Factors affecting public acceptance of wind turbines in Sweden

By

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Foreword

This work was carried out in order to fulfil the requirement of the completion of an MSc Environmental Science programme at LUMES, Lund University, Sweden. This thesis examines social attitudes relating to land based wind turbines in Sweden and aims to show mechanisms that would reduce the conflict surrounding the siting of wind turbines.

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0 Abstract

Sweden has recently seen a substantial development in its commercial wind power electricity generation capacity, which has caused criticisms of its effect on the surroundings. This paper aims to study to what extent the arguments against the siting of wind turbines are valid and what social processes are at work in the locally affected communities. These findings could then incorporated into the land use planning procedure in Sweden to ensure that the current level of antagonism is lessened.

The initial hypothesis states that opposition against the erection of wind turbines is due to the NIMBY (Not In My Back Yard) effect. This was dismissed during the study as it was found that the causes of unwillingness to accept the introduction of turbines are more complex. There are four main factors affecting the community's acceptance of the turbines, these are directly related to the spatial disparity between the impacts and benefits inherit in wind power. Those near the turbines bear the cost, in the form of noise and landscape change, whilst the benefits are felt at a national or international level, cleaner air and increased security in regard to energy sources.

In order to compensate local communities for the costs incurred there should be a balance of benefits, whether financially or in the local services enjoyed, improved connection to the electricity grid for example. Acceptance would also be improved by more participation in the planning process. If residents are able to affect the actual siting of the turbines then compromises can be sought and there is a more transparent flow of information relating to the proposal.

Sweden has a plentiful supply of HEP (hydro-electric power) and a developed nuclear industry which has meant that the perceived need for wind is less than in many other countries, thus reducing the willingness to accept a detrimental change in the landscape to produce electricity when there is not a current shortage. However, if the government's policy to phase out nuclear is fully realised this perceived need has to be heightened to accept changes as the consequence of the phase out.

Clear communication at an early stage could also ease the community's internal disagreement caused by conflicting views of nature and reliance on natural resources. The dominance of certain sections of the community directly affects the level of opposition to wind power proposals.

The study concludes by stating that it is not only the land use planning that is important when siting wind turbines, their introduction into society is also critical. Social opposition towards turbines is valid and should be incorporated into an established planning procedure at the local, regional and national level.

1 Introduction

Electricity is essential to modern life. Ever since the Oil Crisis of the 1970s there has been increased awareness that there are finite resources of carbon based energy sources and a renewed interest in the utilisation of alternative and renewable energy sources. The interest in alternative sources led to the development of nuclear energy, a trend that is slowing down and even reversing in some countries, whilst recent years have seen a greater increase in wind power installed capacity than nuclear power capacity (EWEA a).

There has been a long history of wind power being used throughout Europe to aid economic and industrial development. Windmills and The Netherlands are synonymous; they were also common in other parts of Europe, especially Denmark and Southern France. Sweden too saw windmills becoming an established aspect of its landscape, particularly areas of southern Sweden, Skåne for example.

Wind Energy has been prominent in this commercialisation, especially in Europe over recent years with current annual market growth of around 40% (Hatziargyriou & Zervos 2001). By the 1980s there was commercial interest in the utilisation of wind turbines to contribute to national grids throughout Europe, especially Denmark and Germany as well as stand-alone applications.

This development did not go unnoticed by local populations and certain interest groups, thereby causing an opposition movement to wind power developments. Many of the protests have had similar claims, such as that the turbines are noisy, visual obtrusive and adversely affect the surrounding environment and wildlife population. These protests have had a significant effect on the introduction of wind power schemes as public opinion has often prevented planning permission being granted.

This paper aims to study to what extent the arguments against the siting of onshore wind turbines are valid and what social processes are at work in the locally affected communities. These findings are then incorporated into the land use planning procedure in Sweden with the aim of alleviating the current level of antagonism. Two main hypotheses were tested in the paper:

- Opposition to wind power in Sweden is caused by the NIMBY effect.
- Changes in the planning procedure can be made to accommodate the need and will of society as a whole.

Whilst the focus of the paper will be Sweden, it will be necessary to draw parallels with other European nations and areas further a field, especially North America.

2 Method and Material

This paper aims to answer the research questions posed through a process of literature review, interviews and participation in ‘expert’ meetings. The paper first discovered the level of support for the wind industry, and then determined what are the arguments against wind power; these were then examined to determine the extent of their legitimacy. The underlying reasons for the opposition were analysed and conclusions reached as to the key factors that could then be examined with regard to land use planning in Sweden.

Background data was found by surveying peer-reviewed material in order to determine the main arguments surrounding the issue. These arguments were then incorporated into a matrix where the claims were tallied to show which were cited most often. From this background other material was analysed to ascertain bias and the arguments were then presented. Opinion polls were taken mainly from peer-reviewed sources, or those quoted in such material. Along with these secondary sources primary interviews were conducted with relevant experts and those living nearby, as they are the most knowledgeable in the effects of turbines on the landscape.

Next, the paper aimed to ascertain what motivates public opposition to the siting of wind turbines. One explanation of this response has been the NIMBY (Not In My Back Yard) attitude. This paper tested whether this attitude was as prevalent as often assumed, or if other social attitudes were involved. If NIMBY was not the dominant social attitude then other theories were incorporated. This stage was composed of secondary peer reviewed sources, published opinion polls and interviews with relevant experts in this field. Alternative reasons were proposed using Systems Analysis where causes and effects were expressed using causal loop diagrams.

The paper then examined the current land use planning policies operating within Sweden at the national, regional and local scales. The structure and scope of these planning procedures were discussed to allow more widespread access to decision making and to alter the time scale on which the public is informed and decisions are made. The implications of these were then discussed and conclusions drawn.

Before the findings of the paper are presented an introduction to the physical potential and its place in energy strategies will be presented so that the context and relevance of this study is shown. Further information relating to the technology employed has been presented as an appendix.

3 The need for alternative energy sources and strategies

Fossil fuels have been the dominant source of energy for the twentieth century; they fuel industry, transportation, agriculture and every day life. Fossil fuels are a finite resource that will eventually been depleted or become too expensive to extracted economically, as in the case of oil from oil shale (Rogner 2000). Whilst there is much debate about the lifetime of these energy sources, there is a general consensus that they will eventually become less attractive, economically and technically, as the primary fuels for life. Crude oil reserves have exceeded their peak productivity and their productivity is decreasing (Abrahamson 2002), coal reserves are still being extensively utilised to the determent of the environment and natural gas reserves have a finite limit.

During this period of reliance on fossil fuels the world has experienced a significant increase in commercial annual energy usage from 1970 to 1998, from 56.4 TWh to 98.6 TWh, during the same period Europe experienced growth from 14.3 TWh to 19.5 TWh (Rogner & Popescu 2000). Total energy consumption is expected to increase by an average annual growth rate of

2% in the period of 1990 – 2020 with a 90% dependence on fossil fuels by 2020 (European Commission 1999). This increase in demand is coupled with the fact that many power plants are reaching the end of their expected lifetime and are in need of replacing, thus making the subject of future energy needs a more pressing subject.

The will for a reduced dependence on fossil fuels has led to the usage of alternative sources of energy, such as renewable energy and nuclear power. However, recent years have seen a drop in acceptance of nuclear energy, as exhibited by the 20 year old Swedish decision to phase out this form of energy, the recent British moratorium on new plants and the Dutch decision to close down their single plant in the near future (Aubrey 2002). It is also known that much of Europe's HEP (hydro-electric power) potential has been utilised, around 65% of the technical potential in Western Europe (Rogner 2000). Sweden is a nation that already has a developed HEP system, as 48% of the nation's electricity was produced from this source in 1998 (SNEA 1999). Therefore, with a developed level of HEP exploitation and the political will to close its other large electricity source, nuclear power, other sources must be utilised to safe-guard the nation's capability to produce sufficient electricity.

Definition of sustainability

Before strategies for improving sustainability can be discussed it is important to understand what is meant by 'sustainable' in this context. The Brundtland definition is employed, which is that humanity has "*...to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs"* (WCED 1987). This means that there must be energy resources available in the coming years that meet the needs of later generations. This does not mean that the energy sources currently utilised must be adequate in sufficient volumes to completely meet future needs, merely that known resources are not totally depleted. This thesis aims to consider the social, economic, political and environmental aspects of 'sustainability', with the emphasis being on the social and environmental considerations.

Definition of Renewable Energy Sources

Renewable energy sources are created from three sources, the sun, gravity and the earth's core, thereby including wind, solar, geothermal, wave, tidal, hydropower, biomass landfill gas, biogases and sewage treatment gases.

4 Sustainable Energy Scenarios and Strategies

In an attempt to develop sustainable energy plans the United Nations Development Programme (UNDP) in the World Energy Assessment (2000) uses energy scenarios to indicate how energy needs could be met using an array of different energy sources. All of the scenarios are for increased global energy consumption over the next century and show the future effects of possible energy strategies. There are three cases examined, high economic growth, middle growth that can be considered the 'business as usual' case and the 'ecologically driven' scenario. It is this last case, labelled case C, that can be used as a base for designing an energy plan that meets the needs of sustainable development, with regards to social, economic and environmental aspects.

If the energy scenarios C1 and C2 were used as base, then coal would be phased out by 2100, oil and gas usage would be limited and the increasing demand would be met by renewable sources. Scenario C2 does not rule out the usage of nuclear power, whilst scenario C1 does. Renewable energy sources, such as solar, hydro, biomass and others, including wind energy, are employed as substitute energy sources.

The European Union (EU) has also developed a future energy strategy based on the increasing use of renewable energy sources. The European Commission's 1997 White Paper on renewable sources of energy sets out firm plans to increase the share of the EU's energy provided by renewables to 12% by 2010. Perhaps more critically to the wind power industry this means that 22% of electricity will be produced from renewable sources, including wind (Wallace 2002). As part of the plan the new installed capacity of wind turbines would be 10 000 MW by 2003, as well as fixed targets for photovoltaic systems, biomass plants and liquid biofuel production. If the 12% target is met it is estimated that ∈74 billion would be needed in investments, but it would create 500 000 new jobs and produce annual savings of ∈3 billion in fuel costs. There would also be CO_2 savings in the order of 402 million tonnes throughout the EU. (European Commission 2000)

Over recent years Swedish Energy Policy has strengthened its support for renewable energy sources. The 2002 energy bill proposes the aim that *"the country's energy supply will be secured by an energy system based on sustainable, and preferably indigenous and renewable, sources of energy"* (SOU 2001/02: 143). The bill carried on to state that 10 TWh of electricity should come from renewable sources by 2010, 15 TWh by 2012 if possible, with a national planning objective of 10 TWh from wind by 2015, a large increase from the current 0.4 TWh (SOU 1999:75). To reach this objective for wind it has been estimated that an installed effect of 3 300 MW will be needed, which is around 2000 turbines of capacity 1.5 to 2.0 MW (Energimyndigheten 2001b). This average capacity is allowing for the trend of larger turbines as currently the average turbine capacity is 1.0 MW (EWEA 2001).

5 Wind Energy Potential and the Wind Energy Industry

The global wind energy potential has been estimated to be 500 000 TWh/yr with a practical potential of 53 000 TWh/yr with current available technology (Reddy et al. 1997). The values are estimated based on a wind flow of 5.1 m/s at a height of 10 metres, with the technically recoverable resources 10% of total potential, thus allowing for other land uses such as urbanisation and accessibility of the resource (EWEA 2001). These values have been derived from combination of meteorological data at a number of stations, statistical analysis and computer simulations (www.risoe.dk).

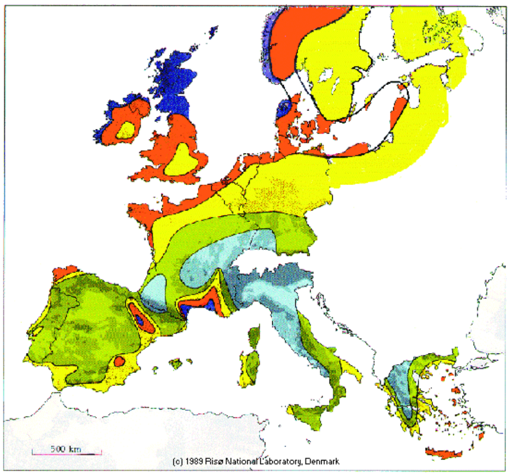

Figure 1 showing the available wind resources in Europe (www.risoe.dk)

Sweden's Wind Energy Potential

The most extensive study done throughout Europe to date has resulted in the European Wind Atlas, a graphic display of the wind characteristics across the continent that categorised the relative power present in the wind. The colours denote the varying intensity with the blue zones being the areas experiencing the most intense wind power, followed by red, yellow and finally green. It should be noted that Sweden is mostly covered by the yellow banding, with the exception of Skåne, southern Gotland and the northern mountains, which are within the red category, thereby indicating higher wind speeds. The power levels are shown in table 3, Appendix 2.

Figure 1 shows that although Sweden does not have the best wind resource base in Europe, it does have a considerable potential. A more detailed study shows that the best wind resources can be found within the higher elevations along the Norwegian border as well as Gotland, the southern and western coasts. The poorest wind energy sites are in the northern inland zones. (Raab & Vedin 1995) It has been calculated that the total gross wind electricity potential is 549 TWh/yr in Southern Sweden alone (Grubb & Vigotti 1997 and Grubb & Meyer 1993), with a technically possible potential of 41 TWh/yr for the entire country (EWEA 2001). As the term 'southern Sweden' has not been defined the former value must be treated with care.

