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A normative structure for the European electricity market

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A normative structure for the European electricity industry is discussed. This model builds upon proposals and experiences in several European nations (in particular the Netherlands and the UK). Two rivalling structures (vertical integration versus open competition) are compared. Our 'open structure' is specific in not allowing TPA (third party access) to the grid, and in making the necessary distinction among 'independent generators' and Independent Generators of Own Power IGOPS. Cost economies (scale, scope and density) are related to the three major functions of a power system (generation, transport, distribution). The performance of the rival models is assessed for five criteria: sustainability, economic efficiency, regulatory efficiency, equity, and institutional feasibility.

Keywords: Normative structure; European electricity industry; Vertical integration model; Cost economies

Introduction[1]

The paper discusses a *normative* model for the European electricity industry. Although most of the characteristics of this normative model are derived by observing existing European power systems, there is no reference made to particular examples.

The normative model is compared with other proposed models and mainly with the present predominant model of vertical integration. The analysis of the models is based on the *cost economies* in organizing the major functions of a power system, ie generation, transmission and distribution.

(1) A complete unbundling of the three major functions of power supply, ie generation, transmission and distribution, is the single most crucial condition for the existence of power markets.
(2) The power industry structure is opened up for competition in generation. A distinction is made between generation companies (utility and independent producers) and independent generators of own power (IGOPs). The latter are recognized to fill a special position as both suppliers and consumers of grid power. Competition is maximized by competitive bidding procedures in licensing plant construction and in committing units for energy deliveries, and in authorizing IGOPs access to the network.
(3) A central role is assigned to the single grid operator, owning and governing the transmission grid, ordering or accepting generation capacities and selling power at the large load canters. The grid operator plays the role of power broker.
(4) There is no free TPA (third party access). Generators can only sell to the grid and customers can only buy at the grid.[2] The system is levelled so that only large generators and customers deal with the grid directly. The others deal with the distribution utilities.
(5) There is one common tariff structure for large customers (industries and distribution utilities alike) based on the short-run marginal costs of power supplies.

[1]This article is a revised version of the 'Electric Power Industry Structure and Integrated Resource Planning' (see de Almeida *et al*, 1994a, 1994b). The original goal of the article was to discuss (and oppose) arguments by colleagues as integrated resource planning would require, (or be best off with) a vertically-integrated power sector (see Finon, 1990). The CEC (Commission of the European Community) is discussing and experimenting a suitable model for the European electricity market, and tries to reconcile opposing visions and approaches. A clear blueprint of the market structure(s) one should strive for, is however lacking (see, for example, CEC–SEC, 1995). This article wants to contribute to the development of the necessary blueprint.

[2]This idea looks similar to the proposition of 'Single Buyer' (as put forward by EDF – Electricité de France, in a reaction on the CEC propositions about market liberalization). The basic difference is however that our model requires complete unbundling of the three functions generation–transmission–distribution, leaving a broker role to the grid operator. The EDF-Single Buyer is pushed by market parties (large customer+independent or foreign producer) to make a fix. In our model the single buyer–grid operator is continuously brokering power between suppliers and customers.

(6) The distribution utilities are preferably public companies with a multi-scope working area and regulated for service companies.
(7) The proposed system only can function with a regulating office at the European level supervising the grids and with national or regional offices supervising the distribution companies.

The performances of the normative structure and of the vertically-integrated structure are assessed with a set of five criteria, ie sustainability, economic efficiency, regulatory efficiency, institutional feasibility and equity.

In "The central function of transmission in power systems", we highlight the central function of the transmission grid in power systems and ask attention to be given to two quite different types of generators, ie those that produce power to sell to others and the ones that produce power (mainly) for their own use. We also argue that regulation in the power sector remains at least as important as competition. "Cost economies and power sector structure" shows that the three major functions in the power industry (generation, transmission, distribution) are characterized by different cost economies and should be organized in different structures.

For evaluating and comparing proposed sector structures we propose a set of five criteria ("Criteria measuring performance"). Sustainability is added to the list commonly used by the CEC. We also put more emphasis on regulatory efficiency and propose to make the criterion of 'institutional feasibility' more explicit than it is in the terms 'graduality' and 'in dialogue with Council and Parliament' of the CEC.

In "The old reference structure: vertical integration", the vertically-integrated structure is evaluated. In "An open structure for the electricity industry", we first discuss a blueprint of an open structure for the electricity industry, and then evaluate the expected performance of the structure for the five criteria. "Conclusion" brings the two evaluation exercises together, resulting in a preference for the open structure.

The central function of transmission in power systems[3]

The grid is the physical market place

The transmission subsystem (the electric power grid) is the physical basis of electricity transactions and can literally be considered as the physical market place for electricity. It is there that supply of and demand for power meet each other and where exchange of electricity for money occurs. When one wants to promote competition in the electricity market, one must look for ways to install competitive conditions in the transmission subsystem, eg a reasonable amount of suppliers and demanders to attain a level of workable competition, free entry to and exit from the market for participants, no discrimination nor distortions (harmonization), free flows of information (transparency) etc. In Figure 1, the left side represents the traditional vertically-integrated structure and the right side the unbundled structure.

