Public Services, Equity, and Innovation: Some Lessons from the French Rural Electrification Regime

CHRISTOPHE de GOUVELLO

Rural electrification in France has entered a new growth phase due to: (i) the development of new end-uses of electricity; (ii) the appearance of new requirements pertaining to the environment and supply quality; and (iii) the prospect of new, tighter European standards. This leads to some questions regarding the adequacy of an institutional framework which has survived for several decades without any major modification. We propose a change in the incentive system based on the following steps: (i) spelling out some of these questions, using a description of the changes that have marked rural electrification in France; (ii) attempting to see them in a new light through an analysis of the development cost of rural grids and the opportunities to realize the cost reductions potentially offered by non-conventional alternatives based on Demand-Side Management; and finally (iii) placing these questions in the general context of an equitable treatment of users and the ensuing balancing-out effort concerning spatial costs in rural areas, considerations which have driven the rural electrification system in France from its inception.

L'électrification rurale de la France est entrée dans une nouvelle phase de croissance en raison des facteurs suivants: (i) le développement de nouvelles utilisations finales de l'électricité, (ii) l'apparition de nouveaux critères en matière d'environnement et de qualité de l'approvisionnement et (iii), la perspective de nouvelles normes européennes plus strictes. Ces éléments nous conduisent à nous interroger sur le bien-fondé d'une structure institutionnelle qui a survécu durant plusieurs dizaines d'années sans subir de changements importants. Nous proposons de modifier le système d'encouragement à partir des étapes suivantes: (i) exposer en détail certaines de ces questions en décrivant les changements qui ont marqué l'électrification rurale de la France; (ii) essayer de les envisager sous un nouveau jour en analysant le coût de développement des réseaux ruraux et les opportunités de mettre en oeuvre les réductions de coût que pourraient offrir des options non classiques qui se fondent sur la gestion axée sur la demande et enfin (iii), replacer ces questions dans le contexte général d'un traitement équitable des utilisateurs et de l'effort conséquent de compensation des coûts géographiques dans les espaces ruraux, éléments qui ont été le moteur du système d'électrification rurale depuis ses débuts en France

The author is with the Centre International de Recherche sur l'Environnement et le Développement (CIRED), Paris.

Introduction

The French electricity sector is known for its high degree of concentration and vertical integration, due to the nearly absolute monopoly of Électricité de France (EDF). However, as in many countries, problems in financing specific additional costs of rural electrification have led to the creation of a particular institutional framework for providing electricity in rural areas. The French case is characterized by highly decentralised investment policies for the rural distribution grid, even though operation of the grid is almost exclusively controlled by EDF. This situation is therefore particularly interesting when analysing variations in distribution costs, since: (1) the departmentalisation of investment allows for a precise measurement of variation by locale; and (2) the interface with a single national operator guarantees that data for different areas are comparable and can thus readily be aggregated. This is of great help when comparing costs across distribution grids, and makes possible assessments of cross-subsidies existing in the system and of potential efficiency gains offered by Demand-Side Management (DSM) innovations in the management of distribution grids.

In France, the "rural electrification regime" affects approximately seven million mainland

Energy Studies Review Vol. 8, No. 1, 1996 Printed in Canada

subscribers out of a total of about 25 million, or a population of close to 17 million inhabitants. This regime, often not well known even though it oversees a public service omnipresent in rural areas, has distinct features which have been preserved despite the profound changes that the French electricity sector has undergone since the 1930s.

For example, for several decades now the pricing of electricity (as well as that of telephone, public transportation, mail, and other "grid" public services) has continually evolved in the sense of better informing the user of the costs that he occasions (for network expansion, maintenance, reinforcement of production equipment, etc.), in order to steer individual choices rationally towards what is optimal for society as a whole.

In the case of electricity, this principle has led to differentiating tariffs as a function of blocks of hours (peak- and off-peak period rates) and more recently as a function of the seasons, similar to the price variations proposed by the Société Nationale des Chemins de Fer (SNCF, e.g., the red, white, and blue days of the "Tempo" tariffs). Electricity pricing in rural areas is one of the most distinctive exceptions to this logic, and illustrates particularly clearly the special nature of the French rural electrification regime: although the cost to society as a whole of serving a consumer located in a not-very-dense rural area is much higher (proportionately more line must be installed to connect him), he is in fact billed by EDF at the same tariff that he would be were he to live in a city. This exception is accepted since access to electricity has been elevated to the status of a public good, thanks to the positive externalities of electricity use in terms of socio-economic development. Therefore, this legitimises the collective payment of additional costs for rural areas through an elaborate system of cross-subsidies. Beyond this principle of "price equalisation," rural electrification in France is characterised by a special institutional arrangement rarely known to the users themselves, which gives a central role to "Local Authorities." Unlike urban areas, where EDF makes nearly all decisions concerning the electricity grid, the contracting authority of rural electrification belongs to the communes, generally grouped together in intercommunal associations. It is thus up to these Local Authorities to cover investment expenditures. They are assisted by a national mechanism, FACE (see Box 1, below), established in 1937, which, in the name of territorial equity, transfers receipts from the sale of electricity in urban areas to projects aimed at the expansion of the rural distribution grids.

Rural electrification has entered a new growth phase due to: (i) the development of new end-uses of electricity; (ii) the appearance of new requirements pertaining to the environment and supply quality; and (iii) the prospect of new, tighter European environmental standards. This leads to some questions regarding the adequacy of an institutional framework which has survived for several decades without any major modification, even if in some of these decades, considerable changes did take place pertaining to the way collectively-owned equipment is managed. In such an evolving context, can one continue to grant unequivocally electricity the status of public good, and maintain a system of cross-subsidies granted indiscriminately regardless of end-uses, including competitive ones? Or is it better to think of reorienting these resources towards developing more effective solutions from society's point of view? Can DSM contribute to greater efficiency in the system for financing rural electrification? If DSM initiatives can be useful in this context, then at what end-uses should these be directed?