Swedish Wind Energy Industry
Although Sweden has been exploring its wind energy potential since 1975 it has not exploited its resource as fully as other European nations, Denmark and Germany for instance. By the end of 2001 Sweden was the sixth largest producer of wind energy in Europe, with an operational capacity of 265 MW, less than 2% of the total European capacity of 16 362 MW. It should be noted that Germany alone accounts for 50% of total operational installed capacity. During the period from the end of 1995 to the end of 2001 total operational installed capacity increased 13 735 MW, a good omen that the EU will fulfil its short term targets set out in the 1997 White Paper. (Ackermann & Söder 2002)

Sweden has seen slow development of its wind development, with much of its increase occurring in the late 1990s. Figure 2 shows the gradual development of the installed capacity of wind turbines throughout Sweden from the end of 1990 to spring 2002. It is clearly evident that much of the development took place in the late 1990s and the start of the twenty-first century.

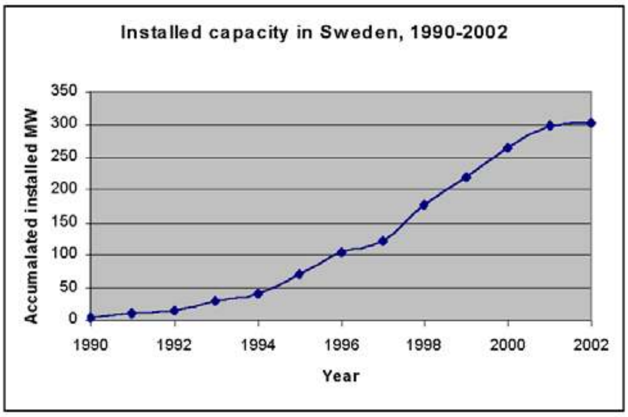

Figure 2 showing the installed capacity in Sweden from 1990 to spring 2002 (table 5, appendix 2)

Gotland is a good example of wind power utilisation, as wind turbines meet 12.5% of the total regional energy demand, 112 GWh (0.112 TWh) out of 900 GWh (0.90 TWh) in 1998 (Ackermann & Söder 2000). This is just an example of what could be seen in many other communities within Sweden. Recent forecasts show that Sweden will have a total installed capacity of 1 285 MW by the end of 2006, a substantial increase from the current installed capacity (WD 2001). Even with a conservative estimate (8000 hours at 30 % efficiency) this projected installed capacity could provide around 3 TWh/year, a significant share of Sweden's annual electricity production, which was in the region of 150 TWh in 1998 (SNEA 1999).

6 Results and discussion - Widespread public perception of wind power

Much will be said in this paper about the opposition towards wind power. There is, however, a wealth of data showing that there is public support for the use of renewables, especially wind power. This does not mean that the claims are in any way minimised by the lack of support, it is just important to understand whether the opposition presented is the belief of the majority or a minority sentiment.

Support of the use of renewable energy sources can be traced back over the centuries to the first windmills to pump water and watermills harnessing the power of local rivers. Since the first oil crisis in 1973 there has been a renewed interest in using renewable resources commercially. Farhar et al (1980) show that within the USA 80% of the population believed that there was an energy crisis in 1979 and this belief led them to investigate alternative energy sources. The same study showed that there was support for wind power as 66% of young adults in 1977 preferred windmills to any other energy producer within 25 miles (45 kms) of their homes. This American trend was continued in Farhar (1994) when wind power and solar energy were the preferred sources to replace non-US oil, 34% of respondents in 1993. North American support was not only confined to the USA, as there was widespread support within Canada as well. In 1995 79% of Canadians believed that wind generated electricity should be promoted on a commercial basis (Krohn & Damborg 1999) with 82% of Canadians interested in buying wind generated electricity (Surugiu & Paraschiviou 1999).

It is not only North America that has experienced high levels of support for wind generated electricity, Wolsink (1996) reports that 90% of the Dutch population support the application of wind energy. This extremely high level of support is seen in other European nations, such as Denmark where a 1993 study showed that four out of five Danes believed that wind should have a higher priority (Krohn & Damborg 1999). During the early 1990s support throughout the UK was also high. Through the examination of research conducted between 1990 and 1996 Simon (1996) found that there was up of 92% support for wind farm production.

This long-term support of wind-generated electricity has also been seen in Sweden. As early as 1979 there was a strong desire, 82% of those asked, for wind power to be used in future energy strategies (Carlman 1982). This high level of support was largely due to the perceived cleanliness of wind energy (Carlman 1986). Widespread opinion has continued to be extremely positive towards wind power (Hammarlund 1997a). Currently national support for the increased usage of wind is 74% (Hammarlund 2002). A 2002 study showed that more people in Sweden were willing to accept wind power production in their locality that any other form of electricity production, 64% of those asked, see figure 3. The study also showed that if another form electricity production were preferred, then all categories chose wind power as the second choice in the multiple-choice survey.

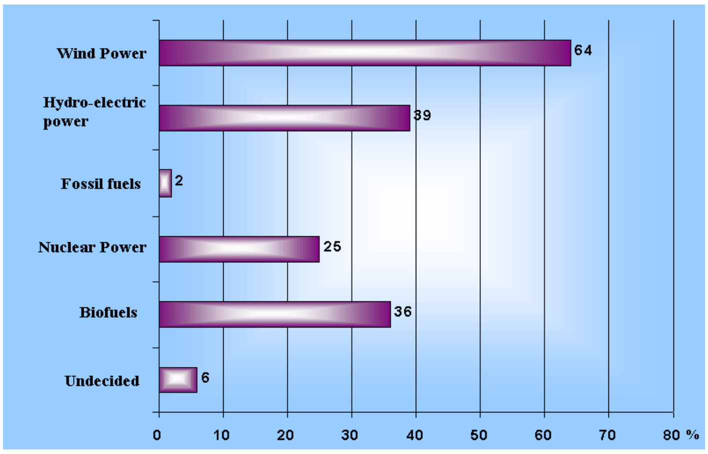

Figure 3 showing the preferred electricity production within own locality (Sifo 2002)

While it has been shown that there is overwhelming widespread support for wind power it must be remembered that this support changes over time and place. Studies conducted in the UK have shown that support for a specific turbine siting alters with time during the planning and implementation stages. A 1994 British study shows that whilst support for a proposed wind farm in Cornwall was 40% prior to installation and rose to 85% after construction, other UK developments have shown similar increases in public acceptability (Simon 1996). In Sweden the rise is not as significant due to the initial high level, increasing from 81% to 83% (Carlman 1986). Figure 4 illustrates public perception in a local area during all stages of construction of wind power plants. It reinforces the trend shown in the UK, USA and Sweden. The existing level of education regarding wind power generation and the media's coverage of the issue can affect the extent of the level of support before and after. (Geuzendam 1998, Gipe 1995, Hammarlund 1997a, Krohn & Damborg 1999 and Wolsink 1996).

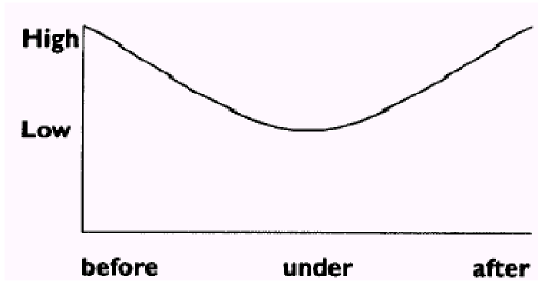

Figure 4 showing the level of acceptance for wind power throughout the stages of construction of a local wind power facility (Krohn & Damborg 1999)

As will be shown later in this paper there is public sentiment opposing the development of the wind power industry, such as the nuclear power funded British based opposition group, Country Guardians. These have been shown to be a minority voice and not representative of the masses. In the studies presented thus far there has been overwhelming wide spread support, that does not mean that all those who do not support wind power are opposed, as those who do not support are comprised of two groups, opponents and those who are neutral on the issue (Walker 1995).

On a national level there is a high level of public acceptance for the development of wind power generation. This support, however, is not always shown when considering specific local proposals. Attitudes can change over time but a high level of local resistance can effectively prevent the project being fulfilled. It has been estimated that in some European countries 50% of wind turbine erection proposals have been denied planning permission, mainly due to adverse public opinion (Gipe 1995), whilst The Netherlands has a refusal rate of up to 75% (van der Loo 2001). A recent Swedish example has been in Skurup, a local authority on the south coast of Sweden. The proposed installation of 28 turbines just under 10 kms from the coastline caused a heated debate (Dahl 2002). The issue was voted on by 7405 local inhabitants, around 75% of the local population, in a local community vote. On the second count the project was voted against, 3601 in favour with 3628 against (www.skurup.se). This result in a country where 74% are in favour of the development of wind power generation leads to questioning of the societal factors that are affecting public perception of individual wind power proposals.

7 Claims of those opposing wind power

"Wind Power is a curse. It makes too much noise, kills birds and will blight vast tracks of Britain's remaining upland wilderness" (Webb 1994). Although these sentiments relate to the

British countryside, those who are opposed to the erection of wind turbines echo them across Europe. One noticeable voice in the anti wind campaign has been a group called the Country Guardian who were established in 1992 as a response to proposed wind farms in Wales (Walker 1997). The group has since expanded to other European nations and is outspoken in its opposition of the development of the wind power industry. Other anti wind organisations have since sprung up across Europe, many in response to specific turbine erection proposals.

In much of the literature similar claims are presented as to the adverse effects of wind turbine siting and the reasons for opposition. The most common causes for complaint are shown in figure 5 below:

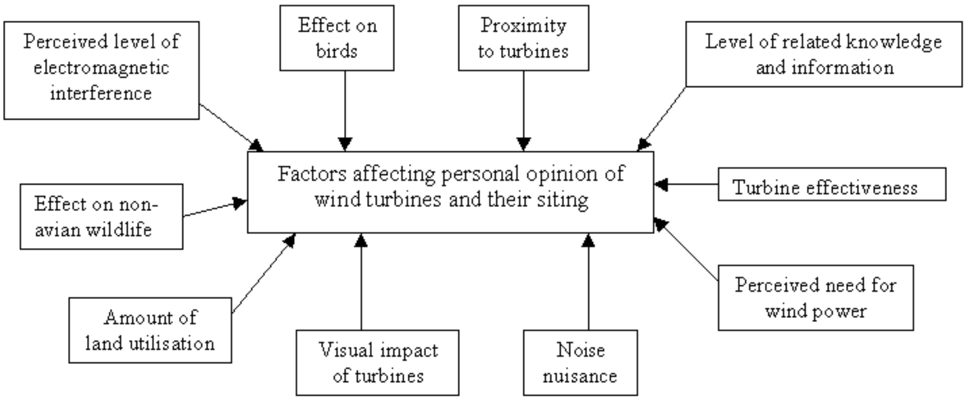

Figure 5 summarising the most common claims of opponents to the siting of wind turbines

Of these causes for concern, the effect on birds, noise nuisance, land utilisation, electromagnetic interference and the visual impact, are cited most frequently in the literature review, as shown in figure 6. The impact on birds, noise and visual disturbance are the core issues that will now be concentrated on, this is not to say that the other claims are of no consequence, they are just not the focus of this investigation.

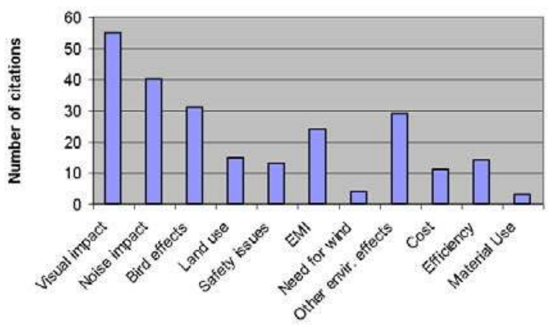

Figure 6 showing the distribution of citations from the literature review (refer to appendix 3)

Visual Impact

The Swedish Commission on wind power found that the visual effect on the landscape was *"the most troublesome effect"* of the turbines (SOU 1999:75). The sight of turbines has evoked strong emotions across the community with them being described as 'lavatory brushes in the sky' (Ingham 1985) or considered a positive addition to the landscape as they evoke the sense of an improving environment and a clearer energy supply.

Landscape is ever changing, whether naturally or through anthropogenic processes. It has its own character and identity (Krause 2001). It is this identity that is altered with the introduction of wind turbines, the rural aspect of the majority of the turbine locations only adds to the impact of their installation. This transformation of landscape has led to the strongest criticism; *"the aesthetic pollution is obvious when a piece of land is transformed into a whirling wind factory"* (Ginsberg 1993). Transformation of land is most upsetting to those who share the Romantic age belief in the intrinsic nature of the land and feel that there should be no development; the land should not be tamed. Others believe that the land has a utilitarian value that can be exploited without harming the surroundings.

The nature of aesthetic judgement is fluid, as has been shown with the attitudes surrounding the Eiffel Tower. Before its construction the plans and sketches were condemned as a 'monstrosity' and a 'gigantic black factor chimney', whereas there are presently only a small minority that maintain this belief, it is generally considered an integral part of modern Paris. (Gipe 1990) Similar sentiments have been displayed during the early stages of construction of other landmarks, including the Golden Gate Bridge (Spowers 2000) and the Pompidou Centre.