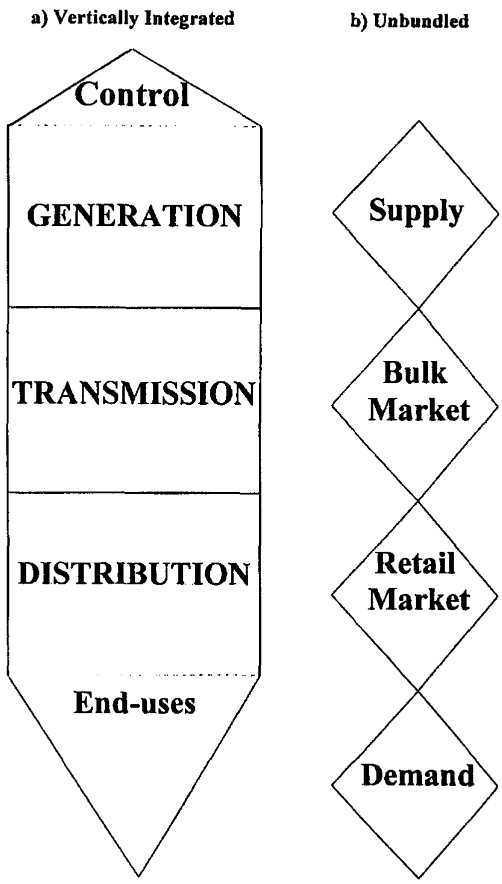

Figure 1 Unbundling of functions as a necessity for market creation

When vertical integration prevails, no markets exist. Consumers of electricity have to join or to leave the system on the conditions prescribed by the system. Even large consumers that could consider self-generation of their own power have to call upon the grid for backup and complementary power. As with most goods, one can install a wholesale (bulk) and retail market in electricity.

A central intelligent authority manages the grid

An electric power grid is not a road network accessible to anybody. The functioning of a power grid requires the continuous monitoring by an intelligent central authority. This authority must govern all transactions, eg by allowing or by requesting production plants to feed power into the grid (also measuring and reimbursing the deliveries) and by transmitting power from supply nodes to demand nodes, by transferring power to end users (again measuring and billing the flows). These transactions have to occur in real time (keeping the frequency of a.c. power in Europe at 50 Hz, keeping voltage in the neighbourhood of rated levels, guaranteeing a very reliable service with a minimum of outages etc).

In addition to its transmission tasks, the present grid operators also look after the despatch of the production

[3]See Joskow and Schmalensee, 1983.

plants of the related companies. The despatching function encompasses essentially three tasks: merit order loading of spinning capacities, unit commitment, and maintenance scheduling. The power companies argue that managing the grid in an optimal way also requires control over the (majority of) generation stations. For them, TPA would raise the transaction costs significantly and lower the service reliability. The force of this type of argument depends on the type of TPA that is installed and how the central grid authority is involved in regulating entries to the system. In any case, it is true that measuring the technical impact and the costs of power transactions over an interconnected grid is pretty difficult, and one has to rely on averages when billing a particular transaction (Vanlommel, 1992).[4]

It is also argued that the separation of production and transmission (unbundling), and the organization of production in a competitive way, would give rise to inefficient despatching of power. This need not be so. The central grid authority can organize biddings to contract for power on a long term, medium term and on-the-spot basis. If the bidding procedures are sufficiently fine tuned, all three elements of the despatching job can be covered effectively and efficiently.

Wholesale and retail markets for power

The wholesale power market consists of the transactions above, for example, 25 kV. The transport system could be separated from the rest of the power system (unbundled) in ownership and in control, and be operated by a unique central authority. This authority or grid operator then functions as a broker, buying power at the generators, transshipping the power and selling at the load centers to large customers or to distribution companies. If separated from the rest of the power system, we have to deal with a monopsony because (many) generators can but deliver to one party, being the high-voltage grid operator. As in any other wholesale market, competition among producers should characterize this part of the power system.

The retail market will normally be geographically segmented in franchised areas where power below, for example, 25 kV is handled. Here we will have a situation of a monopoly selling power to a wide range of users. By assigning full monopsony power at the generation side and full monopoly power at the consumption side of the bulk power market, to one particular institution (the pool or grid operator), it will be necessary to install firm regulatory control over this institution.

Two types of independent generators

At both ends of the market, the wholesale and retail ends, the phenomenon of independent power production is becoming more and more important. In the wholesale market, this poses no problem when more competition is introduced because then an independent producer would get the same rights and duties as the generation branch of any other formerly-integrated power company.

In the retail market, things are more blurred because here, most independent producers have not set up a generation system to deliver power to the grid, but to meet their own demand, for example, as a cogenerator, or to start valorization of renewable resources or waste flows. This type of independent producer turns out to be both a demander for power (supplementary and/or backup power) and a supplier of power to the grid (excess generation). Regulating this type of production becomes more complex but should be given a lot of attention because it is the segment of hope for the future of renewable energy (and cogeneration). We call this type of independent producers the independent generators of own power (IGOPs).

Competition requires regulation

In Figure 2, the consecutive prerequisites for real competition in the power market are shown. When the regulator would want to install diverging objectives and targets for the three main functions (eg profit making for the generators, brokerage for the transmission grid and energy service activities for the distribution companies), it is not feasible to verify performances in a vertically-integrated sector. Therefore, the final link for the establishment of more competitive electricity markets, is the full unbundling of the three main functions. But unbundling is not a natural drive of the power companies (De Paoli and Finon, 1993). In order to establish and to safeguard real unbundling, firm regulatory intervention is necessary.[5] While submitting proposals of market

[4]Although many advances are observed in the theory of transmission pricing (see, for example, Hogan, 1993), we believe that transaction costs will always be very high because of the volatility of power flows and the large amount of variables that determine every second the real cost of a single transaction.

[5]The UK experience is a clear proof of this.

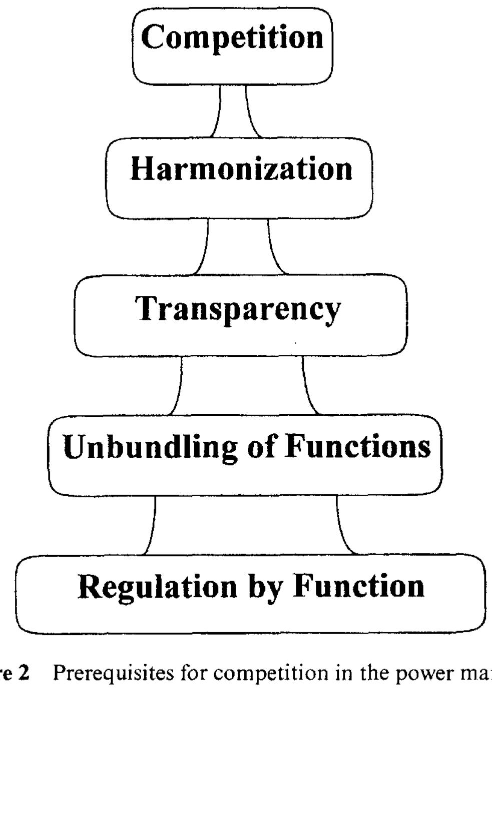

Figure 2 Prerequisites for competition in the power market

reform, one also should present the main lines of the regulatory system that governs the reforms.

