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Industry Infrastructure

This part describes the infrastructure of the industry and the various structures that have been put in place to effect market operation and how they have performed. It introduces the various entities involved in the process and how they interact.

Chapter 1 Approach to Restructuring

This describes the motivation behind restructuring and the various stages of liberalisation. The different approaches taken by countries and the rationale behind them are discussed.

Chapter 2 Market Mechanisms

This outlines the different market structures that have been applied and explains their operating arrangements. It covers the Pool, Single Buyer, Multi-Market, Nordpool and Balancing Markets and their approach to pricing.
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Approach to Restructuring

1.1 INTRODUCTION

The last 20 years have seen restructuring of the electricity sector spread around the world with the expectation that the introduction of competition would lead to a more efficient industry with lower prices. Starting with simple mandatory Pool models, some countries have progressed to the complete liberalisation of both generation and supply with competition at each stage of the cost chain. Other countries have opted to introduce competition in generation with a Single Buyer market model. The approaches have been tailored to meet the developing needs of each country with varying degrees of success in meeting their objectives. In some circumstances it has been an essential prerequisite to encouraging new investment; in others it has been to improve operational efficiency.

The industry now faces a new set of challenges and it will be important to review how well the structures in place are able to meet them. Escalating fuel prices and the impact of emissions on the environment and global warming bring the industry into the forefront of political debate. Attempts to encourage the development of renewable energy sources based on ‘feed in’ tariffs and requirements placed on suppliers for a percentage of their energy to be derived from renewable sources have met with limited success. The introduction of emission trading schemes has sought to establish a market price to realise the least cost abatement approach to reducing emissions. The early phases have not been effectively managed and have had poor results.

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The burgeoning energy demands of the Chinese and Indian markets add dimension to the problems faced. Concerns over security of fuel supply and the prospect of a revival in nuclear energy raise concerns at a political level. Will the structures put in place be robust enough to deal with these issues or do we need to rethink the approach? The management of some of the risks requires the resources of large organisations rather than a fragmented industry. The results of mergers and acquisitions has seen the European sector moving from the industry being structured on a national basis to being controlled by large multi-nationals like EdF, RWE, E.On, ENEL and Iberdrola. At the same time several national markets have merged and moved towards providing the prime cover for several countries: Central Europe, including France and Germany; Benelux embracing the Netherlands and Belgium; Iberia covering Spain and Portugal and an all Ireland market covering the Republic and Northern Ireland. The coverage of the power exchanges has followed suit with activities being merged. It is timely to review the current status of the industry and its fitness to meet the needs of the future.

This chapter provides an overview of the approaches that have been taken to restructuring and the market designs that have been adopted. It discusses:

- the reasons for promoting restructuring of the industry to introduce competition;
- the different market structures that have been applied;
- a comparison of the market models illustrating their strengths and weaknesses;
- some of the results of restructuring.

The initial step in the unbundling process was usually to split off generation from transmission. A further step would be to break up the generation into separate competing generation blocks. The transmission would be regulated as a monopoly business and it is often required to separate out the system operation function to establish a totally Independent System Operator (ISO). The distribution companies may be retained as an entity supplying a franchised customer base or split into a wires ownership organisation and a supply business, managing supplies to customers. The wires business would be regulated as a monopoly while supply would be open to competition. The general approach has been for supply competition to be introduced gradually starting with large consumers and working down to the domestic market. In the EU the target date for completion of the process was mid 2007.
1.2 INDUSTRY PHYSICAL STRUCTURE

A simple schematic of the physical infrastructure of the industry is shown in Figure 1.1. It is made up of generating stations connected to an interconnected super-grid operating at system voltages\(^1\) of typically 275/400 kV and enabling the pooling of generation. The generation voltage is typically 11–22 kV and is transformed up at the station to 275 or 400 kV for connection to the grid. Nearer the load centres transformers at the grid supply points (GSPs) reduce the voltage from the super-grid level to 132 or 33/11 kV.