We propose a change in the incentive system based on the following steps: (i) spelling out the new context, using a description of the changes that have marked rural electrification in France; (ii) attempting to see the context in a new light, through analysing the development cost of rural grids and the potential opportunities to reduce investment using non-conventional alternatives based on DSM; and finally (iii) placing the new context in the general context of an equitable treatment of users and the ensuing balancing-out of effort concerning spatial costs in rural areas, which have driven the rural electrification regime in France from its inception.

The Rationale for the French Rural Electrification Regime: Territorial Solidarity and the Delivery of a Basic Service

It is worth recalling that price equalisation, far from being the anachronistic manifestation of a dark corner not yet illuminated by marginalist economic theory, is instead part of the dynamic, compelling logic of another recognised principle, namely that of territorial solidarity. In the case of rural electrification, the latter has gradually taken form through the demands of representatives from rural areas. Early in this century, several laws provided Local Authorities in rural areas with new powers to take control over their own equipment (through concession laws, state-owned companies, and intercommunal associations). Indeed, since the early 1900s, rural communes have organised themselves to make up for the lack of interest shown by the private sector in rural equipment, forsaken in favour of the much more profitable urban markets. Then in 1933, the creation of the Fédération Nationale des Collectivités Électrifiées (now known as FNCCR), marked the strengthening of the Local Authorities vis-à-vis private electricity companies.

First, FNCCR, which was able to get a "parliamentary electricity group" to take over from it, obtained in 1935 the creation of a "Distribution Costs Compensation Fund," which made it possible to compensate partially rural distributors for their higher costs through contributions deducted from the revenues of urban distributors. It then managed to have voted in Parliament in 1936 the creation of the Fonds d'amortisation des coûts de l'électrification ("Electrification Investments Amortisation Fund," known as FACE), whose mission at the time was twofold: FACE would first operate exclusively as a solidarity fund between towns and rural areas, assuming the bulk of the funding of the construction costs of rural grids; then, beginning the following year, its mission was extended to reducing tariff differentials between distributors, thus beginning a long process of unifying prices over all of the national territory. After some changes in past decades, FACE's function is now to finance directly a portion of the investment in rural grids borne by the Local Authorities (see Box 1).

In 1946, the first draft of the nationalisation of the Service Public d'Électricité provided for the disappearance of all independent distributors, including the companies set up by the Local Authorities, as well as for the revision of the contract terms of the concessions in order to reduce specific barriers to rural electrification. However, the rural electrification associations and FNCCR were anxious to retain their roles and feared that rural electrification would take a back seat when the recently created EDF reconstructed the national grid. They managed to ensure that the rural electrification regime would be preserved: the concession contracts granted by the Local Authorities to the formerly private distributors were transferred intact to EDF. Considering that they had in fact anticipated the spirit of the law, the Non-Nationalised Distributors (NNDs) have been maintained, the associations retain contracting authority, and the FACE mechanism has been retained, its management being entrusted to EDF. The process of standardizing low-voltage electricity prices continued until its completion in the late 1960s. At the time of the decentralisation law in 1982, the special nature of FACE's assistance was preserved again, outside of the overall equipment allowance plan (OEA).

When FACE was created, rural electrification represented the means chosen to spread modern lighting and motor power, two key elements of rural development, which came to be very symbolic ("the Electricity Fairy"). To promote rural electrification was to reduce the gap between towns and rural regions, and to preserve the consistency of the nation's growth, at that time profoundly agricultural. With the grid technology being by nature more expensive in sparsely populated areas (more kilometres of line for the same number of subscribers), the resource transfer mechanisms to sustain the equipment build-up in rural areas and the equal-price principle for consumers, were at the heart of the institutional mechanisms from the outset, guaranteeing territorial equity.

Box 1: Price Equalisation, FACE, and the Electricity Equalisation Fund

FACE finances directly a portion of the investment on the low-voltage (220V-380V) distribution grid serving communes that come under the rural electrification regime. Managed by EDF, FACE is fed by the revenues from a levy on receipts from the sale of low-voltage electricity by distributors (EDF and NNDs). This levy distinguishes between receipts stemming from the sale of low-tension electricity (LT) to urban consumers, for which the levy rate was 1.95% for 1995, and receipts from the sale of LT in rural areas, for which the levy rate is just 0.39%. For this reason, approximately 90% of FACE's receipts stem from the levy on "Urban LT," which often leads to interpreting – incorrectly – the fund's role as transferring from urban consumers to rural ones. It is important to underscore that this is not an additional tax on consumption, but a levy on the receipts of distributors, introducing no pricing differential between urban users and users under the rural electrification regime. Therefore, in no case does FACE's financing mechanism constitute price equalisation; in fact, there is an identical contribution from all users (under urban and rural regimes) who finance (perhaps without their knowledge), via prices calculated at the national level by EDF, a portion of the non-EDF Local Authorities' costs (rural commune associations), whose territories are the most expensive to equip because of the geographic dispersal of users to be served (this is similar to cost equalisation "between Local Authorities"). For the same reasons, since prices are standard over all of the territory (price equalisation "between consumers"), the operating costs of these markets are higher, thus affecting their profitability for those distributors to which the Local Authorities granted the concession (EDF and NNDs). However, there exists a third mechanism: the "Electricity Equalisation Fund." This Fund, not specific to rural electrification, ensures compensation of differences in operating costs across distributors (equalisa–tion "between distributors"). Its resources, also managed by EDF, come from levies on the annual receipts of the distribution organisations, who receive in return annual equalisation grants based on a scale established by the Fund.