Cost economies and power sector structure[6]

It is necessary to separately consider the economic rationale for organizing the three major functions of power systems, viz. generation, transmission (wholesale) and distribution (retail). The economic rationale is mostly represented by three types of cost economies determining the optimum economic structure of activities: economies of scale, economies of scope, and economies of density, being all three very relevant for power systems.[7]

Economies of scale

Economies of scale are measured along the average cost function of an activity. It is observed that most average cost functions are U-shaped, having (sometimes) a broad horizontal bottom like a modern crude oil vessel. The minimum efficient scale corresponds to the smallest activity level to arrive at the bottom of the cost curve; the maximum efficient scale corresponds to the activity level where average cost starts rising.

Economies of scope[8]

Economies of scope follow from the joint organization of various activities under one roof. Economies of scope occur only if they can compete with the economies of specialization being generally important in our societies.

Economies of density

Economies of density is a term we need for studying the economic activities that depend on geographically-spread but fixed infrastructures, such as wire and pipeline businesses. Every extension in space of the activities requires additional investment, but in most cases meeting extra demand within the covered area can be absorbed by the spare capacity of the existing infrastructure (eg increased pressure on fluids through pipelines). Because of the famous 2/3 law in the construction of networks, it will generally prove to be a waste of resources to allow more than one entity to construct a pipeline along a particular traject. This is a true situation of natural monopoly: one entity can deliver the service at lower costs than more than one entity could to together.

Cost economies and power generation

Considering the three types of economies for the three major activity areas of the power system, we find a different picture for each activity (Figure 3). Generation is characterized by

[6]See Hay and Morris, 1979.

[7]We do not consider economies of (vertical) integration as a separate term here because they are the subject of the overall article while comparing the integrated with the unbundled market structure.

[8]See Baumol *et al*, 1982.

Electric activity	*Economies of* Scale	Scope	Density (1)	*suggest as an optimum organisation*
Generation	yes	(2)	-	. regional, national international . single product (or CHP) . competitive and private
Transmission (Wholesale)	yes	-	yes	. international . electricity only . franchised monopoly (3)
Distribution (Retail)	-	yes	yes	. local . multi product . franchised monopoly (3)

(1) when economies of density prevail, one has a situation of a natural monopoly, i.e. a single entity is the cheapest way of providing any level of power
(2) CHP (Combined Heat & Power) is the noteworthy exception
(3) either a public company or a regulated private company

Figure 3 Economies govern the optimum organisation of electric activities economies of scale. These were observed at the unit level, the plant and site level, and the integrated system level. The latter in particular allowed the lowering of reserve margins while improving system reliability, and provided the basis for specialization among units in base, intermediate, peak, and reserve capacities.

Except for the cogeneration of heat and power, there are no economies of scope when generating power, nor are there economies of density (this means that the generation activity is not affected by the geographical origin of the loads it serves).

The three types of economies suggest, as an optimum organization for the generation of power, large-scale regional, national or even international companies, specialized in the production of power, and structured as private competitive companies. That most generation systems turned over to monopolies is primarily due to the economies of integration (common despatch) and is also due to spill over from the natural monopolies in transmission and to nationalistic policies.

Cost economies and power transmission

Transmission of power at high voltage is characterized by economies of scale and of density. The latter makes the monopoly a natural one and this is commonly alleged. The former is less absolute because a larger scale will result in a more hierarchical system with several levels of subsystems depending on the extent of the network, and topped by one overall coordinating center. Economies of scope are completely absent.

As an optimum structure for transmission at high voltage, it follows an international, specialized and franchised monopoly. The franchise area may cover a whole continent or part thereof.

Cost economies and power distribution

In distribution, it is not shown that enlarging the scale of the activities beyond the boundaries of some naturally-given service area (eg an urban metropole, a county etc.) offers any economic benefits. Some minimum scale is required when one wants to take care of specialized technical services, automated billing etc. although these tasks can be undertaken in a joint venture with neighbouring distributors or by specialized firms. It remains however that economies of scale in distribution are very limited and will soon turn out in diseconomies when the distance between distributor and customers becomes too large.

Economies of scope in distribution can be harvested when the ground is broken for cooperation between the various activities. The distribution company can cover, in addition to electricity, natural gas, district heating and even other services such as water distribution, sewerage, waste collection, street lighting and maintenance, public transport etc. It requires an efficient local company to take full advantage of the economies of scope.

The economies of density in distribution are well known and this natural monopoly was the basis for granting franchise monopolies to local distributors or to set up a local public distribution company.

Criteria measuring performance

In order to monitor the realization of the goals assigned to a power system, one can best call upon a series of criteria to measure performance. We propose five criteria: sustainability, economic efficiency, regulatory efficiency, institutional feasibility and equity. This selection, and also the interpretation of the meaning of the five criteria, is open to discussion but the core elements suggested are given next in a brief overview.

Sustainability

(1) The conservation of energy and other natural resources (eg materials and space) should be stimulated continuously beyond the levels reached at a given moment and place.
(2) The implementation of renewables should receive priority whenever their overall resource balance is more favorable than that of traditional solutions
(3) The use of energy sources with negative environmental impacts should be reduced. The phase-out should proceed along the weight of these impacts with emphasis on irreversible, long-term and global effects.
(4) The vulnerability of the electricity supply infrastructure should be as low as possible.
(5) Proliferation of technologies threatening international security should be minimized.