These voltages may be used to supply larger industrial consumers as well as local distribution rings operating at 11 kV. These may also feed larger commercial premises as well as local substations transforming from 11 kV to 415 V that are used to connect to domestic premises supplied from one phase operating at 240 V. There may also be inter-connection to adjacent systems connected at the super-grid level and also smaller generation embedded within the distribution network.

\(^1\)System voltages in three-phase systems are normally referenced by the line or phase to phase voltage and equal 1.732 times the individual phase to neutral voltage.
The physical entities involved are:

- the **Transmission Owner** who plans, builds, owns and maintains the super-grid system typically made up of 275/400 kV transmission lines, transformers and reactive compensation equipment;
- the **Distribution Owner** who plans, builds, owns and maintains the distribution network made up of the 132 kV network and lower system voltages and associated transformers and switchgear;
- the **Generators** who plan, build, own, operate and maintain generation that may feed into the super-grid network or, if smaller, be connected into the local distribution network;
- the **System Operator** (SO) who manages operation of the power system so as to maintain stability and the security of supplies from minute to minute.

Until around 1990 the industries in most countries were operated as monopolies in state ownership with the generation and transmission under the control of one central authority (the Central Electricity Generating Board in the UK) supplying distribution companies with a geographically defined franchise for customers in their area. This was the general arrangement, although in some countries the local distribution was under the control of the municipal authority. The central authority managed the development of the generation and transmission to meet expected load and operated the system so as to minimise the cost of production whilst maintaining security. The authority procured fuel and recovered its costs from the sale of energy to the distribution company against a bulk supply tariff (BST). This tariff was structured with an element related to the maximum demand together with an energy component. In the UK the maximum demand, referred to as the triad, was the maximum demand occurring during three non-consecutive half hours separated by more than 10 days. The fixed element, related to maximum demand, was designed to cover the costs of capital for the investment in generation and transmission required to meet the demand. The energy part of the tariff was designed to reflect the marginal costs of production with cheaper charges overnight and at weekends and higher charges during the weekday working hours. For example the 88/99 UK BST prior to liberalisation was structured as below.

**Capacity charges**
- Peak £23.5/kW based on triad demand
- Base £20.0/kW based on average demand of 300 half hours
Energy rates p/kWh
Night 1.57 (2400–0800 hrs)
Day 2.16 (0800–2400 hrs)
Surcharge 1.0 at peak
The total charges would be made up of:

- the peak capacity charges times the recorded triad demand (the average of three recorded peaks separated by 10 days);
- the base capacity charge time the average demand of 300 half hours;
- the night energy rate times the total energy recorded between the hours of 2400 and 0800;
- the day energy rate times the total energy recorded between 0800 and 2400 with a surcharge added to the recorded energy for the peak hour.

The industry was controlled by external finance limits set by government and was at that time set to be negative, requiring debt repayment. Defined levels of coal were also required to be burned without the freedom to choose fuel sources. It was subject to frequent government interference and used to support general fiscal policy. The industry was driven technologically to achieve improved production efficiency but in operation the dominant influence was to maintain security rather than to minimise cost. Despite this, cost improvements were realised through the development of larger more efficient generation and higher voltage transmission systems. The development of generation capacity in Western Europe is shown in Figure 1.2. It shows the recent and projected trend in capacity with oil and coal declining, while renewable and gas are increasing. The emphasis on security sometimes leads to over investment to avoid shortfalls in capacity during worse than average weather or exceptional plant failures. The lower dotted line of Figure 1.2 shows the demand, while the upper shows the expected available capacity allowing for outages. It can be seen that the margin of spare capacity is expected to be at a much lower level than that planned by the state controlled utilities.

Energy prices were set reflecting average costs rather than the marginal cost of production. The distribution companies managed the development of the distribution system for which they had a franchise. They bought energy from the CEGB and sold to end consumers against a set of user tariffs. Although ownership arrangements varied this was the norm around the world with geographic regulated monopolies.
1.3 INTRODUCTION OF COMPETITION

There was no competition in generation or supply and this was considered to be inefficient. The distribution companies had no choice but to buy from the central generating authority at the prices declared in the BST. End users had no choice but to seek a supply from their local distributor and pay the declared tariff. Various economic advisers suggested reform was necessary because:

- the model gave no incentive to operate efficiently;
- it encouraged unnecessary investments;
- the cost of mistakes were passed on to the public without recourse;
- it was too easy for governments to interfere, creating a stop/go policy.