The impact of the turbines can be reduced with turbine siting and design (Stadsarkitekt kontoret i Lund 1998). This however cannot solve the problem as consensus on turbine design is difficult to achieve and many object to any interference in the natural landscape (Geuzendam 1998). Land use planning techniques can mitigate the visual disturbance by selecting sites with care so that turbines are located in more industrialized zones, whilst natural features can be used to reduce the area visually affected by the turbines (Stadsarkitektkontoret i Lund 1998). These will not solve the problem as wherever they are located they will be seen and this in itself will disturb opponents who feel that the turbines are industrialising the mainly rural surroundings (www.landskapsskydd.nu).

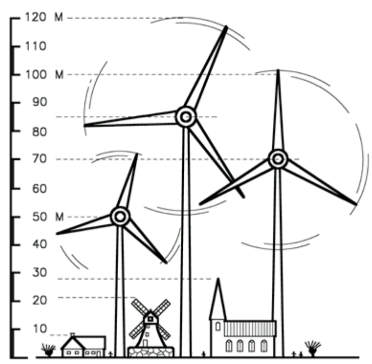

Figure 7 showing the reported relative impact to rural regions (www.landskapsskydd.nu)

Figure 7 shows the extent to which opponent feel that the turbines have a visual presence. This representation is a little unjust as the highest turbine towers in Sweden are around 65-70 metres tall and not the 85 metres shown. The height of the surrounding buildings is also deceiving as there are often taller buildings than illustrated, for example in Lund, southern Skåne, churches can be up to 72 metres tall. Whilst this is an urban church, those in the countryside are often taller than the 30 metres shown.

The aesthetic quality of a structure is an extremely powerful argument as it can neither be proved nor disproved; it is a matter of personal judgement. What is beautiful cannot be defined and thereby cannot be directly measured, only evaluated. If a turbine is considered an object of beauty it is the perception of those who view it, and they in turn can be affected by other factors surrounding the turbine itself.

Noise

"The 'thwump' of the blades and the grinding gears is driving us to distraction…the house has frequently vibrated with sickening sound waves" (CG 2000). Noise has been one of the major criticisms of the wind industry, especially with regard to the early turbines introduced in the 1980s.

Noise is generally considered to be unwanted sound, thereby, it is individual opinion whether a sound is noise, or whether it is just one of the many daily sounds. Whether the sound of turbines at work is noise is an individual perception, thus the level of noise disturbance relates to the level of visual intrusion (Wolsink et al. 1993).

It is a fact that wind turbines create sound. The sounds are mainly from two sources, aerodynamic and mechanical. Aerodynamic noise is produced from the turbine blades, especially the tips. Mechanical noise is generated from the turbine's gears and yaw mechanism; this is generally the lesser of the two. (Manwell et al 2002 and Naturvårdsverket 2001) Both of these sources have been gradually reduced over the past twenty years as turbine technology has improved. Figure 8 shows the improvements made in turbine noise emissions over recent years. The bold line records sound levels at different power outputs for turbines in 1982, whilst the lowest line represents data from 1991 with the circle showing the 1996 average for five turbine designs.

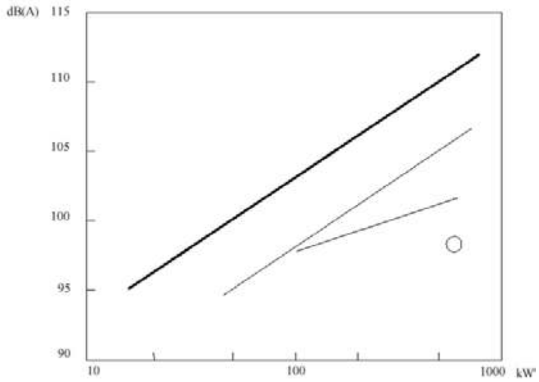

Figure 8 showing the reductions in turbine sound levels from 1982 to 1996 (Naturvårdsverket 2001)

Recent reports have shown that 2 MW turbines have a sound power level of around 102 dB(A) at its source (Manwell et al 2002), whilst smaller turbines range from 90 to 100 dB(A) (Rudolphi 2002). These are sizeable sound power levels emitted from turbines. (Sound power levels are the sound levels emitted at the source and should not be confused with sound pressure levels, which are the levels experienced by the receiver, humans in this case).

The sound power level 100 dB(A) would be an extremely loud noise to live with on a daily basis, therefore the dissipation of the turbine's noise is important to understand so that the level of the noise heard can be related to the level of the sound produced. Sound spreads in a semi-circle distribution downwind of the turbines, within the immediate proximity it decreases rapidly, thereafter it falls by 6 dB(A) when the distance away from the source is doubled (Naturvårdsverket 2001). This means that typical outdoor sound level is 40 dB(A) 500 metres downwind (Rudolphi 2002). This is equivalent to the sound level in a typical living room (Manwell et al 2002). This reduction in sound over distance is shown in figure 9 for a 2 MW turbine producing 100 dB(A) from a hub height of 80 metres into wind at 8 m/s.

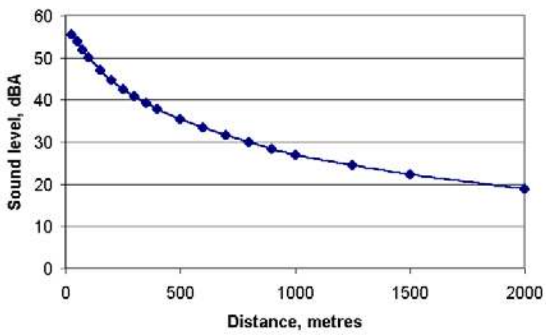

Figure 9 showing turbine sound reduction from a 2MW turbine over distance (Loman 2002)

A complex mix of factors, such as, background ambient noise, topography, weather conditions and terrain conditions, affects the true sound level at the receiver. A typical street in Sweden will be around 60 dB(A) (Hedman 2002), thereby effectively masking the turbine. Dense vegetation could also be used to mask the sound, or at least absorb much of it. Weather conditions are important, especially in the evening and during the winter. Sound waves often travel further in the early evening as the background noise subsides, traffic reduces, the wind slows and there is often less movement within the household. Coupled with this weather conditions alter the way in which sound waves travels, making them more obvious. (Naturvårdsverket 2001)

There can be no escaping the fact that turbines generate noise, yet the level of disturbance is related to public perception. Of the 3 500 turbines in Denmark at the start of the 1990s only 2% were the subject of noise complaints, although residents were often less than 225 metres from the turbines themselves (Gipe 1995). A combined study in Germany, Denmark and The Netherlands found that only 6.4% of nearby residents reported any noise annoyance, with the overwhelming majority stating that there was no noise annoyance at all. It was found that the visual impact of the turbines increases the noise annoyance, an attitude that was supported by anecdotal evidence in Gipe (1995). (Wolsink et al 1993)

Birds

"Wind power is…a hazard to birds" (USA Today 1998). There has been much outspoken criticism of the impact that wind turbine siting has on avian populations. The USA Today (1998) continues by stating that wind turbines are directly responsible for the deaths of thousands of birds, including endangered species like the golden eagle. Many of the deaths of golden eagles occur within the Altamont Pass in California where the species is "of special concern" and is protected under Federal law. This means that it is a felony to knowingly kill one of the species, a fact that has been used in the campaign against the siting of the turbines. The erection of wind turbines at Altamont Pass has had an impact on the local bird population, killing up to 1400 birds per year (Gipe 1995), of this about 30 are golden eagles, with 90% of these attributed to turbine collision (PBRG 1995).

A clear explanation of why golden eagles and other raptors are so affected has yet to be discovered by local biologists. It is currently thought that golden eagles are so affected because of their natural characteristics, the siting of turbines in a migration pass, and the abundance of birds passing through the area (Biosystems 1990 and Sinclair 2001).

Although 30 golden eagles is a significant loss to a diminishing population, the total number of birds lost at a site, even a site as extreme as Altamont Pass, should be put in perspective. Erickson et al (2001) claim that wind related avian mortality in the USA is 0.001-0.02% of the annual collision fatalities. They estimate that between 10 000 and 40 000 birds are killed as a result of turbine collisions every year, whilst up to 980 million are killed due to colliding with buildings and windows, 174 million from power line impact and 50 million from communication tower collisions. The number of collision mortalities is due to the relative size, number and length of each structure. For example, there are 80 000 communication towers and 15 000 shorter commercial wind turbines.

The problem is not only limited to North American, but has also been seen at the 270 turbine site in Tarifa, Spain, where the turbines are said to be *"…wreaking havoc with the natural order of raptor life…"* (USA Today 1998). The exact number of bird deaths was not known, but was expected to be significant as there were many carcasses discovered in the wind park. The area is an extremely high risk for birds as it is the main migration corridor between Europe and Africa, so is the first land contact after the arduous water crossing. (Luke et al 1994) Further studies have shown that although the initial death rate was high within the wind farm, it was not solely due to the turbines, but to an illegal dump that the birds were using as a food source. Once the dump was removed the problem disappeared. (Vizcaino 1997)

The situation in Europe has not been as controversial as has been seen in the USA. The general attitude is that the fears of Altamont Pass being repeated are largely unjustified. There has been much research into the true mortality rates across Europe, especially in The Netherlands, Denmark and Germany. Dannemand (1999) reports that in Denmark the approximately 4 000 turbines cause 25 000 to 30 000 avian mortalities annually, a significant number, except when compared to the one million killed by traffic and the fact that there are around 500 million staging or migrating birds. A survey conducted at the Game Biology Station at Rønde in 1983 concluded that the turbines caused little impact to bird populations, although collisions could occur under special weather conditions (Gipe 1995).

The exact reason why certain species have a larger mortality when in the proximity of turbines is unclear. Raptors and songbirds have a much higher incidence of collision than migratory wildfowl, especially swans and geese. It is thought that the latter group are able to change their course to avoid collision with structures. The reasoning behind this is as of yet not fully understood. (Grubb & Meyer 1993)

The risk of collision is not the only hazard to the avian community posed by the siting of wind turbines; loss of habitat is also threatened. Winkelman (1994) believes that this is the largest hazard posed to European bird populations by the wind power industry. Sweden's open landscape means that birds can fly around structures, but this also means that they have to avoid areas that were previously made up their habitat. For the most part this will not adversely affect Sweden's avian populations. This danger is mainly confined to the offshore siting of turbines, especially off Sweden's Eastern Shore where the few areas of shallow water are needed by the wind industry and certain avian species alike. On-shore, the siting of a few turbines will merely mean that birds use alternative sites in the region, a diversion that is of little consequence to the birds themselves. However, if larger wind farms were established this would remove a significant area of habitat and deprive a larger number of farmers' incomes from the sale of geese hunting rights on their property as the geese will relocate elsewhere. (Nilsson 2002)

Perhaps the strongest evidence that the perceived risk to birds from wind turbines is minimal comes from wildlife interest groups such as SOF (Sveriges Ornitologiska Förening), the UK RSPB (Royal Society for the Protection of Birds) and the US based Audubon Society. All three organisations support wind power if it is sited in correctly. The RSPB expresses the strongest support for wind power believing that "*…the hysterical reaction to wind power will be a thing of the past..."* (RSPB 2002). The chairman of the SOF believes that wind power will be good for the environment if it is sited correctly (Lindell 2002, own translation). Others within SOF believe that wind turbines have the potential to greatly endanger Sweden's bird life if turbines are placed in migration corridors or near other sensitive areas (Sundberg 2001). It is true that wind turbines, if incorrectly positioned could pose a hazard to avian habitats and increase the incidence of collision mortality. However, this danger is minimal for onshore turbines within Sweden as there are abundant alternative habitat areas and there are enough open spaces to allow the birds to fly around such obstacles. This lack of perceived risk is evident in the fact that only one of Sweden's 63 important bird areas remarks on the possible hazard of wind turbine siting (Lindell et al 2000).

Electromagnetic Interference

Wind turbines do interfere and distort telecommunications across Sweden. Electromagnetic Interference (EMI) is especially pronounced with regard to television signals. The situation occurs when the electromagnetic signal interacts with two turbines. The first turbine is sited along the path of the signal, thereby distorting it. This is common with large buildings and structures. EMI occurs at the receiver, generally the household television, when it receives multiple signals simultaneously. The second signal is reflected off the blades of another turbine, thus creating a reflected signal. EMI occurs when these two signal meet. This is noticeable in the picture quality of the television, the picture is jittery and appears to jump at the same tempo as the turbine's blades rotate. (Manwell et al 2002)

The design and composition of the turbine, especially the blades can greatly reduce the level of EMI as composite materials greatly reduce the effects, whilst metallic lightening measures negate these improvements somewhat. Overall turbine design can also diminish the level of EMI experienced. (Manwell et al 2002)

The true effect of EMI is still debated. The British Broadcasting Corporation (BBC) investigated the level of disturbance and concluded that there was no significant problem (Dannemand 1999). This sentiment is echoed by Grubb & Meyer (1993) who explain that the effect is very localised and can be overcome with local amplifiers, some cable connections and the use of digital receivers. Whilst this is true there is still concern within Sweden as the national telecommunications company, Teracom, urge caution and further research in this field (Persson 1999).