Economic efficiency

(1) The use of electricity for its suitable applications and in harmony with other energy solutions (eg natural gas for heating, renewables for heat and light).
(2) Steering electricity demand by efficient pricing, ie short-run marginal-cost prices including social costs and incentive taxes. Efficient pricing schemes transmit to the end users the right scarcity value of the product and are, therefore, the ideal tariff for power varies with time, place and reliability of supply. Efficiency also requires that the consumer is well informed and can decide him/herself about the worth of the goods offered. For power supply, the practice of the power companies deciding paternalistically about reliability levels should be subrogated.
(3) Electricity supply at lowest cost (construction of new plants, operation of available capacity in optimum merit order by optimizing unit commitment and maintenance scheduling, minimization of transport and distribution costs, minimization of bureaucratic slack etc.).

Regulatory efficiency

(1) Minimize the amount of information (and thus people and budgets) necessary to supervise the power sector;
(2) create self-sustainable and self-enforcing incentive mechanisms (ie behavior that the regulator considers necessary should avoid conflict with economic interests of the regulated parties);

(3) regulations must be auditable and enforceable at low cost.

Institutional feasibility

(1) The departure from present structures and habits should be as low as possible and take place in a gradual way (eg in most European nations market-oriented thinking and practices are less spread than in the USA);
(2) none or a minimum of new organizations should be created;
(3) electricity policy making should be embedded in the overall energy policy process.

Equity

- Monopoly profits should not be feasible.
- Cross-subsidies among electricity consumers should be avoided. (This requires a fine-tuned and generally-applied marginal-cost tariff system imposing on each one the real costs he or she causes.) However, many people handle another definition of equity. They consider the application of uniform tariffs as an equitable solution. We argue the opposite: equity means that the party that causes particular costs is also fully charged for these costs. Therefore, one should ban all types of cross-subsidies between and within consumer groups. In particular, the price discrimination inherent in uniform tariff structures should be reduced by applying to the fullest marginal-cost-based tariffs.
- Pricing (taxing) of energy should also look after a more equal distribution of incomes and especially take care of the poor. This consideration may be in contradiction to the former one emphasising marginal-cost pricing. However, in practice small-scale customers will be billed through rather simple tariff structures that cannot fully reflect marginal costs. When tariffs are deviating from the marginal costs, equity considerations can be brought in.

It is possible to extract from the above list of criteria a number of characteristics a good power system should own, such as transparency, competitive procedures, fine-tuned tariff mechanisms, etc. The European Commission in its February 1992 propositions has stated as objectives: free trade, supply security and competitiveness (see our criteria 2 of economic efficiency). In addition, the Commission wanted to respect four basic principles: no excessive regulation (see criterion 3), subsidiarity (see criteria 3 and 4), graduality and continuous dialogue with Council and Parliament (see criterion 4). Our list of five criteria encompasses the considerations by the Commission but are broader.

The old reference structure: vertical integration

In the power business, there has long been the belief that the vertically-integrated power system (see Figure 1) is the most optimal structure to supply power in an efficient way. In the vertical structure, the monopsony of the wholesale market is incorporated within one company; the monopoly in the retail market was considered to be checked by rate-of-return and tariff regulation; the growth of IGOPs was drowned by several factors at once (eg technological improvements in large-scale generation technologies, free access to large fossil fuel and nuclear resources, a hostile regulatory environment for decentralized producers etc.). We evaluate the vertical structure against our five criteria.

Sustainability is not promoted by the old reference system. It has been the vehicle for and is still the promoter of large-scale production with a devastating impact on nature and the environment (large dams, nuclear fuel cycle, risks, proliferation, coal mining and burning, offshore oil and gas exploitation plus transport, etc.). Ignoring the considerable negative externalities on the environment and on the future was common practice and the costs of this practice were not accounted for. Large-scale solutions are twinned with growth in consumption, necessary to acquire the economies of scale.

Proliferation of nuclear know-how, technologies and capabilities to manufacture weapons affects global security in long-term and irreversible ways (NEPSG, 1977; Goldemberg *et al*, 1988).[9] Centralized systems are prone to call on nuclear power.

Economic efficiency is advocated as the major trump of the vertical model. This allegation is based on the amazing gains in efficiency by integrating generation plants into a centrally-despatched network, also allowing the construction of larger plants in a period of increasing economies of scale. The advantages of central despatch in an interconnected network should be preserved and even extended in future power systems by introducing a system of central coordination.

In the vertical structures, there have been also major inefficiencies, for example, the systematic expansion of power systems into chronous overcapacity, the suppression of small-scale alternative sources such as renewables and independent combined heat and power, the foregone economies of scope in local distribution, the neglect of electricity savings opportunities, etc. As D. Tenenbaum, head of the Federal Energy Regulatory Commission (FERC) of the USA, summarizes: 'The traditionally vertically-integrated structure-...has the worst incentives for efficiency. This is because (it) provides no competition and is usually accompanied by some form of cost of service regulation' (Tenenbaum *et al*, 1992). In addition, industrial companies emphasize the necessity of competition to check efficiency [10].

Regulatory efficiency has been the subject of a vast debate,

[9]The main argument of the parties opposing the opening of the electricity markets in Europe, is the risk of losing the benefits of technical and economic despatch in an unbundled structure. EDF and Eurelectric are the most outspoken proponents of this argument. It is extremely difficult to verify the performance of the despatch function in actual systems, but there is no evidence that unbundled structures do not fully master the despatch job (see Loken, 1995).

[10]'We would like to believe that every power supplier today is most efficient throughout the whole spectrum of this operations, each in his particular market place, but we also believe that the real yardstick for this efficiency is the ability to compete with others in the same market place' (Declerq, 1993).

reflected in numerous publications. Inefficiencies caused by the applied rate-of-return rule, eg incentives to invest in capital-intensive equipment (Averch–Johnson effect), suboptimal tariffs, discriminatory pricing, losses in X-efficiency etc. have all had attention drawn to them. The 'capture' theory states that regulatory commissions can switch into a tool in the hands of the regulated party to avoid firm control. The old assumption that state-owned companies should not be regulated because they are owned by the state, and therefore their formal mission is the general welfare of citizens, has little credibility. Public utilities that are not supervised with market conforming incentive and control mechanisms can (will) deteriorate into very inefficient organizations.