The Paradox of Continuing High Investment Costs after the Achievement of Interconnection

Today, almost 30 years after the territory of France was first fully electrified, we see a paradox which leads to questions about the adequacy of the existing institutional mechanisms. Indeed, we observe that the investment requirements of rural service, excluding the replacement of obsolete equipment, have continually increased: from FF 3 billion in 1975, to approximately FF 4 billion annually today, with perhaps further increases in the future. Less than one-half of this amount is currently covered by FACE, the remainder is borne by the Local Authorities under the rural electrification regime; even after recovering the VAT on all expenditures, the latter still bears as much as 55.4% of the investment (see Table 1 and Box 2).

To finance these expenditures, the Local Authorities have been dipping into their own resources or resorting to debt, most often from the Caisse des Dépôts et Consignations or Crédit Agricole, as long as their budgets enable them to meet the corresponding financial charges. The principal budget receipt that is allocated to this is the revenue from two specific local taxes on electricity (LTE) that Local Authorities are authorised to set as high as 4% for the departmental tax and 8% for the community tax. In 1992, the revenue from these taxes amounted to FF 7.1 billion for all authorities combined. In actual fact, rural communes under the rural electrification regime have to allocate virtually all, if not more, of this budget to finance the rural electrification programmes, while communes under the urban regime can freely allocate the latter to the development of other collective services or equipment. Hence, there is a transfer not only between urban and rural consumers, but also between rural taxpayers and rural electricity consumers.

It is therefore interesting, in the case of rural communes, to compare the volume of receipts from LTE reallocated to rural electrification with that of the receipts which the same communes collected from four local taxes (developed-property taxes, undeveloped-property taxes, residence taxes, and business taxes): for communes with less than 2,000 inhabitants,

Box 2: The Contributions of the Local Authorities and FACE to the Financing of Rural Electrification Expenditures

Rural electrification programmes are financed mainly in the following two ways:

i) Programmes Assisted by FACE:

Principal Programmes (PP) or the "AB Section" (Extensions and Reinforcements)

These programmes are supported by a contribution from FACE, the overall amount of which is set at the national level at the conclusion of the "Inventory," an extensive consultation process carried out every five years through departmental conferences, called by the prefects and involving the various local technicians of rural electrification. This FACE amount is then distributed to the départements according to annually-adjusted distribution percentages. The PP were previously divided into two sections, the former section A being financed 50% by FACE and 20% by EDF, and the former section B being 70% financed by FACE. Today, the AB section covers all of the principal programmes and the corresponding expenditures are 70%-financed by FACE and 30%-financed by the Local Authorities who, moreover, recuperate the VAT from all the expenditures.

Once the FACE loans are allocated among the Departments by FACE's committee, an Annual Departmental Programme is generally voted on by the Local Authorities who are members of the departmental association, when it exists; this programme selects among the proposed projects, those which will be included in the principal programmes. The principal programme thus defined is never enough to cover all of the expressed needs; it is therefore complemented by a second category of programmes known as "supplementary," which are entirely paid for by the Local Authorities.

"The C Section" (Integration of Grids in the Environment)

A new line of financing was implemented in 1991. Independent of the AB section, it aims to support expenditures to improve the aesthetics of the rural grids in order to contribute to a better integration into the landscape. These expenditures are 50%-financed by FACE, 20% by the distributor, and 30% by communes, which recuperate the VAT (15.7% of total expenditures, all taxes included). After three years during which the project selection procedure was centralised at the national level, the C section is now divided among general committees according to the same process as the AB section.

**The "DSM-RE" Section*

Since 1995, approximately 5% of the AB section has been reserved for financing operations which substitute for conventional reinforcement and grid extension expenditures. This includes: DSM measures, making it possible to save on expenditures for grid reinforcement; and decentralised production using renewable energy (RE), where extending the grid proves either impossible or prohibitively expensive. This line of assistance, connected to the AB section, has at the moment a project selection procedure centralised at the level of FACE.

ii) Supplementary Programmes (SP)

These programmes are entirely financed by rural Local Authorities. SP's share of total programme expenditures (all taxes included) over the 1990-94 period of the IXth Inventory was 45.1% (compared to 38% in 1983, and 51% in 1987). To finance these programmes, rural Local Authorities principally use funds from LTEs (municipal and departmental). In contrast, urban Local Authorities can use these funds for other collective expenditures, since EDF is exclusively responsible for the development of urban networks.

For this reason, the share of rural Local Authorities in the financing of rural electrification is particularly steep: it reaches 55.4% of net expenditures after recuperating the VAT paid back by the state (or 62.4% of gross expenditures, all taxes included – see Table 1). This means that today the Local Authorities assume more than one-half of the net investment cost of rural electrification.

Table 1: The Financing of the Electrification Regime over the Five-Year Period of the IXth Inventory (1990-1994)[1]

	Programmes Assisted by FACE (VAT[2] included)	Supplementary Programmes (not assisted by FACE) (VAT included)	%, after Recuperation of VAT by Local Authorities
FACE	FF 7,876 million	FF 0	44.63%
Local Authorities	FF 3,604 million	FF 9,446 million	55.36%
TOTAL (VAT included)	54.86%	45.14%	100.00%
VAT Recuperated	FF 1,800 million	FF 1,481 million	15.68%

Source: Based on data from the Xth Inventory of rural electrification.
1/ Work done to reinforce, extend, and bury above-ground LT lines.
2/ VAT represents "value-added tax."

which can roughly be compared to the communes under the rural electrification regime, these receipts amounted to FF17.9 billion for the four local taxes, and to FF 1.9 billion for the two LTEs (or 10.6%), for 1993.

