu (1998). However, Tismaneanu limits his analysis to nationalistic sentiments, while in this particular case it is possible to observe a rather modernistic approach. Instead of turning to traditional (hostile) nationalism, people engaged in the Estonian oil shale industry and research look for compensation in terms of morally justified emissions of greenhouse-gases – “Estonia was betrayed by the democratic world and therefore it has the right to emit proportionally more CO₂.”

produce a sharp reaction from neither Russia nor from international organizations voicing concerns over the status of non-Estonians. Therefore Estonia faces a trade-off. Allowing the oil shale industry to continue on its present path will cause less international complications than any other policy.

This allows for defining a particular cause of a lock-in. When a technological system grows too big in relation to the society that created it, it gains a momentum with its own, occasionally perverted logic. This was the case with the Estonian oil shale industry already in the 1930s, which led to the almost total dependence on Germany. A similar lock-in occurred several decades later when Estonian power generation was constructed on a scale that exceeded domestic demand by a factor of some magnitude. From this can be concluded that Estonia's initial striving to utilize a domestic energy resource later turned out to be a Pandora's Box. A socio-technological lock-in can emerge when the technological system surpasses the embracing capacity of the society that once created it. This phenomenon has perhaps not gained the attention it deserves for reasons that can probably be led back to the fact that most research on similar topics is usually carried out in societies big enough to cope with this kind of danger or in societies that for one or the other reason have succeeded in avoiding political predators in the international arena. In a world made up of a few big powers and numerous smaller countries and which lacks enforceable, strict rules, technological development will follow a few leading countries, even if their size (both in economic and population terms) does not exceed the combined size of the smaller countries. To cling to dominant technologies becomes a way to avoid risk.¹⁰⁰⁸ Diffusion of technology will basically become a one-way street from the big to the small, even if some improvement of dominant technologies might be made in the smaller countries. But seen from another angle, this implies that a lot of capacity for technological development actually might be utilized only at a sub-optimal level.

The conclusion to be drawn from the reasoning above is that the consequences of following one's own path, albeit successful, can turn out to be such that a small country lacks the capacity to cope with them. It can, of course, be claimed that this is just a special case of the consequences of human hubris in attempting at controlling nature through technology. There

¹⁰⁰⁸ Castells (1999) claims that the Soviet military chose to copy Western technology in the last decades of the existence of the Soviet Union out of fear of otherwise being totally left behind in technological development. This came with the cost of always being a few years behind the West and being forced to imitate instead of creating. Not only small countries have reason to be concerned about going their own way.

are probably several similar experiences to be found in world history and thus this phenomenon should be given attention. Oftentimes the only risk associated with a small country going its own way in technological development is that it will likely lack the financial and intellectual muscles needed for long-term development. Here it is worth recalling that Estonian oil shale engineers actually sought cooperation with Soviet structures in the 1950s and 1960s. This fact should not be dismissed straight away as a consequence of Soviet coercion only. It might equally well be interpreted as awareness of the limited capacity of the Estonian oil shale industry to develop further on its own. However, an important question is whether the use of oil shale is predestined to give rise to a big industry instead of a small one. Especially in a case such as the Estonian one, with only little foreign experience to draw experience from (including technological developments), it is possible that the option of a small-scale oil shale industry simply did not exist. The point made here is that if the oil shale industry had tried to develop more in tune with the size of the country, it is possible that it would never had produced the knowledge (and ensuing variety) needed for further development. If this is the case, many of the consequences presented throughout this work were, by and large, unavoidable. If, on the other hand, oil shale industries had been thriving in many, especially big countries, one could assume that diffusion of technology would have made it possible for Estonia to limit the size of its own oil shale industry.