The vertical structure is difficult to regulate for several reasons. Mostly, it has to do with very powerful structures, related through many channels with officials at all levels. In addition, the borders between the three major functions of the system are long (see Figure 1) and a long border is difficult to control for transfers. Regulation becomes really a bravura when the vertical structure should pursue conflicting goals (eg electricity supply and electricity conservation). It will require a highly competent, independent, well-equipped and large staff of regulators to clear this job. This kind of regulation exists in some states of the USA but is not widespread in Europe (Holmes, 1988). Therefore, attempts to introduce competition in generation in a vertically-integrated structure have failed [eg the UK, 1983: Hammond *et al* (1986)], if not guided by extremely complex and continuing buyer regulation (eg the USA since 1978). This is mainly due to a lack of transparancy at all levels, making it very difficult to control the real conditions of access to the grid. Even under advanced competitive procurement in a vertically-integrated structure (eg the regulatory approach of the Massachussets regulatory agency) the power companies have no direct economic incentive to purchase from a non-affiliated supplier since they earn no profit on the purchase (Tenenbaum *et al*, 1992).

Institutional feasibility of the vertical model poses little problems because it is still the dominant model of today. However, one sees a growing opposition against the vertical monopolies by industrial customers operating in a competitive environment, by supra-national authorities (Commission of the European Community), by liberal economists, politicians and citizens, by environmental and consumer groups etc.

Equity has received much less attention than efficiency in the discussion on sector regulation (Mosca, 1993). The aspect of cross-subsidization has been studied (also from an efficiency point of view with the Ramsey–Boiteux pricing rules), but the direction of cross-subsidies has been either unclear or different from nation to nation depending on national policies. Uniform pricing within consumer classes is accustomed in most systems. Special tariffs for the poor and elderly (mostly considered to be small consumers) are established, but initiatives to help them save electricity are rather exceptional. The profits and benefits of the monopoly statute are mostly divided among the power system itself and public interests (officials, local or state treasury). The employees of the power companies have been criticized because of privileged statutes and payment.[11]

An open structure for the electricity industry

The debate about another, more open and more competitive structure for the electricity industry is ongoing. Three major and interrelated developments are influencing the progress and will determine the turn-out of this debate: deregulation, technological evolution and environmental constraints. All three are subject to great uncertainty. Even the deregulation process can be stopped with a return to bureaucratic control. Technological evolution can be directed more to the development of sustainable solutions, or it may involve further environmental decay when the systems go for more energy intensive futures. Preserving nature and the environment will continue demand more attention and economic resources.[12] Continuing pressure to deregulate the new technologies (especially efficient end-use technologies, telecommunication, microelectronics), and the environmental arguments in favor of energy conservation and renewables, make the changing of the power industry inevitable. Reforming and restructuring the vertical model is possible and desirable.

Blueprint for an open structure

An open structure for the electric industry is shown in Figure 4. At the top, one has the generation companies, working in a competitive environment and not related by ownership or management control to the remainder of the sector. Generation companies build and operate power plants and deliver the output to the interconnected grid (as they do today). Entering the power market requires a company to be successful in two bidding processes: the first (eg quarterly) to get the right to build a particular plant, the second (eg hourly) to get the right to deliver power to the grid[13]. Both biddings are organized by the grid operator because he has to look after the optimal composition and the optimal operation of the European power system. There is no valid argument why the pool contracts should be limited to spot transactions. As in one of the most competitive markets of the world (ocean-borne crude oil shipment), it can be expected that the market stratifies from on-the-spot to long-term (eg 20 year) arrangements.

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[11] Employee earnings and status are presumably influential in the debate but this impact is difficult to monitor. In the traditional structure all employees benefit by a safe and well-paid job, with limits on earnings by top management when the companies are public. Liberalizing the market increases pressure on all personnel in the sector, because employment is less secure. Top managers, however, are rewarded by high salaries.

[12] See, for example, WCED (World Commission on Environment and Development) (WCED, 1987). See also '*Agenda 21*' stemming from the Rio de Janeiro UNCED summit in June 1992.

[13] The CEC rejects the idea of limiting the access by Independent Producers through the channel of tendering (bidding) and requires also free entry via authorization procedures (CEC, 1995). This issue is not of great importance to our model. We think that including bidding for construction limits the risks for independent producers. Also we preserve the authorization procedure for IGOPs (see further).