Even though the rural electrification regime was always motivated by the need for national solidarity with regard to ensuring the economic development of rural areas, we see today that it induces a budgetary penalty to rural communities. The major causes of this situation can be found by examining the evolution of domestic electricity demand in rural areas and the diversification of end-uses.

The Spectacular Rise in Electric Heating Resulting from Equalised Prices

We have seen the political foundations upon which the French rural electrification system was based to allow the equitable financing of a public service in rural and urban areas. These foundations rested on specific end-uses, principally lighting, whose positive externalities enabled electricity to gain the status of a public good. Not having any decentralised alternatives, which at the time were competitive with the electricity grid, the search for equity led to the creation of cross-subsidies from the most densely populated regions (cities) to the more sparsely populated regions (countryside). The system worked well, since the original specific end-uses of electricity are now available everywhere. However, it seems that the initial objectives have been overtaken since the amount of financing which passes through the system continues to increase. This leads one to question the effects on rural demand of the indiscriminate maintenance of the cross subsidies, no matter what the new end-uses of electricity add to the demand on the grid.

After a phase of overall stability from 1947 to 1965, the relative weight of low-tension (LT) consumption (in rural and urban areas) rose rapidly between 1965 and 1983: from 21% to 38% of total national electricity consumption. As Table 2 reveals, the specific increase in rural LT consumption was even greater, nearly tripling over the same period, to 14.3% of the national total.

This would appear to be a paradox since the electrification of rural areas was nearly complete by the mid-1960s and the rise in the number of rural consumers came to a halt. Growth in rural LT was thus mainly due to the fact that average consumption per rural customer, traditionally much lower than in the cities, caught up to that of urban customers – whose end-uses continued to grow – in 1975, and even considerably exceeded it from the end of the 1970s, as shown in Figure 1. This phenomenon became more pronounced until the mid-1980s, when average consumption per inhabitant in rural areas was more than 30% greater than that in urban areas.

This growth in consumption is primarily due to a change in the dynamics of LT demand, which occurred in the early 1970s. This demand was boosted by the rapid distribution of a multitude of electrical appliances and, above all, by the increase in non-specific thermal end-uses of electricity, principally heating (see Table 3). Among these end-uses, sanitary

Table 2: Relative Change in Low-Tension Electricity Consumption, 1947-1991

	1947	1957	1965	1983	1991
LT/National Total	19.8%	17.3%	21.0%	38.3%	37.8%
LT Rural/LT Urban	0.36	0.34	0.34	0.60	0.62
LT Rural/National Total	5.3%	4.3%	5.3%	14.3%	14.8%

Source: EDF (1992)

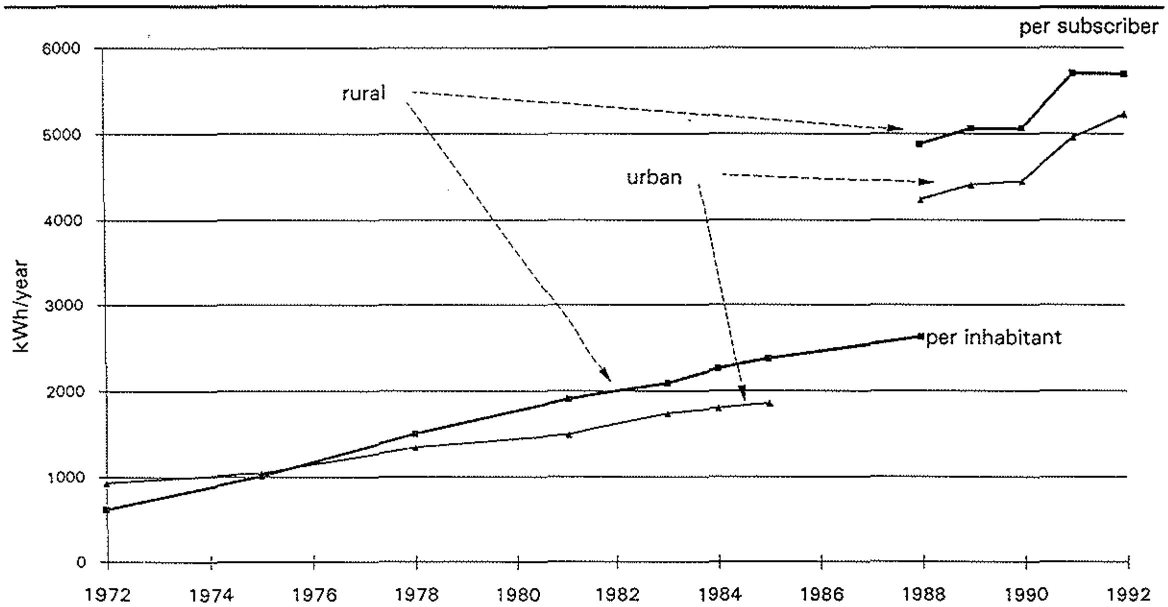

Figure 1: Comparative Evolution of Low-Tension Electricity Consumption in France, 1972 1992

hot water and cooking have levelled off, but consumption stemming from "heating" continued to grow by at least 13% per year until the mid-1980s.

The relative magnitude of the growth in thermal end-uses is even more apparent in rural areas. Despite the diffusion of certain specific end-uses of electricity, such as the freezer (50.1% of rural households were equipped with one in 1981, versus 29.3% on average nationally), the higher consumption by rural customers can mainly be attributed to the increase in electric space heating: 12.5% of rural households were equipped with electric heating in 1983, as opposed to 10% on average nationwide, and their consumption of units of heating are around 10% above average (see Table 4).