Land Utilisation

The true extent of the land utilised for the generation of electricity from wind energy has been debated. The Economist (1994) estimated that over 4 000km^2 would be needed to provide 10% Britain's energy demand by wind power. It is true that wind power is a diffuse form of energy when compared to conventional electricity production, such as fossil fuels and nuclear. This means that more land area is needed to generate the same amount of energy. To install 6 GW around 3 600 km^2 of wind farm installations would be needed. This would equate to around 1.4% of the UK's total land area. (Elliott 1997)

This is not the whole story however. Although the total area covered by the arrays would be 3 600 km^2, the area taken up by the turbines would be just 36 km^2, as 99% of the land under the arrays can be for used for other purposes, agriculture namely (Elliott 1997 and Webb 1994 among others). Farmers are generally supportive of wind power as it means that they can earn another income for their land without sacrificing much of its agricultural productivity. Bager (2002) explains that in Sweden farmers support the development of wind power, as it is a clean alternative energy source that nets revenue. As long as the turbines are not densely packed and located in either non-arable land or along the land's boundaries they do not interfere with farming. There is, in fact, a mutual benefit for farmers and wind power proponents, as they both desire the same landscape, open flat land. If the land becomes developed and building occurs then the wind potential is diminished and there is less land available for the agricultural community.

It is not only the turbines that occupy the land, but also the access roads and grid connections. If these are placed using existing farm access and public footpaths then this additional land use can be minimised (Gipe 1995).

Validity of claims

There is some validity in the opposition claims presented here. There can be no doubt that the addition of turbines does have a visual impact on the landscape, whether this is taken as a positive or negative development is a matter of personal opinion. Noise is a nuisance to those living closest to the turbines, but as explained by Wolsink et al. (1993) this disturbance is heightened by the annoyance produced as a result of the perceived negative visual impact. Within Sweden avian life is not as adversely affected, as is the case in other regions, although care has to be taken to ensure that sufficient space is reserved for the bird populations. EMI requires further attention to ensure that the addition of further turbines does not greatly increase this phenomenon. It must be remembered that the claims represented in the literature are not the only criticisms of wind turbines, new issues such as infra sound and shadowing from the moving turbines in certain circumstances, are starting to appear, especially within Sweden (Boverket 2001, 2003, Fyhr 2002, Stadsarkitektkontoret i Lund 1998, SOU 1999:75 and Wiklund 2001), although the impact of infra sound has been shown to be negligible to date (Fégeant 2002 and Länsstyrelsen 2002).

8 The Argument supporting wind power development

It has been shown that there is some justification for those opposing the wind power industry. There are, in addition, arguments supporting this exploitation of renewable energy, which focus on the environmental benefits of wind power and their place in sustainable energy strategies, such as UNDP and the EU's 1997 White Paper. A summary of the most common advantages can be seen in Figure 10 below.

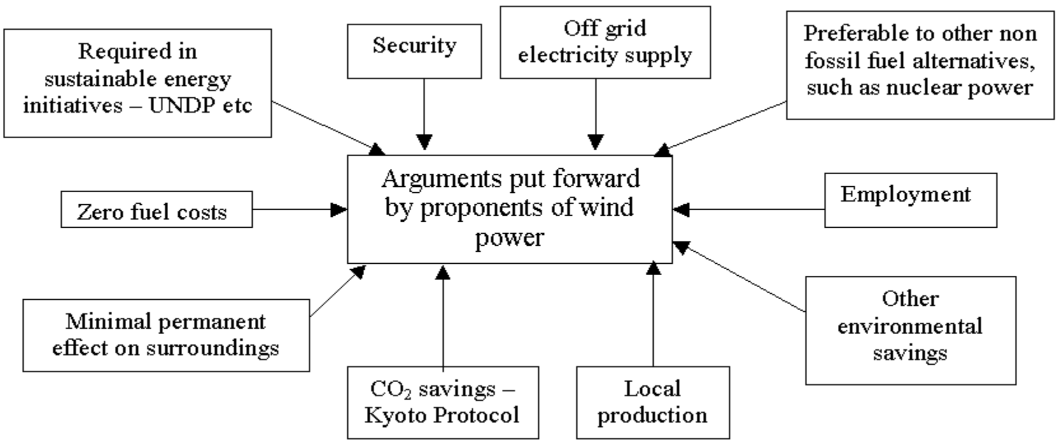

Figure 10 showing the most common arguments supporting the development of wind power

One of the main reasons that the contemporary wind power industry has developed has been as a response to the 1970s oil crisis where alternative energy sources were investigated for commercial viability. Electricity generated from wind turbines was seen as a way to maintain electricity supplies without overly depending on non-domestic supplies of fossil fuels, especially oil. It was also a way to diversify the fuel base of a nation so that there could be a wider selection of fuel sources, and therefore, more security as alternatives were in place if one source should be withdrawn.

Environmental savings

The interest in alternative energy sources has continued over the decades as environmental issues, such as climate change have become more prominent. Wind power generation does not create the same environmental by-products as more conventional energy sources do, such as pollution and hazardous waste in the case of nuclear energy generation. The burning of fossil fuels creates a host of atmospheric pollutants, with the most notable being carbon dioxide (CO_2), sulphur dioxide (SO_2) and nitrogen oxides (NO_x). CO_2 has been linked to global warming; acid rain is caused by SO_2 along with nitrogen oxides that also cause atmospheric smog. Atmospheric emissions have become a political issue, especially since the introduction of the Kyoto Protocol where the EU committed to reduce CO_2 emissions by 8% with respect to the 1990 level (Energimyndigheten 2001b).

Wind power generation produces almost no pollution, either atmospheric or water-borne. This means that emissions can be reduced and savings can be made if electricity produced from wind turbines replaces electricity produced from other sources, fossil fuels for instance. Surugiu & Paraschivoiu (2000) show that significant emission savings could be made in this fashion. For every kilowatt-hour produced 0.96 kg of CO_2 would be saved if coal were phased out, 0.61 kg if natural gas were replaced and 0.89 kg if oil were substituted. There would also be reduction in the amounts of sulphur dioxide and nitrogen oxides released (see table 6, appendix 2). Although these values may seem small, they do become significant on the national scale. If the UK met 10% of its electrical needs with wind power 30 million tonnes of carbon dioxide would be saved (Webb 1994). The savings are even starker when examined on the regional scale, the EU for example. It has been estimated that a 600 MW wind turbine in average wind conditions could prevent the release of 20 000 to 36 000 tons of CO_2 over 20 years compared to conventional sources (Hatziargyriou & Zervos 2001). This long term saving could have a real impact on emission levels across the EU within the coming years.

It is not only environmental costs that would be saved with the carbon dioxide reductions, these savings also can be attributed an economic value. When calculating the avoided costs of this CO_2 reduction Munksgaard & Larsen (1998) estimated that it would be up to 0.044USD per kWh if coal were replaced, and less for other forms of fossil fuels. Furthermore, a recent Swedish study has shown that replacing electricity production of 390 GWh/yr from a coal power station with wind-generated electricity would save 415 million SEK per year due to NO_x, S, CO_2 and particulate reduction (Thorselius 2002). Therefore, wind power can affect a region's atmospheric emissions and make other savings when considering marginal abatement costs.

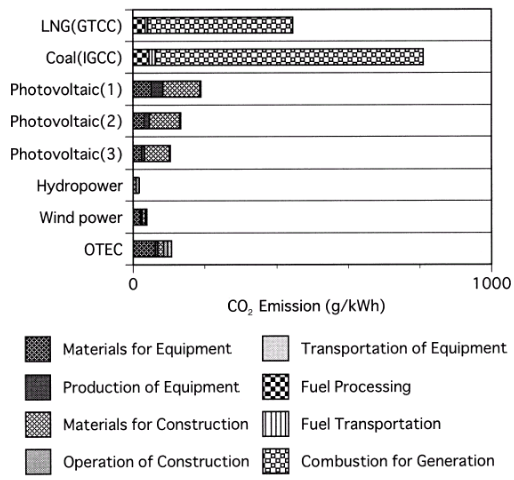

Figure 11 showing the relative levels of CO_2 emissions of a wind turbine compared to other methods of electricity production throughout their lifetimes (Namura et al. 2001)

Although no pollution is created during electricity generation, there has been criticism over the materials used within the construction of the turbines themselves, but as Jacob (2001) notes, this impact is constantly being reduced. Figure 11 shows the relative level of CO_2 emissions of a wind turbine throughout its manufacture, construction and generation. It is clearly noted that wind power has the lowest emissions, second only to another source of renewable energy, namely hydropower. Similar trends can be seen for sulphur dioxide and nitrogen oxides (Namura et al. 2001).

The environmental impact of turbine erection can be kept minimal by using existing access routes and land boundaries and the land can be restored to its former purpose after the turbines' useful lifetime has expired (Bager 2002, Gipe 1995 and Hellström 2002).

Perhaps the best environmental aspect of wind power generation is that it is a renewable resource. Its fuel, wind, is naturally recurring, free and abundantly available in many parts of the world. If wind were used to the extent that is planned in the EU and the UNDP's sustainable energy strategy there would still be a wind resource available for future generations.

Economic and employment benefits
Wind power has economic as well as environmental benefits. The industry generates revenue, especially in rural regions where there are limiting earning possibilities. There are a number of ways in which this income is generated; most widespread are employment and land revenues. Homsey (2001) reports that each turbine tower annually yields between USD2000 and 3000 in lease fees and electricity sales royalties, most of this benefits the farmers directly on whose land the turbines stand.

In Europe over 110 000 jobs are related to the development of renewable energy, with the wind industry representing 20% of this work force (EWEA b). The British Wind Industry alone employs about 1300 directly with 1000 more indirectly (Brunt & Spooner 1998). Many of these jobs are located in rural areas where there is the best wind potential; therefore, this employment is located in the areas of great need. It can be argued that wind is not the only energy source that creates employment, but as Surugiu & Paraschivoiu (2000) state in New York State per watt wind produces 66% more jobs that natural gas and 27% more than coal-fired electricity generation. This reinforces the view of Munksgaard & Larsen (1997) who show that a wind power scenario accounts for significantly more employment than a coal powered energy scenario in Denmark, 1 700 jobs per year compared to 1 200. However, it should be noted that neither of these regions have an active coal mining industry so the effects on local employment levels are dependent on the local economic structure.

Wind power generation has many advantages. It has become a crucial element in many sustainable energy strategies as it is non polluting and freely available. When compared to conventional energy sources, fossil fuels and nuclear, the environmental advantages are stark. The wind industry acts on a regional scale, by providing electricity to remote areas, creating new economic opportunities and offering a greater choice in electricity generation. Whilst wind power will not replace the gains made with increased energy efficiency, it is an alternative to meet the ever-increasing electricity needs throughout the world, and within Sweden.

9 Social Processes

Widespread support for wind has not been sufficient for smooth, conflict free development. It has been shown that whilst there is indeed justification for some of the claims offered by opponents, such as visual impact, a degree of noise disturbance and the possibility of EMI, this does not fully explain the magnitude of conflict caused by the proposed erection of wind turbines.

NIMBY is alive and well

NIMBY syndrome (Not In My Back Yard) has been used extensively to describe opposition; it has even prompted legal measures to reduce its impact (Wolsink 1994). The term NIMBY refers to a widespread supportive attitude to wind power, but a reluctance to accept specific local proposals that adversely affect the individual. In light of the high level of support across Europe and the fact that a significant portion of wind power proposals are rejected, leads many to believe that the NIMBY syndrome is prevalent. Many examples can be used to support this supposition. In July 2002 a proposal to establish two wind farms in rural Ireland were rejected, as local opposition for one of the plans was strong due to the visual impact of the windfarms on the landscape (Deegan 2002). Krohn & Damborg (1999) note a fall in public acceptance for local proposals even when there is widespread acceptance; much of this is due to the aesthetic nature of the turbines, as demonstrated by Spowers (2000). Perhaps one of the most relevant examples when examining Sweden is the previously mentioned local election in Skurup. Even though Sweden has 74% public acceptance level there are residents who are opposed to specific wind power projects. Relevant data shows the spatial distribution of voting preferences with a decline in support for the plan nearer the coast, the area that will be more visually affected by the wind farm. Those from the further in-land voting districts were much more likely to support the plans as a distance of 10 kms lies between them and turbines, thus the visual impact is not as intense as for those living nearer the coast. Figure 12 shows that the opposition is higher, up to 73.9% in areas ranked closer to the coast whilst those further inland tend to have a lower level of opposition, as low as 38.6% were against the proposal. (Highest ranks lie closer to the coast; data and methodology are in appendix 5).

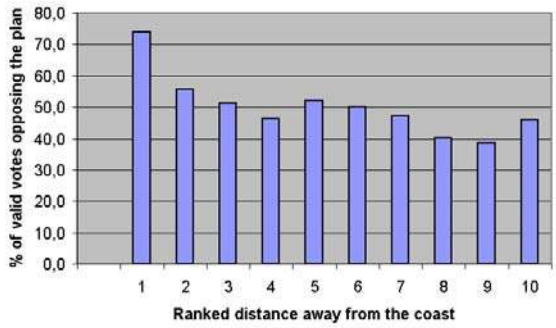

Figure 12 showing the distribution of opposing votes with ranked distance from the coast (Appendix 5)

What exactly is meant by 'NIMBY'?