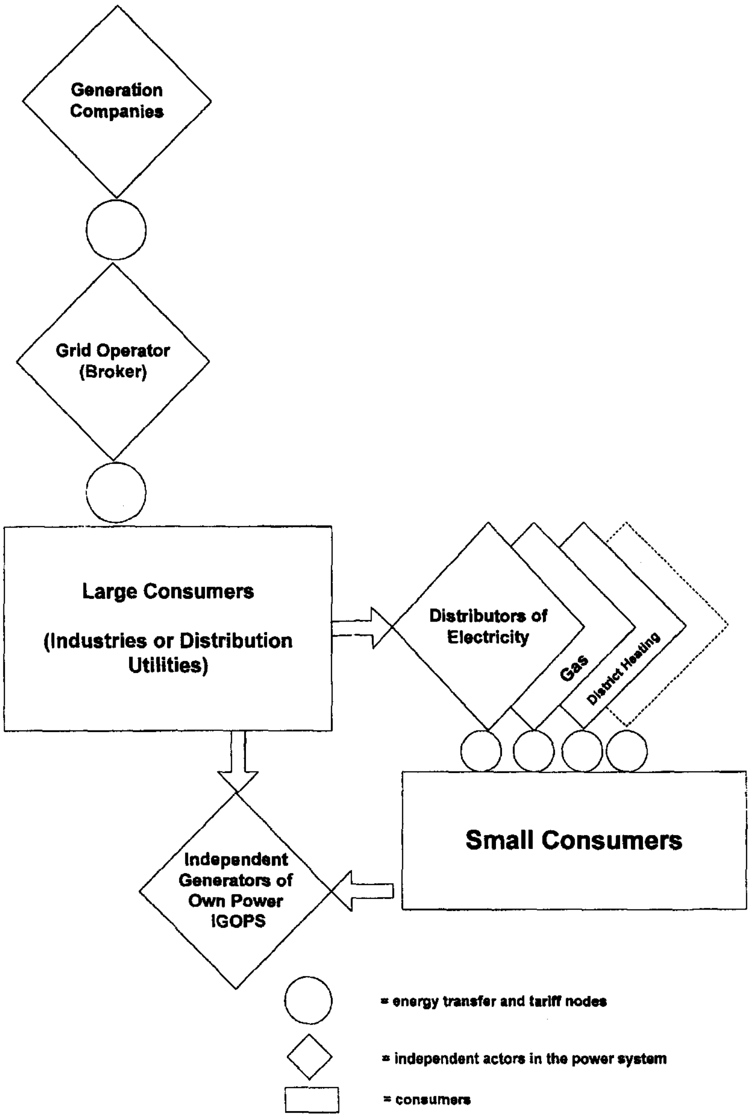

Figure 4 An open structure for the electricity industry

The second rhomb in Figure 4 represents the grid operator, occupying the central role in the integrated functioning of the power system (see the UK system). The grid operator owns and controls the high-voltage network and thus the wholesale market for power (being a European market). The grid company may also be allowed to own and operate non-spinning peak capacities (eg turbojets) and (pumped) storage plants, eventually resulting in total capacity. The pool operator despatches the production of electricity (merit order operation, unit commitment and maintenance scheduling) and ships bulk power over the grid. The role of the pool operator can best be compared with the role of the broker in other wholesale markets. The broker buys power at the generation companies at marginal generation cost (being the profit-maximizing equilibrium of competitive producers). The high-voltage grid delivers electricity only to large consumers. This can be large industries or distribution utilities. The transfer of power and energy is priced for all large consumers at the same tariff and prices truly reflect the marginal cost of the kWh delivered. We strongly support the idea of an instantaneous measurement and billing of power flows between the interconnected grid and the premises of large customers, being industries or distribution utilities. Instantaneous power supply is priced economically right when short-run marginal costs are charged. This pricing practice will generate sufficient cash-flow for the suppliers to cover all costs including investment (Boiteux, 1949). Of course, it is necessary to work out a broad range of contracting terms taking into account more explicitly the aspects of place (type of connection) and of reliability (interruptible loads), but all tariff contracts should be coined as posted standard offers that can be underwritten by large customers.

In Figure 4, the distributors of electricity are represented by the overlapping rhombs at the right side, suggesting their multi-scope structure for at least all energy types characterized by a natural monopoly. The distributors are considered as utilities supplying energy services to the end-users in their franchised areas. They are responsible for energy conservation, the development of local and renewable energy resources, least-cost planning for the area. They are regulated utilities with incentives to gain profits the more conventional energy is conserved or replaced by renewables. The local utilities should organize bidding processes for Negawatts (savings of electricity). This would guarantee a fair treatment for the cheapest solutions to provide electricity services. A real 'open bidding' will be easier to organize in an open than in a vertically-integrated structure. In the longer term, the competition should not be between different distribution companies, but between distribution companies and energy service companies (Lovins, 1990).

The fourth rhomb in Figure 4 shows the IGOPs that may be either large or small consumers of electricity. There needs to be separate regulation and tariff setting for this type of producer/consumer of electricity. On the one hand, one should stimulate IGOPs firmly because they are the carriers of a decentralized power system. There should be a general authorization procedure in use, allowing IGOPs to become 'qualified' when they meet the technical prescriptions. On the other hand, one must avoid an unjustified use of the IGOP statute. There are at least two ways in which this statute can be abused. First, generating companies can try to escape full competition by fellow generators by hiding as an IGOP supplier. Therefore, large-scale IGOPs connected to the transmission grid should deal directly with the grid operator. Secondly, IGOPs may be favored too much by distribution utilities with ambitions to control a large generation capacity. This will occur mostly when joint ventures or other types of partnership between IGOPs and distribution utilities are allowed.

With the rhombs, Figure 4 indicates that the four blocks of the power system are four independent activities, owned and operated by different organizations. The coordination among the activities is based mainly on price signals. Regulation occurs by on-the-spot controls on the pool operator, by setting transfer tariffs between the rhombs and by monitoring the performance of the distribution utilities (especially with respect to demand-side management, energy conservation and development of renewables). In the proposed system, TPA plays a minor role: generators must be guaranteed free entry in the market (when room is there) and all large consumers (industries and distributors alike) would face comparable conditions all over Europe for getting power in their plugs. Small consumers would be the principals of their distribution utility, functioning as a regulated agent. TPA has been at the core of the debate on deregulation and competition in the European electricity market. In addition, the CEC cannot accept the single-buyer model without 'negotiated TPA' (CEC, 1995). We are not convinced that TPA is really essential in reaching the final goals of the deregulation and enhanced-competition process, ie providing reliable power at the least cost in an equitable way (we certainly prefer to add 'sustainability' as an important criterion, see "Cost economies and power sector structure"). When we limit the discussion to cost efficiency, the task of a power system is to meet the loads forthcoming from the customers.[14] The aggregated load on a system can be considered from two opposite points of view: a 'horizontal' one where the total load is the sum of horizontal layers of capacities (MW), and a 'vertical' one where the total load is the sum of aggregated demands at particular moments in time (h).