It is true that the growth in LT consumption slowed at the end of the 1980s, but this did not quash totally the trends prevailing before 1985. In fact, the timing of this slowdown is correlated with the decline in the absolute number of new houses with electric central heating (ECH) built each year: 219,886 ECH houses were built in 1984, versus 167,869 in 1991. However, this was largely due to the drop in new housing starts in general. In fact, the proportion of new houses that are ECH-equipped grew continuously from the 1970s until the end of the 1980s, rising from 37.3% in 1980, to 61.3% in 1985, and to 72.3% in 1988 (EDF, 1992). Thermal end-uses thus continue to be important in the growth in LT demand thanks to the persistent "hard core" of electric space heating in new housing.

First and foremost, thermal end-uses require power, and thus increased capacity, in other words, reinforcement of the distribution grid. Thus, the supplementary LT electricity requirements for ECH would correspond roughly to 400 megawatts (MW) of peak

Table 3: Growth in Residential EDF Consumption by End-Use (terawatt-hours)

	1973	1981	1984	1989
Electric Heating	3.6 (12%)	16.4 (25%)	24.9 (31%)	32.3 (33%)
Sanitary Hot Water	5.0	10.6	13.5	15.7
Cooking	2.0	4.8	5.3	4.9
Sub-Total, Thermal End-uses	10.6	31.8	43.7	52.9
Specific End-uses	19.2	33.2	36.6	45.1
Total	29.8	65.0	80.3	98.0

Sources: Dubois (1984), Lebot (1992)

Table 4: Estimated Breakdown of Rural/Urban Consumption Differentials by End-Use, 1981

Greater Consumption for Specific End-uses	24.6%
Greater Market Penetration of Electric Space Heating	43.0%
Agricultural Consumption	32.4%
Total	100.0%

Source: Colombier (1992)

power, while "normal" LT requirements would add only 265 MW to peak power (Finon, 1992). A study by a local independent rural distribution company (the "Régie de la Vienne," which includes several rural municipalities) also concluded that the peak responsibility of a rural LT client equipped with electric heating was 7.7 kilowatt (kW) per 10kVA consumed, compared to only 1.8 kW for an average rural LT client (Colin, 1987). Thus the continuing link between rising demand for LT electricity and space heating in new houses could by itself have major consequences in terms of future investment requirements.

As a result, it appears that the formidable growth in the electricity requirements of rural LT customers and, in fine, the need to reinforce rural distribution grids during the last three decades were due primarily to the diffusion of thermal end-uses of electricity. These end-uses of electricity are, however, not "specific" to electricity, but are instead "competitive" end-uses since they can be satisfied by other forms of energy: gas, gas-oil, wood energy, solar energy, etc. Hence, the increase in thermal end-uses can no longer be considered part of the initial rationale for the rural electrification regime.

Economies of Scale due to Thermal End-Uses do not Offset Spatial Delivery Costs

One of the key aspects to compare is the cost to society of non-specific thermal end-uses of electricity with the revenue that these end-uses generate via the billing of users. One of the difficulties that has long blocked such a calculation stems from the fact that the cost of rural service is variable by nature, if only because geographical characteristics (relief, demographic density, spatial layout of the houses, etc.) have a stronger impact on rural costs than on those in urban areas.

Having been able to use very detailed data on rural grids of 84 EDF distribution centres serving a significant rural market, thanks to the collaboration of Électricité de France, we were able to quantify the issue for all of mainland France. In particular, the marginal development cost of rural distribution-grid capacity was calculated for each of the 84 centres. These costs are shown in Figure 2.

This confirms the existence of a correlation between costs and the density of consumers on the rural grid (r2=0.62), which varies from approximately FF180/kW. year for a density of 35 customers per kilometre of rural line (MT+LT), to approximately FF 500/kW.year for a density of seven customers per kilometre. At the same time, the level of geographical information available makes it possible to highlight several significant differences: ten centres have much higher costs than average, while ten others have costs that are considerably below the "norm" determined by the correlation.

These costs can also be analysed as the sum of a rural medium-tension cost, a transformation cost, and a low-tension cost. Hence, this shows that the cost-density correlation is mainly attributable to the medium-tension (MT) cost, which increases very rapidly when density declines (the linear coefficient of correlation between the MT part only and density remains significant: r2=0.59). Conversely, the dispersion relative to the correlation has its origins more in the low-tension (LT) grid (the correlation between the LT part only and den-