10.8. Changing Institutions

Douglass North discusses similarities between technological and institutional path dependence. These two are interconnected, although institutional path dependence is likely to be more complex, *inter alia*, due to its embeddedness in cultural values, or informal institutions.¹⁰⁰⁹ In this study a special case has been highlighted in which the development of formal institutions has been interrupted and altered repeatedly, probably affecting even informal institutions. Technology has nevertheless basically remained on a path resembling the surrounding world. The example of Sweden serves to illustrate this point. Notwithstanding the fact that the Swedish oil shale industry came to an abrupt end in the mid-1960s, until then it had roughly followed a similar path to the Estonian oil shale industry. Both were seen as important domestic producers of oil in a world of nation states left to themselves to secure the supply of vital fuels and both were later turned into chemical complexes. The big difference came when Sweden opted for nuclear power, while in Estonia, with only limited control of its

¹⁰⁰⁹ North (1990).

domestic development, the oil shale industry once more changed through the massive build-up of power generating capacity. Even if this would most likely not have been an option in Sweden (i.e. producing electricity from oil shale), both countries stood at the crossroads more or less simultaneously. An independent Estonia might have had opted for another solution than burning oil shale for electricity generation. Instead, saving the Estonian oil shale industry probably contained an element of a wish for at least some sort of stability as compensation for the lack of stability in formal institutions. The oil shale industry and the related technology represented the continuity of Estonia when the occupying power actively tried to erase whatever signs that remained of the once-independent country.¹⁰¹⁰ Under such circumstances, this particular branch of technology became the carrier of an institutional memory. The cultural costs attached to this development turned out to be high. But at that time it must have seen reasonable to interpret technology as an expression of a national institution. Thus a technology with inherent complications, which in the end caused its demise basically all around the globe, could survive as a projection of national aspirations disguised as technology.

When Estonia succeeded in regaining its independence as a result of the collapse of the Soviet Union, the oil shale-based industry was left in disarray. Electricity was still needed, of course, and there were no immediate substitutes available. Other branches of the oil shale industry were left to their own devices in a free market environment they initially lacked the experience to cope with. But remarkably quickly, shale oil production bounced back and became even profitable. This was of course to a large degree a consequence of high world market prices for crude oil, but nonetheless an important part was also played by the fact that routines were maintained despite the dramatic institutional change.

One can, of course, ask what would have happened if the Soviet Union had not crumbled in 1991, but, say, two decades later. A qualified guess would be that excessive mining of oil shale (on the scale that actually took place in the mid-1980s) would quite soon have exhausted the Estonian oil shale deposits with a gradual decline as a result. Today, changes in the technological paradigm fuelled by environmental concerns pose new challenges for the oil shale industry. Being at the same time perceived as the only alternative, but an alternative not in accord with its time, has put the industry in a complicated situation. On the one hand,

¹⁰¹⁰ For instance, hoisting the Estonian national flag was strictly prohibited until the late 1980s. Raun (1991) p. 224.

Estonian know-how is increasingly demanded globally, while at the same time the calls for abandoning oil shale as a fuel have gained ground. This problem might seem unresolvable. Abandoning oil shale will lead to a greater dependence on the surrounding world, and probably the optimal solution for Estonia in this case would be a reliable and countable international environment. At this point it is worth asking the question whether one key component in the global solution on the replacement of fossil fuels requires dramatically increased international trust. Development in this direction is not hard to identify. The European Union is perhaps the most conspicuous example of increased international cooperation in the Baltic region. But regardless of this, the nation state still seems to remain the “provider of the last resort” of energy, or at least this is the perception. Exemptions from this rule can be found, though. Since 1993, the Nordic countries share a common power exchange, Nord Pool, which is the first of its kind in the world trading electrical power across national borders.¹⁰¹¹ But despite such developments, electricity generation in particular has remained a national priority issue,¹⁰¹² which is rather paradoxical in a world where several other sectors, until recently considered equally high-priority, have gradually been losing their top-positions on the shortlist of national concerns. Examples abound, but it should be sufficient to mention airlines, shipping, production of foodstuffs and fuels.

It has been shown that the Estonian oil shale industry survived several major radical changes in the institutional framework. One reason for this is of course obvious; energy is always needed, whatever claims any society otherwise lays on its arrangements. However, this claim can also be expressed otherwise, namely that all (modern) societies demand not only abundant energy, but the cheapest possible reliable energy. Despite often having been seen as a second best solution, the oil shale industry has always found niches of demand. One crucial advantage it repeatedly has had over other options is the simple fact that it exists. This is indeed an illustration of the previously quoted reasoning by Robin Cowan:

”Suppose the bad technology is used, but that it produces good results. Not getting a bad reading, the central authority would be inclined to use it again. This can continue for many adoptions. But each time a technology is used it advances along its learning curve, so the

¹⁰¹¹ For more details, see www.nordpool.com (accessed on April 17, 2007).