The physical reality corresponds with the vertical approach and it is only due to the difficulty of measuring and trading in real time that the horizontal approach became dominant in, for example, tariff structures (two-part tariffs with a capacity and utilization charge). In the vertical approach, a just and equal responsibility is attributed to all consumers that build up a load at a particular moment in time. With tariffs based on the SRMC of supply, they all pay the same price for the same good and this is the most efficient and equitable solution. This solution is, however, only attainable in our system of unique grid operator. When the working of the single-grid operator is traversed by TPA trading, particular horizontal slices are cut out of the load structure, reserving the sliced part to one particular producer and to one particular consumer. This cutting out is no real problem when the TPA traders do not count upon the integrated system for backup and complementary power. However, they mostly do because otherwise they lose the significant economic benefits of integrated operation (low reserve margins, merit order functioning etc.). When they have to pay the right price for these benefits, the advantage of TPA transactions become small or negative (Boiteux, 1949).[15]

In the following discussion about the expected performance of the open structure for the five criteria ("Cost economies and power sector structure"), we will explain its functioning more in detail.

Expected performance of the open structure

Sustainability is promoted by two characteristics of the open structure. First, the conflict in interest between production growth and between energy conservation is no longer pursued by one organization. Second, demand management is the mission of local utilities, being in touch with end users and local circumstances, both necessary for developing local (renewable) resources and for trading-off various energy sources. Transforming distribution companies from the local sales departments of vertically-integrated power systems, towards local utilities regulated for a new mission, will lift a lot of barriers to energy conservation and to renewable energy. Barriers will become vehicles for change. The open structure

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[14]We do not discuss the important questions of load management and energy conservation at this point, but accept the loads as given.

[15]Also TPA transactions bear information, contracting, monitoring, etc costs. The major advantages of TPA remain, in the short-run, the support for efficient producers (significant when the power generation system is far out of equilibrium at present-day factor prices) and, in the long-run, the continuous pressure of potential competition.

provides fair opportunities to efficient technologies for decentral generation and for end use, both lowering the dependence on the central system.

Nuclear technologies, as they are today, are unlikely to flourish in the open structure, when they have to compete with market-tested solutions and when subsidies are abrogated. When the industrialized nations develop decentralized and sustainable electricity systems, they will also export these to the less-developed nations of the world. This new type of international aid and trade will considerably bring down the vulnerability of third-world electricity supply and the dangers of proliferation.

Economic efficiency in the open structure will certainly be higher than in the vertical monopolies. Competition in generation is coupled with the merits of planning for an optimally-composed generation system, while the merits of the present optimal despatching are conserved. This is realized by the double bidding process: first to build and become a member of the pool, second to operate on the basis of its marginal cost. The pricing of power supplied by the producers to the grid, and of power supplied by the grid to large consumers, is based on the marginal costs of power generation and transport. This way of pricing is the best in attaining economic efficiency, as the former president of EDF, M. Boiteux, has shown in his masterpieces on tariffs for electricity. A ceiling is put on the chronous over-expansion of power systems when peak demand is charged the full cost. It will improve transparency and will lower transaction costs significantly. It will require state-of-the-art metering and billing at the few 10 000 nodes in the grid where power is delivered and power is taken over by large consumers. Microelectronics have no problem with this task.

The local utilities for energy servicing must integrate the economies of scope and of the development of local resources and energy savings. These should be regulated in an efficient way and in many countries with a poor tradition in local authority, it will prove necessary to support the local regulators by national agencies. The local utilities need to be regulated for efficiency; we believe this is a more accessible task because of the separation from other activities in the power sector, because of the clear and nonconflicting new mission, and because of the direct control by their constituent end users. The latter factor must be improved significantly compared to present practices. Consumer councils, procedures to file complaints and get payment for quality shortfalls etc. should be a continuous check on the utilities' performance. In our proposition, the small consumers do not get the opportunity to 'shop around' for another supplier because we think this would increase transaction costs significantly without improved efficiency gains. Quality performance control by regulators and consumers alike open brighter perspectives for keeping the X-efficiency of local activities in line.

The stimulation of the IGOPs by a fair regulatory regime and by fair tariffs, will guarantee a spawning of activities in local electricity generation, including renewables. In addition, the energy tax instrument can promote high levels of energy conservation, opening the way to renewables. The local utility must support conservation efforts with information, investment credits, third-party financing etc.

When local utilities are publicly owned, they should be organized as a limited company, allowing the application of flexible and efficient procedures as any other private company.

Regulatory efficiency in the open structure is expected to score higher than in the vertical structure. We see the need for a two-level regulatory authority. The top level works at the European scale, supported by offices in every member state. This level has to regulate the working of the grid. The second level of regulation is at the local level, with support from the national offices. This level regulates the local utilities.

The expectation of high regulatory efficiency is based upon the unbundling of the various power functions and reducing the borders between the functions to a limited number of gates that are more easy to control. Generation will be organized as a competitive bidding activity, an area that is well under regulatory control and well-understood by private enterprise. Collusion at the producers' side can be avoided by high penalties when uncovered. The widening of the market to the European scale offers even more hedging against opportunistic behavior.

Regulating the pool operator is the most central task for the European regulator, encompassing several aspects. Mentioned above was the regulation of the bidding processes for generation. Next the despatching function (merit order loading, unit commitment and maintenance scheduling) should be verified. The investments in the grid and quick-start and storage capacities must be monitored too. Finally, tariffs for power purchased and power sold by the pool must be set based on the marginal costs of generation and transport. One should aim at an incentive-based regulation, comparable to the way earnings are paid to brokers in commodity markets. The pool operator's profits should increase with the number of kWh he can ship, be inversely related to the price of the traded power (or preferably to the sales volume), while quality and reliability measures should adjust his profits to his technical performance at any moment in time.