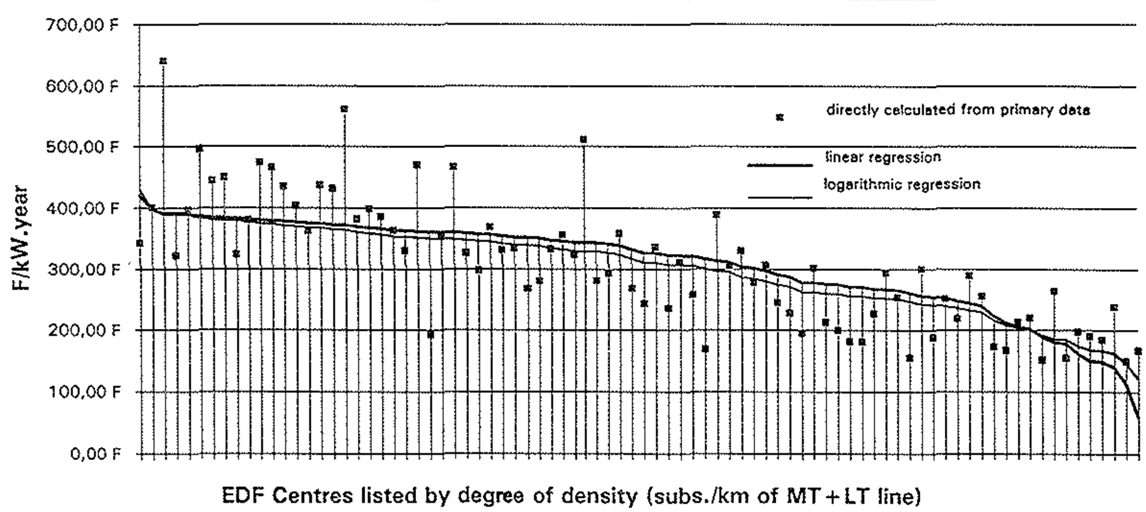

Figure 2: Estimate of the Marginal Cost of Rural Grid Development for the 84 EDF Distribution Centres

sity is very poor: r2=0.33). This shows that a more detailed analysis of the centres showing cost differentials is necessary, since relying on density as the only explanatory variable is clearly unsatisfactory.

Based on these grid costs, it was possible to undertake an exercise aimed at differentiating the development costs of some supplies delivered through the grid, where the differentiation would correspond to groups of end-uses representative of the major categories of LT consumers: "small household appliance consumer" (6DT), "sanitary hot water consumer," and "electric central heating customer" (12DT). Since power-need characteristics are specific to types of end-uses, each group has different peak characteristics, which leads to divergent supply requirements. Based on this, there are cost variations from one type of supply to the next. Moreover, these costs are not proportional to the quantities consumed or demanded by the different categories of customers. Calculating the increasing costs of these supplies for each of the 84 EDF centres allows for a precise assessment of the magnitude of the difference in 1992 between the annual cost of the service to a rural customer by supply-type and the annual bill which he pays for this supply (Figure 3). This calculation also provides an economic benchmark for a comparison between the cost of reinforcing the grid and the costs of alternative technologies for some end-uses.

Regarding 12DT supplies stemming primarily from heating, these differentials are greater than 25% for three-quarters of the centres, and reach as high as 50% at some centres. For example, at some 40 centres the differential between the cost and the annual bill is greater than FF2,000 per customer (about US$ 400 per year). Some independent local distributors are aware of this phenomenon. They realise that serving "heat" clients is a money-losing proposition (Colin, 1987).

On the other hand, this fact is not generally known by rural Local Authorities, who nevertheless bear in fine the resulting costs of reinforcing the rural grid, but have only partial information. For EDF, this phenomenon is not problematic since the rate scales are calculated at the national level based on the costs of MT/LT distribution effectively borne by the company (about 65%), the rest being paid by Local Authorities under the rural electrification regime. Hence, from the point of view of the public service mission of the nationalised distributor, it is normal to charge only for costs for which it is directly responsible.

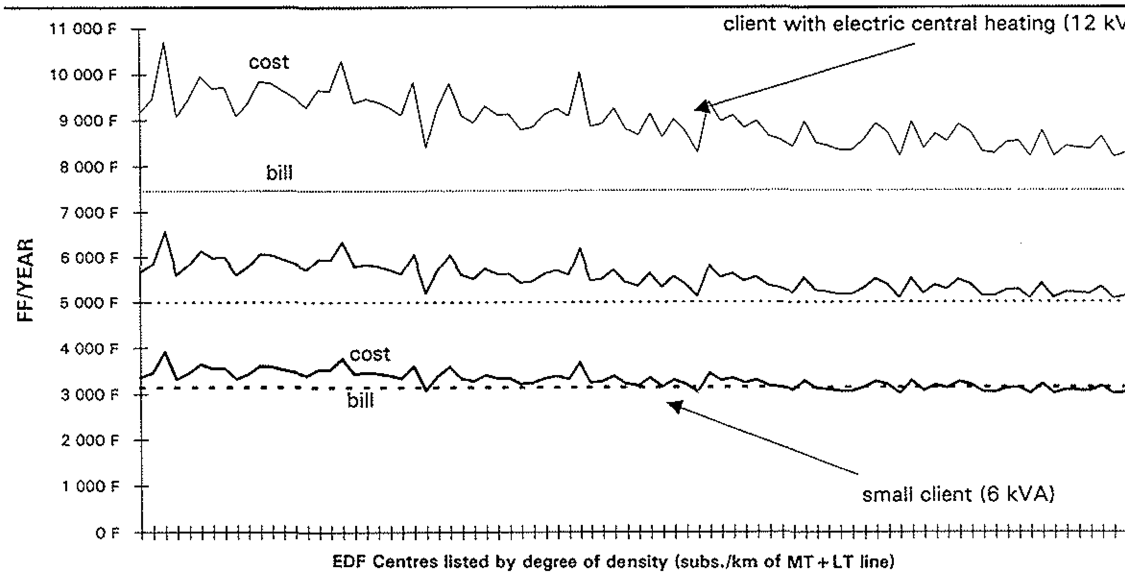

Figure 3: Marginal Development Costs for Three Categories of Rural Domestic Clients across the 84 EDF Distribution Centres

The New Factors of Rising Costs and the Paradoxical Eviction of Technical Alternatives

Beginning in the early 1980s, it became increasingly important to examine whether to continue using an incentive system that leads to billing consumers of non-specific (competing) electricity end-uses at well below their actual cost. The question has become even more pertinent today due to the rise in unit costs and the additional public expenditure requirements that will be triggered by the new European regulations on the homogenisation of household voltage.