Before opposition can be solely attributed to NIMBY, measures must be taken to ensure that the understanding of the term is consistent among those using it. As an idea NIMBY is widespread, which means that it is open to many interpretations. Simply stated NIMBY is considered to be when individual self-interests are greater than the individual perception of common good. This means that the individual will make selfish decisions that will benefit themselves more than society as a whole. This negative connotation has resulted in the attitude being called a 'syndrome', thereby, likening it to a disease or a negative condition. (Wolsink 1994)

NIMBY actually represents a specific social dilemma, psychologist's social dilemma theory (Wolsink 1994), which tries to explain why some public goods are not produced within a society, even when society as a whole deems it optimal. Individual decisions', weighing the personal costs and benefits, prevents the public goods for being produced. (Wolsink 2000) For wind this means that there will be support for the erection of wind turbines elsewhere, as wind power is deemed a common good, but they are not welcome in the individual's vicinity. Thereby, reinforcing the notion that NIMBY attitudes are a selfish way in which to protect perceived personal benefits.

Freudenburg & Pastor (1992) argue that the perception that opponents are reluctant to accept new developments out of self-interest is incorrect. They go on to argue that opponents devote a lot of time to campaigning against the facility siting, at a personal loss to themselves and their families. Whilst preventing the development might benefit them financially, preservation of property price for example, siting would also have financially benefited the developers had their succeeded in erecting the wind turbine. Lack of information cannot be the cause of NIMBY as opponents often go to great lengths to understand the implications of the development, whilst supporters can be satisfied to accept the information and assurances given by developers.

Research has shown that NIMBY is not always evident. Wolsink (2000) cites research in The Netherlands where less than a quarter of a community facing a proposed wind power project exhibited NIMBY tendencies, whilst over a half were willing to accept the local disadvantages as they felt that the project had common good. This result mirrors earlier Dutch surveys that show that 66% of residents in Friesland were willing to accept more turbines in their own communities, than were willing to accept the erection of turbines elsewhere in the region, therefore, showing unwillingness to move the plans to someone else's 'back yard' (Krohn & Damborg 1999). Investigations within Sweden *"...stand in some opposition to the existence of a NIMBY-syndrome"* (Hammarlund 1996). Denmark has seen the introduction of 6 000 turbines over the recent decades with generally good acceptance by local communities. Freudenburg & Pastor (1992) record that local acceptance of a proposed nuclear waste facilities was higher in proximity of the proposed location, Nevada, than nation-wide, although the nation as a whole was not as affected as Nevada itself. This higher acceptance could be due to the number of jobs created by the plan, but does reflect a level of non-NIMBY attitude shown by citizens who would not directly benefit.

If not NIMBY, what then?

There will always be a degree of NIMBY-ism regarding the siting of wind turbines, but this cannot be considered the sole explanation of the level of local opposition to proposals. There has to be other social factors operating within these communities. It is known that the projects have a common good, as has been shown earlier, it is also known that there is wide-spread support for the development of wind power in general, yet there is significant local opposition. Therefore, it can be argued that there is generally resistance to a specific plan, not to the industry in general or a desire to simply relocate the proposal.

The reasons lie in the distinct spatial distance between the costs and benefits of wind power. The benefits of a wind farm are felt by the masses in improved environmental quality, diversity of energy resources and compliance of international agreement such as the Kyoto Protocol, whilst the costs, social, economic and environmental, are borne locally (Bosley & Bosley 1988, Gipe 1995, Hammarlund 1997b and Walker 1997). In addition to this spatial aspect there are also differing opinions within a community, those who are dependant on the land for survival and those who view their home as a retreat from the world. The manner in which the proposal is discussed by the utilities, media and the local authorities can have a great impact on the success of a scheme, as can the level of community participation within the planning process (Hammarlund 1997a and Wolsink 1996).

Perceived need

If there is a perceived need for wind power then there will be a greater acceptance in a community to bear the visual and audible impact of the project, thereby reducing the level of opposition. This was shown in Denmark where there has been a severe need for wind generated electricity as the country has very few natural energy resources and decided not to use nuclear power in 1985 (Brunt & Spooner 1998 and Carlman 1988). This meant that locals believed there was a need for the introduction of turbines, as it would benefit them. They were serving the 'vital needs of society' and were compensated for this, often financially as part of co-operative ownership, through the provision of electricity or by discounted electricity production (Brunt & Spooner 1998 and Morthorst 1999). The compensation was effective, but also necessary was the perceived need for wind power, there was an obvious benefit derived from the blossoming wind power industry. By accepting the turbines the nation's installed capacity was expanded as more proposals were realised, refer to figure 13.

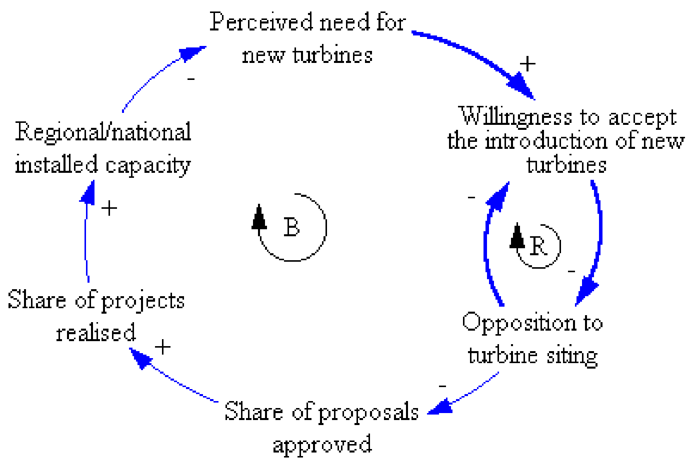

Figure 13 illustrating the key role of widespread perceived need for new wind turbines

This perceived need has not been evident in Sweden, a country rich in HEP and an established nuclear power industry. In 1998 Sweden produced almost 75 TWh from nuclear and the same amount from HEP, thus accounting for around 95% of Sweden's total electricity production (SNEA 1999). The distribution of HEP's potential and wind's potential varies greatly across Sweden as much of the HEP potential is located in the sparsely populated northern areas of Sweden whilst the greatest wind potential is in the populated southern sections of Sweden, as shown earlier in figure 1. This perceived lack of need for wind power and the lack of investment into efficient technology (Carlman 1988) can partly explain why there is greater opposition to wind power in Sweden, which currently possess fewer than 600 turbines, than there has been in Denmark which boasts 6 000 turbines (Hammarlund 2002). This reduced acceptance has meant that there is a low approval rate for plans, which means that there is a slower growth in the regional capacity. The social situation is not as simple as being centred on the apparent need for wind, but it is one of the many factors involved.

Figure 13 shows the key role that the public's perceived need plays in the acceptance of new turbines. If the need is apparent, as was the case in Denmark 10 years ago, then there is a greater willingness to accept the turbines and less opposition will be evident. If this is reduced then more projects can be realised and the installed capacity will increase. The level of opposition affects the acceptance of turbines, as less opposition will result in a higher level of willingness.

If there is an obvious need for a development there will generally be less opposition towards it, as shown in figure 13. An example of this can be seen in the level of opposition towards the

Öresunds bridge construction. When first proposed opposition was extremely high, but as individuals began to realise the usefulness of the bridge the level of support rose. Before there had not been a perceived widespread need for the bridge, but this changed and with it a greater support was derived (Loman 2002).

The balance of cost and benefits

Just as in Denmark the need for a project is closely linked with the benefits derived from the proposal. If the plan will benefit the individual, financially, socially or culturally, then the individual is more likely to be in favour. This self-preservation is shown at every election where individuals have the right to choose who will lead them in their own best interest and in the way that they believe is best for the region or nation. This same awareness of own interests affects our perceptions and acceptance of turbines. Those who benefit directly are more open to the idea of new turbines, as shown in figure 14 with the reinforcing relationship between willingness to accept turbines and local financial gain. The erection of turbines can support those who own the land, often farmers as they own flat open stretches of land as shown by Bager (2002) and Homsey (2001). This level of additional income has started to create another phenomena, the PIMBY attitude (Please In My Back Yard), where landowners are offering their land to utilities for the siting of turbines as a means of earning money (van der Loo 2001). The growth of this phenomenon is due to two societal factors, the level of compensation and the view of nature.

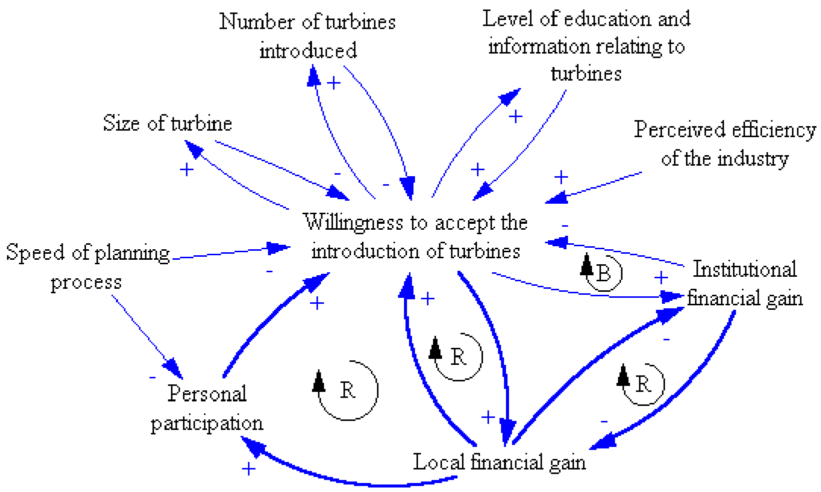

Figure 14 showing the relative importance of local financial gain and personal participation in the acceptance of new turbines

In Sweden the majority of wind turbines have been owned by the utilities and electricity providers (Elforsk 2001), this means that the economic benefits are distributed among shareholders, employees and company directors (institutional financial gain), they do not flow to those affected by the siting of the turbines, with the exception of those receiving rent for land usage. The wind power industry does create employment and a flow of wealth, as has been stated previously, but little of this revenue will reach the affected Swedish communities. In other European nations this is not the case as turbines are either privately owned or co-operatively owned so there is a greater distribution of income. In Denmark there has been a tradition of private and co-operative ownership since the introduction of commercial wind power generation, by the end of the 1990s the vast majority, around 80%, of wind-generated electricity was produced from single owner turbines, with co-operatives and power companies producing the remainder. The majority of these single owners were farmers who could sell excess electricity to the grid or local consumers. Co-operatives are bestowed special tax regulations that can encourage more residents to invest. (Morthorst 1999) Gipe (1995) describes the mutually beneficial relationship between the financial sector and turbine owning co-operatives. The members of the co-operative generally see a return on their investment, as do the lending institutions. In the Netherlands local communities and individuals also benefit from the establishment of wind turbines, as the turbines are liable to property tax that is paid directly to the local government. This means that if a cluster of turbines is sited within the community they will be taxed and the money earned can be used as desired within that community (van der Loo 2002).

This lack of individual compensation can be summed up by Haettner (2002) a locally affected resident of the proposed Lillgrund offshore wind farm, when explaining that the motives behind opposition were predominantly linked to the visual impact. Possible effects on house prices and the loss of the view from individual property were perceived to be significant, thus showing how the visual impact can be directly linked to the individual costs incurred. This mentality is also shown by Bergström (2002) as an example of how attitudes can change due to the offer of shared benefits. When proposing a development in Sjöbo, southern Sweden, a particular local resident was strongly opposed to the plan, but when profit sharing was introduced he became very enthusiastic. This flow of benefits is neatly summed up in Brunt & Spooner (1998) in the view that local *"...communities should see tangible benefits*" as they are the one with the highest costs.

Local financial gain is critical in the acceptance of new turbines, as shown in figure 14. If more people benefit directly from the turbines, then there will be less opposition (refer to figure 13). Local financial gain, in the form of shares, reduced bills or local taxation, affects local participation inherently as those who have a financial stake are involved in the process. Other factors, such as the level of information regarding the proposal and the details of the proposal itself affect acceptance as the efficiency, size and number of turbines determine the local impact, thereby determining the local impact of the plan. Institutional financial gain is used to describe the profit produced by energy utilities and producers.

Public participation

Financial benefit to affected communities can be seen as bribery if the suggestion of it is not handled in the correct way (Hammarlund 1999). After entrenchment between opponents and prospers has occurred the suggestion that the community would benefit financially can be seen as bribery. This can be avoided if there is meaningful dialogue between all parties at an early stage in the planning permission. By discussing the proposal with the residents and other interested parties, such as environmental groups, there can be a greater level of public participation that can lead to a greater support for the plan, as shown in figure 14. Early participation can help prevent nasty 'surprises' later in the planning process as opinions can be aired before a lot of time and expense has been put into the proposal. By having public participation in the project throughout its planning stages compromises can be sought and entrenchment can be avoided, it can also give the community a sense of ownership of the proposed installation (Hammarlund 1997a, 1997b, 1999, 2002). This participation would also allow the community time to adjust to the idea of an altered landscape. Unlike other facilities wind turbines can be erected within an extremely short time and drastically alter the aesthetic nature of their environs. Although renditions and photographic simulations are often produced, they do not soften the initial impact and often heighten opposition as the negative visual impact is highlighted, whilst the benefits derived are not apparent (Hammarlund 1997). Therefore, the early participation of those involved can lead to a reduction of resentment as individual opinions are incorporated into the project and there can be a greater sense of openness and transparency within the planning process.