Regulating local utilities should also be based on incentive regulation promoting the conservation of energy. It will be necessary to develop reliable energy-intensity indicators as yardsticks for measuring performance. Presumably, one will also need some kind of conduct regulation, being difficult and costly. Many advantages may be expected from the procedures that give power to the end users in filing claims and in getting payment for shortcomings by the utilities. Local utilities will be given the franchise of their service area; they will be obliged to serve all end users (except the large ones) and they will be free to apply either uniform tariffs or more incentive-based pricing mechanisms. Pricing and taxing in order to promote energy conservation should be warranted in any case.

Institutional feasibility of the open structure remains a big question mark because it will not be welcomed by the vertically-integrated power companies in Europe and neither by the free marketeers because it does not entail TPA. However, the structure strives for the maximum economic efficiency and regulatory effectivity and efficiency, with an outlook on the path towards a sustainable energy future. It also takes into account the concerns of many interest groups[16] and heavily underpins the integration of the European market. The structures needed to make it operational are at distantly available [eg the UCPTE is the embryo of the grid operator; a European regulatory office has to be set up with national regulatory commissions such as OFFER (UK) being its national offices]. The major obstacles for the open structure are the weak local authorities in many member states and the strongly-organized power of the vested vertically-integrated power companies. The first 'stepping stone' of realizing the open structure has already been taken by the European Commission by urging progress in price transparency and unbundling production and distribution activities and in increasing transit facilities for third parties. We think that (particularly) unbundling needs to be realized much more quickly and fully for two reasons. First, unbundling and assigning specific roles to the three activities generation, transmission and distribution, are conforming with the cost economies of the activities. Secondly, without unbundling, it is impossible to install workable competition in the electricity market and to figure out an effective and efficient regulatory supervision.

Equity is but partly realized when structuring economic activities for sustainability and efficiency. Because of the transparent structure of the open system, cross-subsidies between the various customer groups becomes impossible. Bulk power supplies by the grid will be priced at standardized tariffs for all large consumers, be it industries or distribution companies. Within the service area of local utilities, one may expect the application of uniform tariffs, implicitly entailing cross-subsidies among the consumers. One should strive for cost-based tariffs anyhow and carry out social policy through other means, eg direct investment in energy conservation for the poor. When tariffs are changed to stimulate energy savings (eg by making the rates progressive), this will not necessarily have negative income distribution effects. In the open structure, monopoly profits become much more unlikely than they are today.

Table 1 Overview of the evaluation of two market structures for five criteria

Criteria	Vertical integration	Open structure
Sustainability	–growth oriented	+new role for distribution utilities
	–nuclear proliferation	+decentral options +energy conservation
Economic efficiency	+central dispatch ± large–scale units –overcapacity	Competition +grid coordination +marginal cost pricing
Regulatory efficiency	–low transparency –mighty organization –conflicting goals	+high transparency +consumer control +proper goals
Institutional feasibility	+present dominance –not compatible withcommon market	–new solutions +meeting criticism ofsocial groups
Equity	?cross subsidies ?monopoly profits	+open markets +same tariffs for the same uses

+=good performance.
–=bad performance.
?=uncertain.

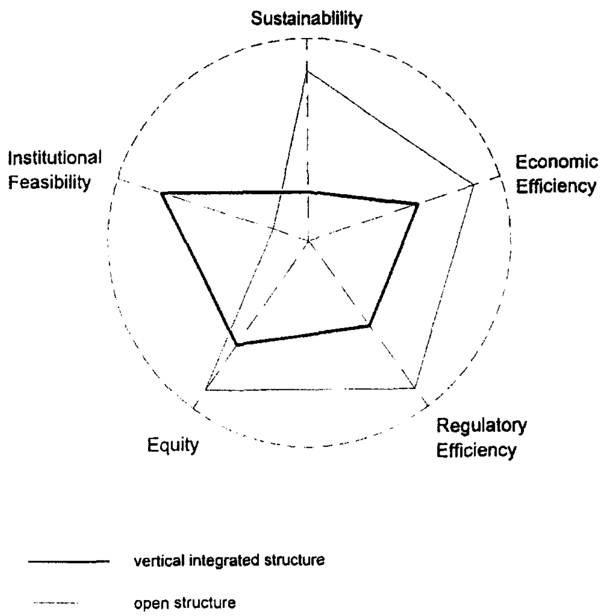

Figure 5 Performance of the vertically integrated and the open structure for the five criteria

Conclusion

A comparison between the performance by the vertical and by the open structures, is shown in Table 1 and in Figure 5, with the pentagon as a tool used frequently in multicriteria analysis. Our arguments in "The old reference structure: vertical integration" and "An open structure for the electricity industry" result in a better score for the open structure on four of the five criteria: sustainability, economic efficiency, regulatory efficiency and equity (Pierce, 1994).[17] As expected, it falls behind the vertical structure regarding institutional feasibility. Overall, the open structure covers a larger area of the pentagon than the vertical structure, even without weighing differently the five criteria (eg sustainability may be assigned far more weight than institutional feasibility).

The open structure will support least-cost planning in a more consistent way than the vertical structure, with its ambivalent and conflicting goals. The local utilities play a central role in the transition to a sustainable energy system. They only can play this role when not governed by the interests of large-scale production companies, but directed

[16] In 'Changes in the European Power Industry' (PowerGen Europe, 1993, Conference papers, Vol. 2) With contributions from Mr Lionel Taccoen, EDF; Dr Daniel Declercq, IFIEC and Air Products NV; Ms L. Mosca, BEUC; Ms Penny Boys, OFFER.

[17] For similar conclusions, see Pierce (1994).

by effective and efficient regulation (eg profits of the local utilities should be related to the success of demand side management and of energy conservation campaigns). It is a deep-rooted misunderstanding to prefer vertically-integrated monopolies for realizing least-cost planning when one wants least cost planning tending towards a sustainable energy future. It is much better to create transparent structures where every party can play its natural role and pursue its natural objectives. Clear and slim regulatory authorities must conceive the mechanisms for correlating the natural objectives of every part (being generally selfish goals), with the progress in social welfare. They will be far more successful in an open structure than in the house of many rooms of our vested power monopolies.

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