Unit costs have been driven higher since the early 1990s for the following three major reasons:

- Gains in equipment reliability: the objective of reliable, high-quality distribution requires large investments in MT lines, in particular to install new MT/LT transformers to reduce the number of clients vulnerable to problems. It also entails burying lines exposed to the elements and restructuring the grids by shortening the average length of MT lines (from 50 to 35 kilometres on average over the 1986-1996 period) and by looping the main lines.
- Modified standards: new technical regulations pertaining to the construction of distribution grids have either recently been or will soon be adopted: lower grounding resistance, the installation of lightning protection everywhere, modified anchoring, modified rules for calculating supports and their foundations. Based on the IXth Inventory, the expected outcome of this technical evolution was a 22% expenditure overrun to be applied to all reinforcing projects during the period considered.
- The environment: since the early 1990s, and after the attention devoted by the media to the burying of some high-tension (HT) lines, requests of municipalities to "obliterate" LT grids in small villages and around tourist sites have exploded. This can be measured against the volume of aesthetic and line-burying public expenditures undertaken by Local Authorities without the assistance of FACE: these increased by an annual average of 40% from 1990 to 1994, even after the installation of FACE's "C Section" (see Box 1). As it happens, the cost of burying a line is frequently more than five times higher than the reinforcement cost of an above-ground line. Yet certain municipalities now require that all reinforcement work should automatically lead to line burial.

In addition to these rising unit costs, new European standards will soon come into effect. These will be concerned with the customer's absolute voltage change interval instead of the current focus on the relative voltage drop measured exclusively on the LT grid. Despite the prospect of developing new methods to reduce the standard deviation gradually, which will make it possible to integrate the existing margin of manoeuvre upstream of the LT grid, it is already clear that, as a result, tolerance thresholds will become increasingly difficult to respect. These will be even more easily exceeded as new loads appear (typically due to thermal end-uses). As of today, a strategy of simply upgrading the grid, which would abandon any possibility of reconverting the most expensive demand portion, could lead to a 50% increase in public expenditure requirements for grid reinforcement over the period of the Xth Inventory (1995-2000).

It is therefore not an exaggeration to affirm that rural electrification in France has entered a new phase since the end of the 1980s. In this phase, restructuring the rural distribution grid requires a very high level of investment, even during a period of slow growth in demand, due to the requirements for public expenditures triggered by the new constraints, either internal and mainly technological (reliability, quality), or external (environment, security, European homogenisation).

All in all, the current rural distribution system will, in time, become intrinsically more and more expensive to maintain. At the same time, pressure on the budgets of Local Authorities is already quiet severe, and is penalising rural municipalities relative to urban municipalities.

In this context, there are at least two negative consequences in continuing with the status quo:

- Under the rural electrification regime, Local Authorities will have to draw heavily on their investment capacity to adapt the grids for these growing non-specific end-uses of electricity. We note that the current situation will make the rural "users-taxpayers" bear an increasing share of the investment cost for reinforcement (via the LTEs). This results in a partial price inequality with the apparent maintenance of the single price signal.
- Alternative solutions to reinforcing the grid are doubly penalised. These solutions are based on other forms of traditional energy (gas-oil, gas) or modernised forms of older types of energy (wood), which would satisfy the same needs. There are also numerous DSM possibilities (e.g., distributing more efficient equipment, scheduling usage, insulating houses). In effect, the rural electrification regime not only reduces the real cost of electrical energy in a rural area to an average level (equalisation), thereby inducing distortions in favour of using electricity supplied by the grid, but it also encourages a shifting of investment toward current expenditures. The user who wants to try an alternative solution must assume the initial investment.

The question of adapting the territorial regulation system of rural electricity distribution to the new realities is therefore associated with two significant challenges: loosening budgetary constraints for the Local Authorities concerned, and revealing niches for competitive innovative solutions. Such solutions are typically innovations developed primarily over the last fifteen years (and partially abroad, because of the not-very-conducive environment in France). Their use is hindered by the special institutional arrangement set up around the grid. As a result, measures for decentralised energy production from renewable energy and DSM became only very recently eligible to receive FACE subsidies (since 1993 for windmills and photovoltaic systems, and since 1995 for DSM at the experimental level).

DSM: A Way to Reconcile Territorial Equity, Efficiency, and Innovation

While the shift to decentralised production from renewable energy (RE) is already significant in the French overseas territories (and, to a lesser extent, in Corsica), where a large part of the electricity requirements are still "off grid," the already very high density of the mainland rural grid leads more to a search for innovative alternatives, which could substitute for the most expensive grid reinforcement work. Thus, the real challenge in mainland France today is opening the system to DSM measures.

From a general perspective, DSM initiatives aim to reduce the present value of the overall cost of final energy services achieved through electricity, rather than the present value of the overall kilowatt-hour cost. Based on this theoretical definition, three forms of intervention measures are generally noted, corresponding to three levels of the energy chain extending from useful energy back to primary energy: (i) saving final energy by improving equipment performance; (ii) managing the load curve by scheduling usage; and (iii) energy substitution (Garcia, 1992).

An examination of the experience in North America, where the first steps in this area were taken in the 1990s, shows that virtually all programs carried out were motivated by the search for alternatives in order to reduce production requirements (DIGEC, 1993). Investment in production became more difficult to finance and more risky due to: the concerns of regulatory authorities; uncertain demand; and growing concerns about the environment (S02 and greenhouse gas emissions in the case of traditional thermal energy; the risks associated with nuclear production; and the local impacts of hydroelectricity).