Conflicting views of nature

This openness would also aid in the resolution of differences within the community itself. As has been mentioned earlier in this paper personal views of nature are not the same throughout society, the same is said for our perception of beauty. Within Sweden there are many cohorts that reside in the countryside, the area usually selected for the siting of turbines, this is especially true in the region of Skåne, southern Sweden, which possesses much of the nation's wind potential. The time spent within the region and the nature of employment can affect what is considered 'acceptable' within the region, thereby affecting the level of opposition to what is considered 'unacceptable'. As has been shown those who work on the land, farmers, are more willing to accept the introduction of turbines as they earn their livelihood from their land are accustomed to the seasonal changes within the landscape, also illustrated in figure 15. On the other end of the scale urban residents who own summer property are less willing to accept turbine introduction. Lee et al (1989) note that permanent rural residents were more accepting of the turbine siting than predominately urban dwellers. Temporary occupancy of rural property can lead to a more untamed, less utilised image of the countryside, which does not allow the intrusion of wind turbines. Permanent residents, especially those whose livelihoods come directly from the natural resources, express a more practical and utilitarian view of rural regions (Hammarlund 2002 and Homsey 2001).

Figure 15 shows that this view of nature affects the aesthetic valuation of the landscape; this term is used to describe the value that is put on the untouched 'natural' aspect of the scenery. It is assumed that permanent residents, such as farmers, will be more willing to sacrifice the untouched quality of the environs in order to financially benefit in the form of land rent or employment. There are likely to be less temporary residents, summer guests, in a more industrialised landscape where there is more willingness to accept alterations in the landscape. This is based on the idea that summer guests use the area as a 'retreat' from more urbanised locals (Hammarlund 2002). Figure 15 assumes that there is a reasonably constant population as a more industrialised region will deter temporary residents and attract permanent residents who have the opportunity to secure employment and possess a more utilitarian view of nature.

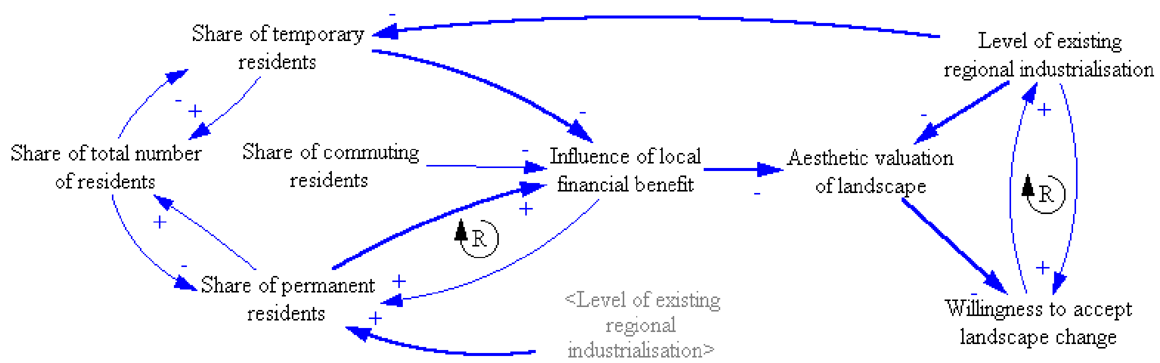

Figure 15 showing the effects of the different views of nature

It is not only the share of permanent or temporary residents that affects the community's willingness to accept change, but also the power each section of the community holds. If the temporary residents are dominant, or the most powerful cohorts are not financially dependant on the region, then there will be stronger resistance to proposals as the influence of local financial benefit is weakened, as represented in figure 15. Examples of this can be seen in Skurup where prominent political temporary residents participated in an effective campaign to prevent the proposal and in Cape Cod, an area renowned for housing a number of wealthy summer residents, where plans were opposed as it would interfere with their summer residents (O'Bryant 2002).

Overview of the social processes occurring in locally affected communities

The main aspects determining social acceptance of wind turbines are the level of financial gain, the level of participation, perceived need and to a lesser extent, the view of nature. All four factors impact the willingness to accept the introduction of turbines into the landscape, which in turn determines the level of opposition to proposed turbine siting. As has been stated earlier, more opposition will lead to a stagnant capacity, i.e. fewer turbines will be installed. Opposition is affected by willingness to accept the introduction of turbines, which is affected by the proposal itself, as fewer turbines are more acceptable than a large wind farm (Bager 2002 and Haettner 2002) with a growing preference for larger, slower machines (Boverket 2003 and SOU 1999:75). The amount of information presented about the plan is important as a lack of information can lead to suspicion about the plan (O'Bryant 2002) whilst providing interested parties with sufficient details can aid in gaining support (Hammarlund 2002 and Krohn & Damborg 1999 among others).

The main four factors are all linked to the willingness to accept turbines into the landscape. Perceived need increases willingness, which in turn dampens opposition and allows for a fuller development of the wind power industry. However, as the installed capacity increases the perceived need falls, as has been seen in Denmark in recent years. Personal participation is increased as a result of more local financial gain and improves local support for the plan, as does the improved level of local financial gain. A more permanent local population base adds importance to the aspect of local financial benefit, which means a higher acceptance for change in the landscape and therefore greater support for the plan. An overview of these processes can be seen in figure 16.

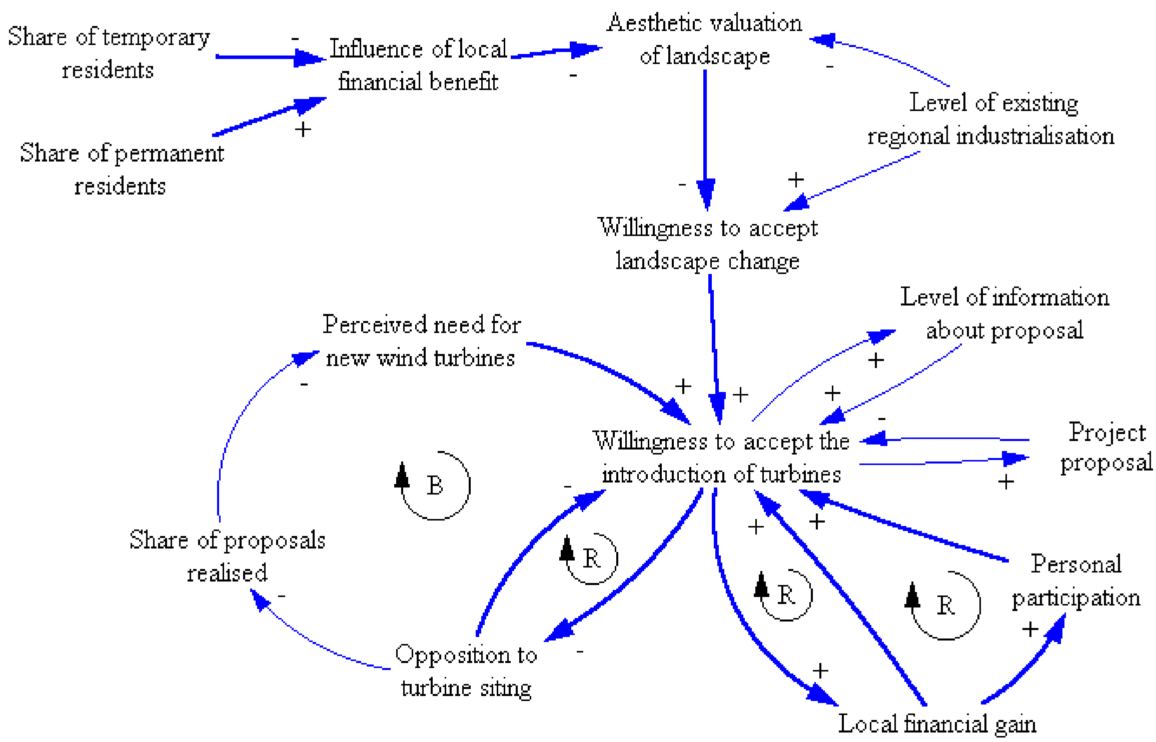

Figure 16 showing the overview of factors affecting the willingness to accept the introduction of turbines into the landscape

10 Wind Power planning

Sweden uses a top down approach to planning wind power strategies and physical land use plans. Recent government plans have proposed a firm target for the increased utilisation of renewable energy sources and a goal for the development of wind power capacity. These targets were suggested by governmental agencies, such as the Swedish Energy Agency (energimyndigheten). These aims are then passed down to regional and local authorities, 'länsstyrelsen' and 'kommun' respectively. In Sweden the local authorities are responsible for the physical land use planning and selecting specific sites for the turbines, which are then subjected to local political rule. Local authorities have a degree of independence from the government and are not required to act in strict accordance with the government's wishes. (Hellström 2002) The regional authorities are controlled by the government and are the main instrument of achieving the set targets (SOU 2000/01:130).

The size of a wind power proposal determines the level at which permission must be obtained; all plans below 1 MW are the local authority's responsibility, whilst those between 1 MW and 10 MW are approved by the regional authorities and larger wind farms are approved by the Environmental Court (Boverket 2001 and SOU 1999:75).

Environmental Targets

Whilst there is no specific regional or national wind energy plan, there are 15 environmental targets, 'miljömål', of which wind power can be related to 12 (SOU 1999:75). Specific environmental targets are designed to promote the use of renewable energy sources. Achieving these objectives is the responsibility of the regional authorities. The targets should be used as a starting point for the local authority's work after dialogue with stakeholders and regional agencies. (SOU 2000/01:130) Local authorities are required to create a master plan based on the locality's physical aspect and characteristics. It is in this plan that the suitability for wind turbine siting is discussed and the aspects of the siting are first disclosed, such as number of turbines, proximity to housing and design of the turbines themselves. Whilst this plan should reflect national, international and regional concerns, local authorities are under no compulsion to do so (Boverket 2003).

Planning timescale

As the physical plans and the approval of certain turbines are under the local authorities control the timing of the planning process cannot be governed by national policy. This cannot be said for turbines between 1 MW and 10 MW, which are regulated by regional agencies (Boverket 2001). Proposals are promoting faster decision-making processes that can increase the rate of development and therefore allowing the 10 TWh goal to be achieved (SOU 1999:75). Thus bringing government proposals into conflict with reports arguing that a longer time frame would allow more social acceptance, furthermore improving the reputation of the wind power industry (Hammarlund 1999).

The speed and location of the planning process affects the amount of public participation that takes place. When decisions are made at the regional level there is very little contact with local residents, as complaints are filed at the local level, not directly with those who are making the decision. The Environmental Court can always be used to hear appeals and objections for certain plans, but is not easily accessible at the early stages of the planning process.

Role of early participation
Studies in Härjedalen, Sweden, have shown that early participation in this process is effective in realising plans and allowing concerns to be addressed (Boverket 2003). A recent study by Skåne länsstyrelsen (2002) has shown the need for cooperation in the planning stage. Physical plans can impose a minimum distance between dwellings and turbines, the larger this distance; the fewer turbines can be introduced into the locality. When looking at Skåne, southern Sweden, as a whole, the recommended regional target of 2 TWh can only be reached, from both onshore and offshore sites, when the minimum distance between turbines and homes is 400 metres. This distance will only be achieved if there is acceptance of the turbines by those most locally affected. This participation will also allow all parties to understand what is desirable in a wind power project, as studies have shown that there is often a large disparity between what the government and local officials perceive as the most serious and what is prioritised by local action groups and residents (Bosel & Bosel 1988, Carlman 1984 and EWEA 2002).

11 Implication of findings

Although there is widespread support for the development of wind power in general, the level of opposition is affected by visual impact, disparity between local costs and benefits and the lack of public participation. Whilst there is some noise and environmental costs attributed to the installation and operation of turbines, these are overshadowed and exacerbated by their visual impact. This does not mean that the others should be discounted, as more research is needed in order to fully understand all the implications on birds, other wildlife and land use. As the wind power industry matures, more issues and aspects will be incorporated within the discussion, like the issue of shadow effect, which is growing in importance in Europe, especially Scandinavia (Fyhr 2002, Boverket 2001 and 2002).

Participation in the planning process
It is not only the physical siting of the turbines that requires attention, but the introduction of the turbines into the locality. Turbines make a large visual impact that can change the character of the landscape in a short time; therefore, they must be introduced with care. The current top down physical planning has been determined by the opinions of qualified professionals, thus leaving little scope for those who will be directly affected to participate meaningfully in the siting process. A more bottom up approach has been used in Spain with effective results (EWEA 2001) as there is more allowance for local sentiments to be expressed and the views of those most affected can be incorporated into the plan. This bottom up planning would allow the local topography and landscape to be taken into account when the detailed siting and turbine design is undertaken. Local preferences for turbine colour, number of blades, size, and total number of turbines introduced could be taken into account. As these preferences are known to vary within the general population early participation would allow the local consensus to affect these characteristics. The design of the production site includes the surrounding paraphernalia needed to connect the turbine to the electricity grid and general maintenance. By having an input in the overall production site design those who are bearing the local costs can have meaningful participation and a sense of control of their local environs.

Participation is required, as land use planning does not happen in isolation, it is ultimately subjected to political will, which in turn is dependant on public support. Land use plans are made by local authorities, but as the elected representatives have the ultimate decision on whether these plans will be accepted or not, these plans must respond to the public sentiment which affects local politics. Therefore, politicians who are responsive to local concerns regarding the development of the wind industry are likely to have reservations about approving a land use strategy that is based solely on the physical aspect of planning. This means that there could be a growing political awareness of the need to include more into the planning and decision process.