¹⁰¹² Holmberg (2005) claims that the decision in Finland in 2002 to construct a fifth nuclear power reactor was by and large motivated by such “national arguments”.

expected value of its true benefits increases. If this technology continues to be used, it will eventually have advanced sufficiently along its learning curve that the other one, no matter how good, will have been left behind.”¹⁰¹³

True, in the case of the Estonian oil shale, it cannot be claimed that some potentially better technology would have been left undeveloped, but the fact remains that the oil shale industry has been far from a perfect match for the Estonian society. Still today, oil shale is treated with an uneasy acceptance, and it is tolerated for the reasons that it enhances social stability in the north-eastern parts of the country, it guarantees stable, domestic electricity supply, and it generates profits (at least for the time being). In Sweden the oil shale industry was finally shut down as unprofitable, because imports of oil and other end-products were cheaper and while nuclear power was perceived as far more promising. In addition to this, there were no sharp social issues connected to the Swedish oil shale industry.¹⁰¹⁴ After a massive build-up of oil shale-based power production in Estonia, the emergence of nuclear power in the Soviet Union put the oil shale power production into the role of a minor actor. But today the oil shale-based power production is not only a major, but basically the sole actor in Estonia - a result of institutional change only, without any noteworthy technological development. Against this background it can be worthwhile returning to von Tunzelmann’s interpretation of the firm as a knowledge-processing unit, where the input is information and knowledge of technology and the output knowledge of products and markets. von Tunzelmann claims that the disconnection of these two aspects of the firm (on an aggregate level) eventually contributed the collapse of the Soviet Union.¹⁰¹⁵ In the particular case of the Estonian oil shale industry, however, the picture is different. The connection between input and output was inherited from the beginning of the oil shale industry and it appears not to have been lost, albeit perhaps weakened. The many shifts in focus of production as well as the adaptation to market conditions in the 1990s indicate a remarkable capacity to adjust the processing of one type of knowledge to another.

It has previously been discussed what factors maintain the present lock-in into the oil shale-based energy-technological system in Estonia (see chapter 8.7.). These factors can be divided into causes defined either by nature or human society, but they can also be analyzed in terms

¹⁰¹³ Cowan (1991) p. 806.

¹⁰¹⁴ This can be expressed even more directly: there is no branch of the Swedish economy which, if closed down, would lead to a sharp, condemning reaction from the surrounding world.

¹⁰¹⁵ von Tunzelmann (1997) and von Tunzelmann (2003).

of exogenous or endogenous with respect to the energy-technological system. Moreover, a distinction can be made between positive and negative forces. By positive forces is meant that the system is pushed or pulled further along its trajectory while negative forces are those that simply counteract change without otherwise developing the system. It is the interplay between these forces in combination with eroding forces that maintain the lock-in. When the surrounding world, or institutions, undergo profound changes, this seems actually to strengthen the technological path. One explanation for this is probably that when a new institutional set-up is introduced, it initially lacks the power to carry out extensive restructuring of the technological landscape, because most of the attention is dedicated to ensuring the new order. Existing practices or routines are left alone as long as they function, albeit on a sub-optimal level. Only with passing time do the actors of the new institutional framework gradually turn their attention to less urgent spheres of the society. Thus a sort of interregnum occurs, which intentionally or unintentionally strengthens the existing structures. As has repeatedly been pointed out throughout this work, Estonia underwent several institutional changes in the 20th century, all of which indirectly contributed to the persistence of the oil shale industry. It was therefore not for instance the Soviet Union *per se* that was the cause for the survival of the oil shale industry, but rather the fact that it represented an entirely different framework of formal institutions.¹⁰¹⁶

In contrast, informal institutions change rather slowly. In Estonia, the oil shale industry maintained a lot of its appeal to the Estonians well into the 1960s, they perceived it as their “national technology”. This support eroded in the 1970s and it has not returned, in spite of the fact that being able to domestically generate all the electricity demanded (and even export) has significantly contributed to the self-confidence of today’s Estonia. The reason for these values being hard to change is twofold. First, there the oil shale industry became over time associated with attempts at Russifying Estonia. Although this perception is likely to remain in the near future, it is certainly not far-fetched to assume that values and opinions originating in this issue will fade if developments in the country otherwise point in a positive direction. Second, the oil shale industry is not in concordance with environmental concerns and this conflict of interests is not likely to disappear in the future.