As a result, according to the logic of DSM, demand can become a source of fictive production of what Lovins (1989) calls "negawatts" since they erase part of the peak power requirements. This constitutes a cultural revolution in the electric companies because DSM initiatives can now compete with supply projects (Garcia, 1992).

In France, the situation is different in that for the next few years the sector has excess production capacity. On the other hand, large investment savings could be achieved at the distribution level through DSM measures. If correctly applied in rural areas, measures to reduce energy demand may significantly reduce the need to reinforce the rural grid. From this perspective, rural areas appear to be ideal for launching DSM initiatives, since in addition to reducing costs at the production level, one can also reduce costs significantly, probably by even larger amounts, at the level of distribution grid development. Thermal end-uses, particularly important at the peak because of their large power needs, thus naturally constitute the ideal target for DSM measures such as: scheduling of room heating temperatures according to when the rooms are occupied, better insulation of buildings, heat accumulation, substitution of solar energy for heating water, bi-energy boilers, development of wood as an energy source. In such cases, DSM initiatives could lead to a considerable reduction in expenditure requirements for rural grid development. This could also reduce part of the Local Authorities' complementary programmes, and thus rebalance the relative role of FACE and of taxes on rural users' bills.

Conclusion

Without questioning the objective of territorial equity on which the French rural electrification regime was based, microeconomic calculations have enabled us to analyse the costs of different end-uses of electricity in rural areas and to underline the need for changes in the underlying incentive system. In particular, if it does not concern specific end-uses of electricity, it seems inconceivable that the institutional and regulatory structure could restrict the adoption of new techniques which can compete with reinforcing the distribution grid, and could remain indifferent to a growing difference in budgetary and fiscal pressure between rural and urban communities.

One can rightly ask if preferential recourse to electricity for thermal end-uses still falls under the original rationale for electricity being called a public good. When actions on the demand side lead to effective reorientation towards more competitive solutions, or effectively reduce the impact on the public grid, they become much more legitimate recipients for resources transferred from urban to rural consumers than is conventional grid reinforcement. In fact, such reinforcement does not in itself produce positive externalities that can justify its being the only technical choice possible.

Evidence of the investment reductions

made possible by DSM led the FACE council to create in January 1995 an annual "DSM-RE" envelope of FF100 million over three years, taken from the main AB section, which finances conventional investment for development of the rural grid for distributing electricity. Thus a signal was sent to Local Authorities encouraging them to broaden their range of technical choices when investing to maintain the quality of electricity distribution.

Still to be defined are the adjustments needed in the incentive system aimed at the user, to make these customised measures attractive and acceptable to everyone, while at the same time respecting the equity principles of public services – which remain unchanged with regard to specific end-uses of electricity in the rural areas – and guaranteeing the same level of service for all end-users. From this perspective, adjusting already outdated institutional dispositions which determine the technical choices of rural electrification, as much at the level of users as at that of local authorities in charge of the distribution grid, becomes a condition for ensuring territorial equity, which is at the heart of public service.

Acknowledgement

This article uses the results and conclusions of research conducted by CIRED over several years, and whose recent developments were financed by the French Ministry of Industry (DGEMP-DIGEC) and by the Economic Studies Department of Agence de l'Environnement et de la Maîtrise de l'Énergie (ADEME).

References

Boiteux, M. (1970) *Neutralité tarifaire et entreprises publiques*, appendix to the NORA report, pp.109-21 (Paris: Bulletin de l'Institute International d'Administration Publique).

—(1971) 'La vente au coût marginal,' pp. 56-68 in Morlat and Bessière (eds.) *Vingt-cinq ans d'économie électrique* (Paris: Dunod) (first appeared in 1956 in *Revue française de l'énergie*.).

Colombier, M. (1992) *Régulation économique et projet technique. Le jeu des compromis entre efficacité, équité et innovation dans le cas de l'électrification rurale en France*, unpublished Ph.D. thesis, École des Hautes Études en Sciences Sociales, Paris, 370pp.

Colin, J.P. (1987) *Note de service promotion des ventes* CL-87/3, internal memorandum, Régie du Syndicat Intercommunal d'Électricité du Département de la Vienne, Poitiers, 8 p.

de Gouvello, C. (1995) *Maîtrise de la demande d'électricité et surcoûts de la desserte rurale*, rapport de recherche pour la DGEMP (Ministère de l'Industrie) et l'ADEME, Paris, 92pp.

Direction du Gaz, de l'Électricité et du Charbon (DIGEC) (1993) *Rapport d'activité 1992*. (Paris: Ministère de l'Industrie).

Dubois, J. (1984) 'L'effet sur le réseau national du développement du chauffage électrique,' *Revue de l'énergie* 368:438-51.

Électricité de France (EDF) (1992) *Annuaire statistique 1991* (Paris: EDF).

Finon, D. (1992) *Impact du niveau de pénétration du chauffage électrique sur le montant des investissements de distribution électrique*, Rapport final de la Convention Observatoire de l'Énergie, Centre National de la Recherche Scientifique, Institut d'Économie et de Politique de l'Énergie, Grenoble, 20pp.

Garcia, F. (1992) 'Du côté de la demande d'électricité...Un regard sur l'expérience américaine,' *Revue de l'énergie* 440:378-85.

Juricic, R. (1971) 'Lois théoriques des quantités d'ouvrages dans les réseaux électrique,' *Revue générale de l'électricité* 80:4:323-29.

Lebot (1992) *Campagne EDF sur la valeur de l'électricité – commentaires de Département Bâtiment & Collectivités*, internal memorandum, ADEME, 9 p.

Lovins, A. (1989) 'The Great Demand-Side Bidding Debate Rages On,' *The Electricity Journal* 2:2:34-40.