It was argued by advocates of deregulation that market disciplines would lead to lower prices and benefit consumers and the country. It was recognised that the industry had some special characteristics but that these did not present insurmountable problems.

There were opponents to the proposals who saw counter issues including:

- the need to maintain strategic control of a key part of the country’s infrastructure;

![Figure 1.2 Developing plant mix Europe](image-url)
• the need to coordinate investment planning centrally to establish adequate levels of capacity;
• the need to maintain a plant mix by fuel and type;
• the ability to finance large high capital cost investments;
• the need to fix responsibility for maintaining system security.

The opponents argued that these factors were more important than any benefits that might accrue from introducing competition. Despite these misgivings, it was proposed that a path of liberalisation should be pursued in the UK as well as elsewhere. A number of factors needed to be addressed to ensure a successful outcome including:

• the structure to be put in place to facilitate competition;
• the number of separate owners necessary to realise competition;
• the mechanisms to recover the costs of the transmission/distribution monopolies;
• the mechanisms that needed to be put in place to establish competition through a liquid market with many participants including the demand side;
• the mechanisms to ensure that security was maintained;
• the mechanisms to enable the System Operator to balance the system and maintain the security and quality of supplies;
• the realisation of the optimum levels of investment;
• the implications to equipment suppliers.

Of these, establishing a liquid market where the transaction volume exceeded the physical volume was kernel to establishing effective competition.

There was no universal answer to all these issues and each country that chose to pursue restructuring adopted a different approach tailored to meet their priorities. In most cases the first step was to un-bundle ownership. This meant separating ownership of transmission from generation, splitting up the generation into a number of competing blocks and establishing an Independent System Operator to manage dispatch to meet end consumer needs. Secondly restructuring would put some form of market structure in place to facilitate trading and competition.

1.4 RESTRUCTURING OPTIONS

Various restructuring options have been proposed and applied in different countries including the following.
1.4.1 The Gross Pool

This is the model originally applied in the UK in 1990 where it was mandatory for all energy to be traded between generators and suppliers through the pool shown schematically in Figure 1.3. This model was adopted by other countries such as South Africa. The price paid by participants or the market clearing price was set in advance, based on a unit commitment study. This was based on an optimisation algorithm with the objective function of minimising the total cost of production based on the prices submitted by the generators. In the UK model transmission constraints were initially ignored and generation was selected in cost order irrespective of whether its use would violate a network security. It was argued that network structure was not the responsibility of generators or suppliers and the same energy price should apply irrespective of physical location. A separate operational study was then used to determine the practical generation utilisation taking account of the effect of network constraints. The additional generation costs incurred were shared between all suppliers. Most players hedged against the volatility of pool prices by striking two-way hedging contracts (contracts for differences – CfDs) to adjust pool payments to a pre-agreed contract price. This model has been used in South Africa, Singapore and Spain.

The supply side of the business has also been liberalised with the franchise of the local distribution companies being progressively removed, enabling consumers to have a free choice of suppliers. The free choice was initially given to those consumers with a demand greater than 1 MW followed by an extension to those with a demand greater than 100 kW in 1994 and for all consumers by March 98. This pattern of progressive liberalisation of the supply side has been mandated by a European Union Directive for completion in 2007.

Figure 1.3 Mandatory pool
1.4.2 Multi Market (Bilateral Trading + Balancing Market)

This model is widely used across Europe with most of the energy traded directly between generators and suppliers through bilateral contracts as illustrated in Figure 1.4. These may be established though OTC trading or through a tendering process. Nearer the event, positions will be adjusted by trading on exchanges for the day ahead. Finally, since in practice the level of demand and the availability of generation cannot be accurately predicted, a Balancing Market (BM) is used to clear the residual energy and any un-contracted demand. It has been argued that full competition is not realised through this process as the bilateral contracts are not visible publicly to enable price discovery. The process will also be sub-optimal in that although individual generators will be able to optimise their particular running arrangements the opportunity to establish a national optimum is lost and overall costs will generally be higher. This arrangement, sometimes called the net pool, is widely used across Europe with most of the energy traded bilaterally with exchanges used to adjust to meet short term needs and a Balancing Market used to enable the System Operator to effect real time balance.