¹⁰¹⁶ This phenomenon is well known in the form of the expression “The more things change, the more they are the same”. The explanation, as I see it, is that while the new order secures its grip, it has to loosen control over many areas, which then use the opportunity to gain strength.

10.9. Escaping lock-in

One aspect that has been identifiable throughout this study of a unique industry in a small country is that the sheer size of the industry has actually caused a *lock-out* of alternatives. There are simply not enough resources, be it human or financial, to develop alternatives. It has been claimed by Gregory Unruh that lock-ins have not been paid enough attention to.¹⁰¹⁷ In order better to understand the reasons behind the worldwide difficulties to cope with climate change (and other environmental hazards), more research on these complex states would likely be rewarding.

In table 8.6. in chapter 8.7 an attempt was made to classify those forces that might erode the lock-in in the Estonian case. As such forces the following were identified: 1) Changes in the knowledge base in Estonia, 2) Slow technological progress in the oil shale industry, 3) The development of competing technologies, 4) International cooperation and increased trust, 4) Societal attitudes, 5) Depletion of oil shale resources, 6) Environmental hazards, and 7) The settlement structure and geography of Estonia. In the following, each of these aspects will be addressed. In this context, a few words on the classification made by Bassanini and Dosi are required (see chapter 3.2.5.) They identify four factors that may lead to a break-up of a lock-in, namely the emergence of a new technological paradigm, imperfection in adaption to the social surroundings, declining fitness vis-à-vis the socio-technological environment and finally new organizational forms from the outside.¹⁰¹⁸ Starting from the last factor, it can be stated that this has not been the case in Estonia, but rather the opposite. Despite profound organizational changes throughout its existence, the structure of the oil shale industry remains more or less intact. Concerning the other three factors, so far the oil shale industry seems to have stayed rather immune to signs of change of the energy-technological paradigm from fossil to renewable (despite some improvement), while the rather uneasy adaptation of the industry to its social surroundings has not seriously hampered the industry since WWII. What remains is the question whether various aspects of fitness of the oil shale industry in relation to the socio-technological environment are declining.

Changes in the knowledge base in Estonia. Earlier in this work, Mark Roe was referred to, who claims that path dependence is often maintained by pressure groups who want to avoid

¹⁰¹⁷ Unruh (2000).

¹⁰¹⁸ Bassanini & Dosi (2000) p. 62.

radical change, or by lack of information on alternatives.¹⁰¹⁹ Especially from the second half of the 1950s and onwards, there existed a strong scientific community in Estonia with vested interests in the oil shale industry. As was shown especially in chapter 6.4.2 (“The Debate of 1968”), an occasionally polarized debate took place within this community. But despite this, the sources indicate no suggestions proposing the outright closure of the oil shale industry. In brief, it can be assumed that so much effort had been invested in knowledge creation within this community that a diversion from the oil shale path was simply unthinkable. In this respect, the Estonian oil shale community was advancing along a technological trajectory as described by Giovanni Dosi.¹⁰²⁰ Today, much of the work done in the past decades is perceived as being of little value, especially in the field of oil shale chemistry, and oil shale research does not any longer attract young engineers to the same extent as before, although power generation still holds some of its positions.¹⁰²¹ Therefore, this knowledge-accumulation-related aspect of lock-in is more or less broken in today’s Estonia. Moreover, the argument based on the importance of a “national technology” has also been significantly devalued, unless this aspect is re-vitalized among the Russian-speaking population of the oil shale region.

Slow technological progress in the oil shale industry. There remains, however, one particular aspect in which the knowledge accumulated in Estonia has a certain role to play. On the global scene, oil shale poses a particular kind of threat to producers of crude oil, not because of its actual role, but its potential. The very fact that there exists vast amounts of recoverable oil shale, that there exists technology to utilize oil shale and that the deposits of oil shale are often located elsewhere than the deposits of crude oil are enough to justify the claim that oil shale, although not a competitor to crude oil, corresponds with the Schumpeterian notion of threats to a monopoly. Were crude oil prices to reach a critical level, or were political developments to become increasingly unfavorable for the oil importing countries, oil shale might break into the market. However, oil shale is probably not even the second best fossil fuel, but can be thought of as standing further behind in the queue, behind liquefied natural gas or bitumen. Thus, worsening the competitive position of crude oil does not imply that oil shale would emerge as an important source of fossil fuel. It is perhaps more plausible that oil

¹⁰¹⁹ Roe (1996).