Profit sharing and co-ownership

Meaningful cooperation is not only limited to dialogue, but also includes the financial aspect of the development. Being a stakeholder or part owner in a turbine means that a greater number of households benefit from the development, as well as bearing the bulk of the costs. If financial benefit is derived from a turbine operating in the vicinity then there is likely to be greater acceptance of the noise and visual costs incurred. By encouraging locals to participate financially there is a reduction in the spatial disparity of costs and benefits as locals are profiting, as well as bearing the greatest costs. Locals do benefit from improved air quality and a more secure energy base, but the immediate negative impacts more than outweigh these advantages if there is no additional financial benefit.

If there is an increased level of local financial gain then there will be less institutional financial gain, i.e. the utilities and commercial producers will retain a smaller share of the profits. As more locals benefit from the introduction of turbines, there will be a greater willingness to accept the turbines, which in turn can lead to even more financial gain as more turbines could be introduced. This increased local flow of benefit decreases the flow of profit to the utilities and commercial producers, as their share of the gain will lessen. However, as these institutions gain less per turbine the social acceptance of their production, wind turbines, will improve as more can share in their good fortune, thus allowing them to develop more sites as they have an increased level of support. Long-term survival of the wind power industry in Sweden needs a sharing of the benefits that allows the local community to see the tangible benefits in the form of profit sharing.

The Industry's view

The European wind power industry itself has recently been discussing the benefits of wider participation and the sharing of benefits, citing experience from proposed offshore developments in Denmark and studies conducted by van Erp et al (1996) and Gershensen (1997) as proof that the strategy worked. When asked why the industry had not acted on these well-known suggestions the response was that there was reluctance to act in a way that would diminish corporate profits. Community education and participation require capital investments, whilst profit sharing erases corporate income. Therefore, the industry seems willing to ignore measures that are essential to their livelihood and must be incorporated before BANANA (Build Almost Nothing Anywhere Near Anyone) (Childs 1996) is seen.

Role of the government

It is not only the local authorities and the wind power industry that needs to adapt to social attitudes, the government also needs to respond to public sentiment as they too are elected representatives. A formal structure for the early participation could be initiated that will ensure that residents have access to decision-making bodies and the wind power industry has support and guidance to achieve meaningful contributions. Recent reports by governmental agencies, Boverket (2003) for example, have started the discussion of dialogue in the planning process, which is a move in the right direction. However, this move needs to be augmented by national policy that requires early consultation as part of the planning procedure. This notification could take place at the same time that regional authorities are notified in medium sized proposals. Studies have shown that early meaningful participation is effective in the development of wind power and in order to reach the declared governmental targets an established procedure of notification should be implemented.

It is not only a scheme of participation that should be implemented, but also firm national targets for the expansion of installed capacity. The most recent energy policy proposed clear targets for the use of renewable energy and an aim, but no firm target, for the expansion of wind power. In order to strengthen the national drive for the use of renewable energy, firm targets ought to be adopted with a regional breakdown. This regional allocation could take the same form as the existing environmental targets, 'miljömål', as these are also the region's responsibility for the national policy. This break down has occurred to some extent with the general aim for wind power, but in order to definitively establish policy regarding the continued development of wind power, firmer governmental directives are required.

Project timing

There is a disparity between the energy's policy's need to speed up the planning process and reports claiming that more time is needed to win social acceptance. This delay would oppose the government's plan, but it is argued that it would allow greater acceptance, therefore leading to greater willingness to accept turbines and a reduced level of opposition. Whilst these two ideas appear to be at odds with one another, both are crucial to the increased availability of renewable energy, especially wind power.

The disparity could be resolved by using a carefully constructed planning process. By informing all parties at the first instance, negotiation time would be increased, thereby allowing major problems to be discussed at the start of the process, which is both cheaper and saves time as work will not be carried out needlessly. This early participation would allow the local community to have more time to adjust to the idea, and longer for the developers to inform residents of the costs and benefits of their proposal. By involving more parties into the planning process the procedure becomes more transparent, thus reducing the feeling that information is being withheld.

The entire approval procedure can be set out so that all parties are forewarned as to what to expect, the EIA (Environmental Impact Assessment) stage is no exception. If developers and relevant authorities are prepared to carry out the same level of impact study then there is less confusion and more information can be exchanged. An example of good co-operation was the EIA for Öresunds Bridge that was extremely detailed, but all parties understood what needed to be done (Nilsson 2002). Using a modified form of this EIA, as the proposals are generally of a much smaller magnitude, there can be less confusion about what is needed from the developers in order to meet the requirements of the planning authorities. It would also allow interested parties to have a clearer understanding of what is considered in the decision making process. This would, in addition, make the system more transparent.

Early participation can help prevent unwelcome surprises and set backs to developers, if there has been meaningful dialogue. If, however, developers have ignored reservations a lengthy procedure could ensue, as there is no direct contact for opponents to air their grievances, except for appeals in the Environmental Court. Permitting direct contact with the decision makers could reduce time and afford an opportunity for more views to be considered.

Addressing the perceived need for wind power

If there is no perceived need for wind power, or any renewable energy sources, then there will be less willingness to bear the costs of these alternative energy sources. There has been a long-standing initiative in Sweden to phase out the use of nuclear power, which has resulted in the closure of one reactor and the planned closure of more. However, although these plans are well known their implications have not been fully realised. If the installed nuclear capacity is reduced then other energy sources are needed to replace this capacity and accommodate future increases in demand. Therefore, with a fully exploited HEP potential and a desire to use non fossil fuel sources, renewable energy sources must be used. These issues are not recent developments, they have been discussed since the future of nuclear power was debated, they are, however, issues that have been somewhat ignored in recent years. If the will of the Swedish people is to have electricity produced from renewable sources, as indicated in figure 3, then there must be a more open and frank discussion of the implications relating to their usage.

This discussion could be initiated by the government or by other interested parties. The success depends on the magnitude and honesty of the discussion, as well as the willingness to replace nuclear power's installed capacity. The Danish wind power base grew as a result of a decision to seek non-nuclear means of electricity production. The same growth could be seen in Sweden if there is a real will to replace nuclear power and a strong desire to use the country's available natural resources, namely wind and biomass. Denmark's need of a secure and domestic energy base was an important national issue and as such it received the attention it needed. The oil crises clearly showed the magnitude of insecurity regarding at the national energy level, which was further heightened by the issue of the adoption of nuclear power. Therefore, there was a real and present need for wind that translated into a strong desire for an alternative domestic source, a high level of perceived need for wind. This perceived need has fallen as the ability of the nation to provide for itself has increased, as shown in figure 17. The point at which the perceived need will be outweighed by the impacts of the turbines is not yet known, but the increasing opposition to plans indicates that the perceived need has diminished and that the point of equilibrium is nearing.

The same cannot be said for Sweden as the national energy base has an entirely different characteristic. Well-developed HEP and nuclear power industries have meant that the nation is able to provide for itself without a high degree of dependence on imports. This has resulted in the low level of perceived need shown in figure 17 when compared to the situation in Denmark. The rise in Sweden is related to the increasing desire to replace nuclear power with other forms of electricity generation. It is this rise that needs to be continued. The point at which the perceived need will over power the opposition towards wind power has not been determined, but is approaching as need grows stronger. Figure 13 has shown that opposition falls as need increases, which will allow for an increased installed capacity. As the installed capacity

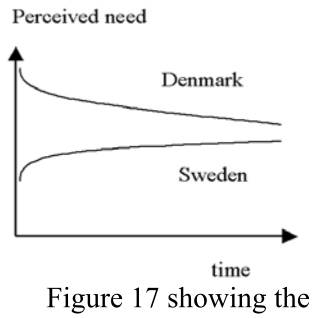

Figure 17 showing the levels of perceived need for wind power in Sweden and Denmark over time as awareness of electricity provision ability alters increases, so the perceived need falls, as has been seen in Denmark over recent years. The point at which these nations will converge in their attitudes to wind power is yet to be seen, but must be moving ever closer.

Debate is not the only factor that will alter perceived need; the availability of energy sources and other factors affecting the usage of the energy sources, such as taxation will also have an effect. Imposing a carbon tax would affect the price per unit of fossil fuels, thus pushing up prices and bringing more conventional energy sources in line with alternative sources like wind power. Other financial mechanisms can also affect the relative pricing of energy sources, thereby creating a new balance of cost effective electricity.

The role of the local economy

It is not only the different of views of nature that affects local attitudes to turbines siting, it is also an individual's economic situation. Across the community the income earned from land rent and employment has to be balanced against loss of income from tourism as the landscape becomes more industrialised. The siting of turbines does provide a direct form of income to those owning the land and those deriving employment from the turbines, however, without actual financial participation in the project much of the profits flows out of the community to the energy producers and utilities. If the region derives much of its revenue from tourism then the aesthetic quality, the untouched rural aspect of its scenery, will be directly linked to the community's annual turnover, assuming that the siting of the turbines does adversely affect tourism, a link that cannot always be proven (Mori 2002). Therefore, at some point there will have to be a balance between the costs of the turbine siting in terms of loss in tourism revenue and the benefits derived from the turbines. This should be calculated at the local level, either by the residents themselves or by local authorities. By allowing a more transparent and accessible planning process this trade-off can be discussed at an early stage and compromises sought before an expensive and timely planning process has been undertaken.

There will, of course, be differences in opinion when discussing the balance between costs and benefits as the whole community depends on different aspects for their economic livelihood. This difference in opinion will be exacerbated when there are also differences in the power held by those in the community. If temporary residents, who are not economically dependant on the region wield the greatest power then there will be a stronger tendency to reject proposed changes in the landscape. In Cape Cod the extremely dominant trade in tourism has led to rejections of offshore plans, which would diminish the untouched nature of its coastal landscape (O'Bryant 2002). As tourism is dominant and there is a large share of temporary residents who are financially independent of the region such plans are likely to keep being rejected unless sites can be chosen in partnership with the local community, i.e. plans would benefit the local community without destroying one of their main tourist attractions, the open coastal landscape.

12 Concluding remarks

In conclusion it can be stated that it is important to consider not only the physical planning of wind turbines, but also their introduction into the local community. The introduction of a proposal is the responsibility of the developer and the local authorities with sufficient assistance and structure at the regional and national levels.

The turbines themselves do affect local environs, as they are visible, produce noise and alter the ecological balance. These costs are borne by the local residents whilst the benefits are shared on a national and global basis through the reduction of pollution and the security of a wider energy source base. In order to increase the acceptance of turbines into the landscape there must be a reduction of this disparity by allowing those most affected to benefit from the turbines as well as developers and utilities. This benefit can take the form of joint ownership, profit sharing or local property tax that can be used by those in affected communities. The level of local financial gain required depends on the landscape characteristics and the economic base of the locality itself and should be designed to meet the needs of the specific site.

It is not only financial participation in the project that is required but also active participation by residents and interest groups in the planning process. Allowing participation in a clearly defined planning process would allow the community to have a longer timeframe to accept the development, whilst preventing nasty 'surprises' late in the process as concerns would have been discussed and compromises sought before a great deal of time and money has been expended. A clear process allowing for early participation would also mean that the process were more transparent and information would be available to more parties.

Improved participation and local financial gain will improve acceptance of turbines to a certain extent, however, if there is not an apparent need for wind energy in Sweden then there will still be a great unwillingness to accept what can be considered as an unnecessary change in the landscape. The general understanding and awareness of current and future energy plans needs to become a subject of debate and discussion throughout Sweden, especially if the plans to reduce the nuclear capacity are implemented. An increased awareness about the opportunities for, and implications of, a non-nuclear energy resource base is essential for increased acceptance of the impacts associated with diffuse forms of electricity production, such as wind power.

This paper has shown that the introduction of land-based turbines requires a level of local financial gain and public participation, the precise level of gain needs to be determined for a number of communities with varying landscape characteristics and economic bases. The exact form of the financial gain should also be researched, whether it is co-ownership, profit sharing, cheaper electricity, property taxes or another form of financial flow. The effect of varying views of nature and the share of permanent residents on this financial gain are worthy of further research, as is the balancing of costs and benefits within the community and the strategy for achieving a community wide consensus on this issue.

It is not only the financial gain that requires more research, but also the claims of opponents. Throughout Europe, and especially Scandinavia, there has been increased concern over the shadowing effect and infra sound emitted from the turbines. As both are a more recent addition to the discussion not enough information is known relating to them. The issue of offshore turbine siting is also a more recent development that requires a multitude of answers about its effects and introduction into communities most affected.

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Appendix 1: **Explanation of units used**

Standard prefixes:

10^3	k	kilo
10^6	M	Mega
10^9	G	Giga
10^{12}	T	Tera
10^{15}	P	Peta
10^{18}	E	Exa

Energy is often expressed using the unit of a joule, J.

Power is the amount of energy for a unit of time. The most commonly used unit is the Watt, W, which is one joule every second. This unit is often used to show the potential of an installation.

KWh, Kilowatt-hour is a commonly used unit when describing a total amount of power.

1 KWh = 3 600 kJ
= 3 600 000 J

Installed Capacity
Installed Capacity, measured in MW, is the maximum rate that a turbine can produce electricity. For example, 500 MW installed capacity will produced 500MWh (0.5 GWh) in the course of an hour if the wind is blowing at the installed capacity of around 12m/s. Generally the wind does not blow at this rate so the output of the turbine will be less than its maximum.

Sound Levels
Sound is measured using a logarithmic scale called decibels (dB).