1.4.3 The Single Buyer

With this approach a nominated authority acts on behalf of all registered consumers to collate demand predictions and negotiate with generators to buy energy and services as indicated in Figure 1.5. Agreements will include the purchase of existing station outputs and establishing contracts for the output of new stations. The arrangement has been criticised in that the authority represents a monopoly that is not in itself subject to market forces. However, it does realise competition in generation and enables the
development of generation and transmission to be coordinated and optimised in both the planning and operational timescales. A progressive introduction of the single buyer model is possible with a mixture of state and independent generation in varying proportions. The buyer should not own generation to avoid a conflict of interest and to maintain impartiality. Countries such as China, Abu Dhabi, Oman, Egypt and Namibia operate single buyer models. This model is popular where there is significant system development being undertaken that needs to be coordinated centrally.

1.4.4 Power Boards

In this arrangement the price of energy is set for defined geographical zones that are tightly coupled by transmission and dominated by a vertically integrated company as illustrated in Figure 1.6. This means that generation within

![Figure 1.5](Image) Single buyer market

![Figure 1.6](Image) Power boards
the zone can usually be used freely without limitations due to transmission. Trading is effected between zones depending on the level of interconnection capacity and price differentials. This approach introduces additional complexity but highlights the importance of transmission and creates an incentive to invest. It is therefore appropriate where the existing network is weak and the introduction of more inter-zonal transmission capacity would bring consumer benefit. The capacity of the interconnecting transmission is usually auctioned and can be bought by parties on both sides of the link. The trading could be between the pool authorities or directly by generators who have bought capacity to enable them to bid into adjacent areas/pools, as happened with Scottish and French generation who bid into the UK pool. Where generators are also allowed to register as suppliers they may acquire local distribution and supply companies and become vertically integrated power boards.

1.4.5 Open IPP Access

With this arrangement the main body of generation is retained with a state interest but the system is required to enable the entry into the market of a proportion of non-utility generation (NUGs). The benefits of integrated planning are retained and a measure of competition is introduced to the utility generation. The system provides a useful intermediate step to introducing full competition in generation but it is claimed that the utility always favours its own generation and true competition is not realised while the buyer owns generation. The French introduced a system whereby external parties could contract the output of EdF generation capacity to meet their supply commitments. The Republic of Ireland adopted a system to encourage new entry through the provision of prices for ‘spill’ and ‘makeup’ energy. This enabled independents to balance their position by buying ‘makeup’ energy to meet their commitments when their own output was restricted or selling excess ‘spill’ energy when in surplus.

1.4.6 State Utility

This model is essentially a fully integrated utility where all the generation is under state ownership together with transmission and sometimes distribution. In this model the government sees the need to retain a national champion to safeguard its strategic infrastructure. The absence of competition may lead to inefficiencies but this can be in part offset by introducing a proportion of financing through the private sector to exert influence. The main advantage is that it enables integrated generation and transmission planning and can create a relatively stable environment in which to encourage investment. For
a developing country it has many advantages and allows the state to adopt a tariff policy that encourages the development of the infrastructure of the country as well as supporting the financing of major projects like hydro schemes. Some new investment may be encouraged through the establishment of long term Power Purchase Agreements but subject to central control.

1.5 COMPARISON OF STRUCTURES

It is difficult to draw quantitative comparisons between the various market models because the outcome depends on the structure of the utility to which they are applied and its state of development. However, a qualitative guide is shown in Table 1.1, illustrating the strengths and weaknesses of each option. The table columns shown make comparisons assuming the following.