¹⁰²⁰ Dosi (1982).

¹⁰²¹ It is worth mentioning that the students of oil shale power technology are increasingly Russians from the oil shale region. This comment was made by Arvo Ots, professor at Tallinn Technological University, during our discussion on April 8, 2005.

shale would be one of the last options were the world to be looking for yet another fossil fuel infrastructure.¹⁰²² Therefore, on a global level, experiences accumulated in the Estonian oil shale industry might have a role as fallback fossil technology were supply from other sources to be put under serious threat, both in political and economic terms. This is shown by the interest shown of other countries in the Estonian experiences, which is, no doubt, limited, but certainly not non-existent. However, with increasing global awareness of the hazards of emitting greenhouse gases, increased utilization of oil shale would likely encounter widespread protests. So far, the emergence of any solution allowing for the utilization of this resource seems very distant indeed.¹⁰²³

The development of competing technologies. Estonia is under no circumstances at the international frontline in developing renewable energy technology, but on the other hand, there is growing interest in several alternatives. Small-scale hydro power might offer a partial solution, as might bio fuels and wind power. Since re-independence in 1991, Estonia has shown a remarkable capacity and willingness to absorb new technology, especially information technology and telecom. Therefore there should not be strong resistance (i.e. informal institutions) against the introduction of new modes of electricity generation and other forms of energy. As was discussed above, the vested interests of scientists and engineers in oil shale have weakened and they have not been replaced. In this sense, Estonia faces an almost clean table. With its track record of technology diffusion in other areas,¹⁰²⁴ Estonia would probably have no particular difficulties in absorbing new energy technology. Moreover, the retreat of oil shale in the scientific and engineering arenas has probably left room for focusing on alternatives.

International cooperation and increased trust. Oil shale has repeatedly been a resource in extraordinary times, such as in Sweden during WWII. It also appeals to a widespread understanding of the need for national self-reliance in energy supply. There are, as has been shown in chapter 4, several examples of this. Historical evidence seems to point in the direction that the more countries have to rely on themselves, or the more they feel they have

¹⁰²² California requires a 10 per cent reduction in CO₂ emissions throughout the life cycle of fossil fuels. This will make "unconventional oils", including shale oil, less competitive, because the processing of oil shale causes significant emissions. Source: *The Economist* June 2nd-8th 2007 "The drive for low emissions".

¹⁰²³ It is worth noticing that gasification of both coal and biofuels seems to be back on the agenda. This is of course a process similar to what was once done with oil shale in Estonia, but so far there is no evidence of attempts to brush up those skills. On gasification today, see Jönsson (2006).

¹⁰²⁴ It should suffice to mention that in March 2007, Estonia was the first country in the world that allowed online voting in national elections.

to do it, the more likely is oil shale (or some other suboptimal energy source) to become an important element in the energy basket. This reasoning could be followed in the opposite direction: The more international trust there is – real or perceived – the less likely it is that environmentally hazardous and expensive energy resources will be utilized. The notion of the nation state standing alone is gradually being replaced with the understanding of nation states in close cooperation with each other. The expansion of the European Union to encompass most of the Baltic Sea area has had a major role in strengthening collective safety in the area. Moreover, the EU-policy for increased energy cooperation will, if successful, have a profound impact on energy policy in Estonia. The plans to construct a joint Baltic nuclear power plant, although still in an initial stage, illustrate the increasing awareness of broad cooperation.

Societal attitudes. When the oil shale industry was created, Estonia was capable of making a radical choice. At other times and in other spheres, Estonia has in a similar fashion shown proof of a remarkable capacity to implement radical changes, such as the institutional reform immediately after the demise of the Soviet Union. These reforms, especially the currency arrangement and the unique implementation of a flat tax rate paved the way for a blossoming economy.¹⁰²⁵ But already during the Soviet period, experimentation in various sectors of the economy made Estonia different from most of the other parts of the Soviet Union. With this heritage of radical change, it is almost a contradiction that the energy sector has been left basically unchallenged. If there is a genuine wish in Estonia to cope with tomorrow's energy challenges, many of the tools for change already exist, some of which are to be found in the early days of the oil shale industry; namely the bold moves in order to develop something new. The recipe for how to break away from oil shale dependence should be fundamentally the same as the recipe behind today's successful economy. One particular aspect of societal attitudes that deserves special attention is the role of a free debate. When freedom of expression increased in the late 1980s in Estonia, long suppressed concerns on the environmental impact of the oil shale industry surfaced, putting the role of the industry in a new light. But this issue runs deeper than so. From the very beginning of the Estonian oil