Tonnage
1 ton = 1000 kg.
1kg = 2.2 lbs

Mileage
1 kilometre = 5/8 mile

Appendix 2: **Summary of data used**

Table 1 showing worldwide and continent-wide energy trends

	1970 values	1970 values in standard form	1998 values	1998 values in standard form
World Energy Usage	203.2 EJ	56.4 TWh	354.9 EJ	98.6 TWh
OECD Europe	51.6 EJ	14.3 TWh	70.1 EJ	19.5 TWh

(Various sources, cited in relevant section of the paper)

Table 2 showing global and local wind energy potentials

	Values in standard form
Global Wind Energy Potential	500 000TWh/yr
Global Wind Energy Practical Potential	53 000 TWh/yr
Sweden Wind Energy Technical Potential	41 TWh/yr
Southern Sweden Wind Energy Potential Output	594 TWh/yr

(Various sources, cited in relevant section of the paper)

Table 3 showing the speeds and power of winds within Sweden over a variety of terrains

	Terrain	Sheltered	Open plain	Sea coast	Open sea	Hills& ridges
Yellow zone	Velocity m/s	4.5-5.0	5.5-6.5	6.0-7.0	7.0-8.0	8.5.10.0
	Power W/m	100-150	200-300	250-400	400-600	700-1 200
Red zone	Velocity m/s	5.0-6.0	6.5-7.5	7.0-8.5	8.0-9.0	10.0-11.5
	Power W/m	150-250	300-500	400-700	600-800	1 200-1 800

(www.risoe.dk)

Table 4 showing operational wind power capacity in Europe

	Operational Installed Capacity (MW) by the end of 1995	Operational installed Capacity (MW) by the end of 2001	% total installed capacity by the end of 2001	*New installed capacity 1995-2001*
Germany	1 136	8 100	49.50	
Denmark	619	2 417		
Spain	145	3 175		
Netherlands	236	483		
UK	200	477		
Sweden	67	264	1.61	
Italy	25	560		
Greece	28	273		
Ireland	7	132		
Portugal	13	127		
Austria	3	86		
Finland	7	39		
France	7	87		
Luxembourg	0	10		
Belgium	0	18		
Total for EU-15	*2 493*	*16 248*		*13 735*
Total for Europe	2 518	16 362	100.00	

(Ackerman & Söder 2002. *Italics: own work*)

Table 5 showing the accumulated installed capacity in Sweden from the end of 1990 to spring 2000

Year	Accumulated installed capacity by the end of the year in MW
1990	5
1991	10
1992	15
1993	30
1994	40
1995	70
1996	105
1997	121
1998	178
1999	220
2000	265
2001	290
2002*	304

* Data records installed capacity at the end of spring 2002 and not at the end of the year, as is the case for all other years.

Sources:
1990-1996 European Commission 2002
1997-2000 Energimyndigheten 2001a
2001-2002 WD 2002

Table 6 showing the atmospheric emission per Kilowatt-hour generated per fuel type

Fuel	CO_2 lb/kWh	*CO_2 kg/kWh*	SO_2 lb/kWh	*SO_2 kg/kWh*	NO_x lb/kWh	*NO_x kg/kWh*
Coal	2.12	*0.96*	0.0136	*0.0062*	0.0079	*0.0036*
Natural Gas	1.34	*0.61*	$7x10^{-6}$	*$3.2x10^{-6}$*	0.0046	*0.0021*
Oil	1.96	*0.89*	0.012	*0.0056*	0.0036	*0.0016*
Wind	0	*0*	0	*0*	0	*0*

(Surugiu & Paraschivoiu 2000. *Italics: own conversion)*

Appendix 3: **Literary and primary source review of relevant data**

	Visual Impact	Noise Impact	Effect on Birds	Land Use	Safety Issues	EMI	Need for wind	Other environ. effects	Cost	Effic & Reliabil	Material Use
Bosel & Bosel 1988	x	x			x	x		x		x	
Boverket 2001	x	x		x	x	x		x			
Boverket 2003	x	x			x	x		x			
Brunt & Spooner 1998	x	x									
Carlman 1982	x			x							
Carlman 1984	x	x				x				x	
Carlman 1986	x	x				x				x	
Carlman 1990	x	x	x			x		x			
CG 2000	x	x	x	x	x	x	x	x	x	x	x
Dannemand A. 1999	x	x	x		x			x			
Deegan 2002	x		x								
Economist 1994	x		x							x	
Energimyndigheten 2002	x	x	x	x				x			
Ericson 2000	x	x	x					x			
EWEA Discussion	x	x						x	x	x	
EWEA-envir. Aspects	x	x	x			x					
Fyhr 2002		x						x			
Geuzendam 1998	x	x	x	x				x			
Gipe 1990	x										
Gipe 1995	x	x	x		x	x	x	x	x	x	
Grubb & Meyer 1993	x	x	x		x	x					
Haettner 2002	x	x							x	x	
Hammarlund 1996	x	x	x			x		x			
Hammarlund 2002	x										
Hanley & Nevin	x										
Hellström 2002	x	x		x		x					
Hjelm 1999	x		x					x			
Hoischen 1998	x		x		x	x	x		x		
Homsey 2001				x				x			
Krause 2001	x										
Krohn & Damborg 1999	x	x					x		x	x	
LaRoche 1999	x								x		
Lee et al 1989	x					x		x			
Lillenberg 1999	x	x	x		x						
Luke et al 1994	x		x					x			
Länsstryelsen 2002	x	x	x			x		x			
Milne 1991	x										
Nielsen 1996	x			x							
SOF Debate 2002	x		x					x			
SOU 1998:152	x	x	x	x	x	x		x			
SOU 1999:75	x	x	x	x	x	x		x			
Spowers 2000	x	x	x					x	x	x	x

Stadsarkitektk. 1998	x	x		x	x	x					
Surugi & Par. 1999	x	x	x	x		x		x			
Surugi & Par. 2000	x	x	x	x		x		x			
Torok 2002	x			x						x	
USA Today 1998	x	x	x	x							x
Varley et al 1989	x	x	x			x		x	x	x	
Walker 1995	x	x						x			
Walker 1997	x	x	x			x					
Webb 1994	x	x	x					x			
Wolsink 1989	x	x	x		x	x		x	x	x	
Wolsink 1993	x	x									
Wolsink 1996	x	x	x			x		x			
Wolsink 2000	x	x	x						x	x	
Wolsink et al 1993	x	x									
Number of citations	55	40	31	15	13	24	4	29	11	14	3

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Appendix 4: **Wind Energy Technology and Design**

Wind Energy is a renewable energy source as it utilises the power that is present in the winds that constantly flow across the earth's surface. Winds are created as a result of the pressure differences created in the air as a result of solar insolation. Air tries to flow from one area of high pressure to a low-pressure area, thus creating a flow of wind. (Dunlop & Wilson 1982)

Turbine Technology and Design

The technology that current wind turbines are based on has a long and productive history. The first written evidence of wind energy being harnessed is from the Hero of Alexandria in the second or third century BC. Windmills spread to Europe by the middle ages and were used in England from the 11th century. (Dannemand 1999)

From water pumping and grain grinding windmills have developed into wind turbines that are capable of generating electricity. Whilst the design and utilisation of windmills have altered, the basic laws governing the extraction of energy from the wind have remained constant. Wind force varies with the square of wind velocity, whilst the power (rate of work done) is related to the cube of velocity. These relationships are shown in Equations 1 and 2 below.

Eq.1 $\text{Wind Force} = \text{Wind velocity}^2$

Eq.2 $\text{Wind Power} = \text{Wind Velocity}^3$

(Moretti & Divone 1986)

This means that small changes in the velocity of the wind can have large changes in the power derived. Wind is a diffuse source of energy; this means that a small surface area of wind will only harness a modest amount of energy, similar to the energy flow resulting from the sun's radiation. Moretti & Divone (1986) estimate that a reasonable wind speed of 6 m/s has an energy flux of 130 W/m^2, an amount that cannot be completely extracted from the wind turbine. This understanding resulted in large surface areas being utilised in the design of present day wind turbines. Ambient temperatures also affect the power derived from the wind, as colder air is denser and can result in a larger power outage.

Modern turbines are seen in many forms, but most have similar structures, as shown in figure 18. Most turbines have a tall tower (1), upon which rests the nacelle which contains the gear box (3), the yaw mechanism and the generator (4) that produces the electrical current which is transferred to the ground through the tower's cables. Perhaps the most striking components of the turbine are the blades (2) that can be over 30 metres long. Two-bladed and three-bladed turbines are the most employed, with three-bladed turbines currently preferred in Sweden (Boverket 2003). The blades are attached to the hub, which is connected to the nacelle and the gearbox. (EWEA a)

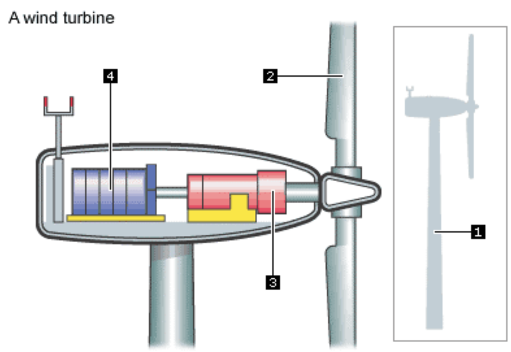

Figure 18 showing the components of a wind turbine (www.bbc.co.uk)

Designs are changing as gearless models have been introduced, such as ABB's Windformer model (EPN 2001). Such developments are designed to increase the energy output and reduce maintenance costs. New materials, such as glass fibre with epoxy resin have allowed the blades to increase in length without exceeding the maximum allowable weight (Jacob 2001).

Wind turbines are designed to produce the most electricity whilst conforming to stringent limitations of aesthetics, technical restrictions and cost. The taller the turbine tower is, the stronger the wind that can be utilised. This is because air flowing over the ground will encounter obstacles such as vegetation, landmasses and manmade structures. These obstructions enhance the friction effect of the ground, which results in a friction layer that slows the winds. If the turbine tower can rise above this layer of friction then the winds it is exposed to will be stronger and allow more electricity to be generated. However, if the tower becomes too tall then they are more costly, more noticeable and could be less stable as the materials used will not be able to support the increased mass. New materials have allowed current towers to reach 90 or 100m. (Hatziargyriou & Zervos 2001) With increased height comes new problems, one being interference with controlled air space. Towers can become aviation obstructions and therefore need to be lit accordingly, thus ensuring that wind turbines are visible day and night to pilots and residents alike (Gipe 1995).

It is not only the height and level of illumination that affects the visibility of turbines. The finishing determines the level of reflectivity and the periods when the towers are visible. In Wales towers are generally off-white of light grey so as to blend into the background as much as possible given the cloudy climate. The perception of the final coating is largely a matter of individual taste, as some believe that some painted towers are less industrial than galvanised ones. Individual preferences extend to opinions of the shape of the tower, colour, number of blades, speed of rotation and overall design. (Geuzendam 1998, Gipe 1995, Lee et al 1989, Länsstyrelsen 2002)

The desire to tap the potential of increased wind velocities has driven research into turbines that can harness the higher jet streams 8 to 12 kilometres up (Torok 2000). This research is as yet unproven but illustrates the diversity of possible future technology and the different directions in which turbine technology and design shapes its acceptance.

Appendix 5: **Data and methodology for Skurup Case Study**

The case study used data from the 15th September 2002 local votes regarding the acceptance of 28 turbines less than 10 kms from the coast. The question posed asked if inhabitants would like to have sea based wind turbines established within the locality (own translation of question from www.skurup.se). The results are as follows and apply to the voting districts shown in figure 19:

Voting district	Map district key	*Proximity Rank*	Yes	No	Invalid	Total	*% valid votes that are yes*
Skurup 1	1	*10*	660	559	31	1250	*54.1*
Skurup 2	2	*7*	410	368	16	794	*52.7*
Skurup 3	3	*6*	493	493	24	1010	*50.0*
Skurup 4	4	*5*	394	426	18	838	*48.0*
Skivarp 1	6	*4*	322	338	20	680	*48.8*
Skivarp 2	7	*1*	178	505	26	709	*26.1*
Slimminge	10	*9*	279	176	15	471	*61.2*
Svenstorp	5	*2*	190	239	11	440	*44.3*
Villie	9	*8*	351	236	10	597	*59.8*
Örsjö	8	*4*	309	265	11	585	*53.8*
Total			3586	3605	182	7373	
Total after recount			3601	3628	155	7384	

(Colmo 2002. *Italics: own work*)

It must be noted that the ranked distance from the coast was the author's own work and was based purely on the location of the perceived centre of the voting district. No account of population distribution was used; neither was the precise distances involved, nor the social characteristics of the voters themselves. The case study was merely an attempt to show the general distribution of voters within the locality relative to proximity to the coast.

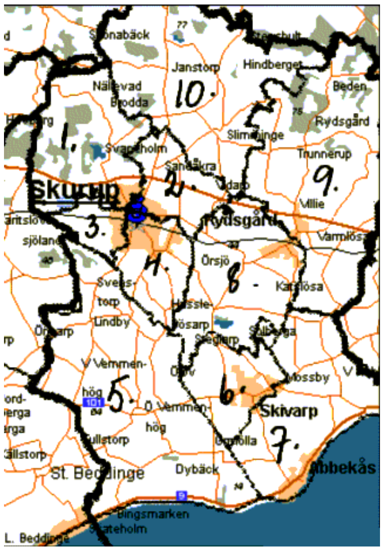

Figure 19 showing the relative locations of voting districts within Skurup (Colmo 2002 and www.skurup.se)