¹⁰²⁵ When, in 1994 Estonia introduced a flat tax rate (of 24 per cent), this radical move was met with some suspicion abroad and fears of "tax dumping" were frequently voiced. However, today it is increasingly recognized that Estonia started what could be called a flat tax revolution in Eastern Europe. With the introduction of the flat tax, Estonia accommodated much needed capital creation while at the same time discouraging abuse stemming from complicated tax laws. The flat tax has been criticized in Estonia for favoring the rich over the poor. The Estonian experience of a flat tax has not gone unnoticed in the surrounding world. For newspaper articles on the topic, see for example "A Land of northern Lights, Cybercafes and the Flat Tax" by Mark Landler, *The New York Times* December 21, 2005 and "Pioneer of the 'flat tax' taught the East to thrive" by Toby Harnden, *Telegraph*, September 4, 2005.

shale industry, few really critical voices can be traced. In the 1920s and 1930s there seems to have been consensus on the importance of developing the oil shale industry, and therefore its role was usually not challenged. During the Soviet years, there was from time to time an intense debate, but only within certain frames. The fundamentals were never questioned. Today, freedom of expression in Estonia is no different from that in Western Europe, but the dominant position of the oil shale industry in Estonia's energy basket seems to curb not only policy but also the debate on alternatives. One lesson that can be drawn from the Estonian experience is the need not only to allow, but also encourage a critical debate on all energy options, without prejudices. When one form of energy is perceived as lacking alternatives, this will soon be established as the truth. Drawing parallels to today's carbon-based global energy system is rather straightforward.

Depletion of oil shale resources. Oil shale is convenient; Estonia will not run out of it in the immediate future and it provides a reliable supply of electricity while at the same time continued reliance on oil shale is a guarantee for social stability. Thus, the dependence on oil shale prevails for the time being despite wide-spread recognition of its drawbacks. Identifying a technology as inferior is not sufficient to provoke a serious attempt to break away unless there is an understanding about what actually counts as superior. Moreover, the need to respond to today's demands effectively blocks changes which would probably be beneficial in the future. But more or less all estimates point in one direction, namely that it is a question of decades (rather than centuries), when Estonia will run out of easily recoverable high calorific oil shale. It is possible that improved mining technology or boilers may remedy this problem, but only in a relatively short perspective. Sooner or later, Estonia will be forced to find a new energy source.

Environmental hazards. Damage caused by the oil shale industry to the environment has been debated in Estonia for decades. Already in the 1970s, there were publicly expressed concerns. In the 1980s, environment and the struggle for independence became intertwined. Thus, there is plenty of understanding for environmental issues among the Estonian public. However, despite significant improvement of environmental standards, there is no acute threat to the oil shale industry from environmental concerns, because of the lack of obvious, short-term alternatives. This situation is aggravated by such rather bizarre calculations as drawing a base line for emissions of greenhouse gases at a level high enough for the electricity monopoly to cash in on selling emission rights. It probably goes without saying that providing the oil shale-

based power industry with such an additional source of income will not stimulate the development of alternative sources.

The settlement structure and geography of Estonia. One of Estonia's strengths in this process should be, perhaps somewhat surprisingly, the dispersed population pattern. Today, it is widely assumed that the next generation of renewable energy will be characterized by decentralization,¹⁰²⁶ which would suit the particular needs of Estonia well. When the oil shale industry was founded, it was in concordance with the requirements of its time. Today, a shift to small-scale units for energy supply could once again turn out to be a good match between necessity and national interests.

At present, some key components of the lock-in into oil shale have been weakened. This fact should stimulate the attempts to start breaking away from oil shale, although the process is likely to be lengthy. But this would, in turn, allow for the gradual reconstruction of the economic base in the oil shale region, thereby avoiding social unrest.

¹⁰²⁶ See for instance Elliott (2000).

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APPENDIX I

Oil shale output 1918-1940 by all producers (in tonnes)

Year	All government mines	Eesti Kiviõli	Vanamõisa Oilfields	Kütte-Jõud	Port-Kunda	Estländska Oljeskiffer-konsortiet	New Consolidated Gold Fields	Total Private + Government	Private share in % of total
1918	16	-	-	-	-	-	-	16	0
1919	9,631	-	-	-	-	-	-	9,631	0
1920	48,714	-	-	-	-	-	-	47,714	0
1921	95,528	-	-	-	-	-	-	95,528	0
1922	138,935	3,200	-	-	-	-	-	141,595	2.3
1923	204,602	6,600	3,340	-	-	-	-	214,542	4.6
1924	231,187	1,713	712	-	-	-	-	233,612	1.0
1925	238,656	15,625	8,740	25,102	-	-	-	288,123	17.2
1926	334,135	37,417	7,677	47,292	4,040	-	-	430,561	22.4
1927	255,740	30,161	3,562	87,647	12,566	-	-	389,676	34.4
1928	318,345	19,338	215	82,283	25,921	-	-	446,102	28.6
1929	355,658	26,436	149	110,292	25,117	-	-	517,652	31.3
1930	296,908	52,755	395	109,515	38,382	-	-	497,955	40.4
1931	271,223	102,915	1,356	99,096	24,935	-	-	499,525	45.7
1932	252,883	116,545	-	83,408	39,770	-	-	492,606	48.7
1933	209,310	150,496	-	106,828	30,268	-	-	496,902	57.9
1934	237,400	183,919	-	126,341	41,298	-	-	588,958	60.2
1935	249,840	189,446	-	123,079	41,922	-	-	604,287	58.7
1936	364,680	177,181	-	143,222	58,231	22,789	-	766,103	52.4
1937	415,900	390,738	-	146,825	61,172	79,617	25,225	1,119,477	62.8
1938	588,200	509,971	-	136,587	70,131	103,344	65,933	1,474,167	60.1
1939	666,500	509,754	-	126,238	62,701	228,112 (216,707)	73,593	1,666,898	60.0
1940	859,900	535,129	-	135,241	57,838	226,412	77,154	1,891,674	54.5

Source: A/S Esimene... (1938), Loit (1994), ERA 2491-1-84 p. 24, ERA 2491-1-70 p. 3, 27-28, own calculations.

APPENDIX II

Shale oil production by companies in the oil shale industry 1921-1940 (in tonnes)

Year	<i>A/S Esimene Eesti Põlevkivitööstus</i>	<i>Eesti Kiviõli</i>	<i>Estländska Oljeskifferkonsortiet</i>	<i>Vanamõisa Oilfields</i>	<i>New Consolidated Gold Fields</i>	<i>Total</i>	<i>Total private sector share,%</i>
1921	115	-	-	-	-	115	0
1922	259	-	-	-	-	259	0
1923	361	-	-	-	-	361	0
1924	337	-	-	-	-	337	0
1925	2,652	-	-	466	-	3,118	14.9
1926	5,784	-	-	-	-	5,784	0
1927	4,237	-	-	54	-	4,291	1.3
1928	6,595	-	5,271	-	-	11,866	44.4
1929	5,453	1,774	3,549	-	-	10,776	49.4
1930	6,318	3,747	-	1	-	10,066	37.2
1931	6,829	8,716	-	18	1,586	17,149	60.2
1932	9,001	23,406	-	-	4,188	36,595	75.4
1933	10,404	22,930	-	-	4,283	37,617	72.3
1934	11,031	26,139	-	-	9,706	46,876	76.5
1935	11,758	25,523	-	-	9,991	47,272	75.1
1936	22,868	22,927	7,954	-	9,643	63,392	63.9
1937	30,008	55,562	15,525	-	10,626	111,721	73.1
1938	48,977	65,079	14,938	-	10,638	139,631	64.9
1939	60,545	70,012	36,944	-	11,398	178,889	66.1
1940	59,808	68,195	35,197	-	10,930	174,130	65.6

Source: A/S Esimene...(1938), Loit (1994) , ERA 2491-1-84 p. 24, ERA 2491-1-70 p. 34, ERA 2491-1-81 p. 76, own calculations.