1. Competition in generation gives cost saving through the introduction of more efficient generation such as combined cycle systems and CHP reducing the fuel bill.
2. Integrated planning saves in avoiding excessive capital costs by ensuring the ideal plant margin and generation mix with no excess capacity.
3. A monopoly results in inefficiency and additional costs resulting from higher staff levels and a reluctance to use generally available standard equipment.
4. The cost–benefit rating indicates the combined effect of the key factors affecting costs.
5. Column five gives a subjective view on the implications of the chosen market structure on the likelihood of securing new investment.
6. Column six gives the likelihood of the chosen model maintaining system security.

Table 1.1 Market comparisons

<table>
<thead>
<tr>
<th>Structure</th>
<th>Generation competition</th>
<th>Integrated plan/ops</th>
<th>Efficiency</th>
<th>Cost–benefit rating</th>
<th>Invest. rating</th>
<th>Security rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross pool</td>
<td>VG</td>
<td>M</td>
<td>M</td>
<td>B</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Multi Market</td>
<td>VG</td>
<td>B</td>
<td>M</td>
<td>G</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Open IPP access</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>B</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>State utility</td>
<td>VB</td>
<td>VG</td>
<td>VB</td>
<td>VB</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>
Table 1.1 uses these factors to provide an indicative comparison of the different market structures ranging from: very good (VG); good (G); medium (M), bad (B); very bad (VB).

The **gross pool** realises price competition in generation by splitting up the state generation. This assumes that sufficient competing groups are established to ensure competition but in practice this is sometimes difficult to achieve. Central control and coordination is maintained at least for the operational process if not planning. The culture of the state utility will continue to operate and the removal of inefficiency and excess staff will be slow.

The **Multi-market model** enables bilateral trading with a Balancing Market and also realises competition in generation and, whilst losing some central operational coordination, it shifts the culture to a more efficient competitive level. Participation in a day-ahead market and the BM is optional.

It can be seen that the **Single Buyer** model scores high with a very good cost–benefit rating in that it enables the benefits of competition in generation and the coordination of central planning whilst removing a lot of the inefficiency of a state utility monopoly culture. A difficulty with its application is in managing operation against a contractual framework based on PPAs. It is sometimes difficult to apply the strict terms of a complex contract into the management of day to day operation of the plant.

**Power Boards** introduce competition between each area through trading across inter connectors. Each Board may operate as a vertically integrated utility internally so generation competition is not complete nor is central planning globally coordinated. Each Board will operate within its area largely as a monopoly with limited improvement in efficiency.

**Open IPP access** introduces limited generation competition to the residual state generator but IPP entry is sometimes difficult to attract because of the market domination. Some central planning is retained and some improvements in efficiency can be expected.

The **State Utility** maintains the benefits of optimal central planning and coordination but this benefit is largely offset by the inefficiency of the monopoly in operation. There may be some small benefit derived from enabling access to a few IPPs that set benchmarks.

The best model for a particular country will depend on the state of development of the network and the need for new investment in transmission and generation. It may also be influenced by the perception of risk in the country and the need to encourage electrification of under-developed areas.
A number of countries such as South Africa have adopted a Pool-like model as a relatively simple transition with a view to further development as experience develops. The Multi-market model is the one most widely applied in the developed countries of Europe where the emphasis is on improving the efficiency of systems that are largely established. In developing regions, such as Africa, there is often a need to encourage inward investment and this may be more easily realised if Power Purchase Agreements (PPAs) can be put in place. This can be best undertaken by a Single Buyer acting on behalf of the end users and able to underwrite the contract. In some small states in the Middle East there may be insufficient generation to establish a viable competitive market and the Single Buyer model has been adopted.

1.6 SUMMARY

This chapter has described the motivation behind the introduction of competition into the power sector with the expectation that it would drive prices down and provide customer choice. Opponents to liberalisation argued that the loss of central control would undermine the investment process and endanger system security but on balance it was decided that the potential benefits outweighed these disadvantages for the UK. Some countries followed the UK approach but others pursued different approaches. The various market models that have been applied have been outlined and a coarse comparison is drawn between them. It is recognised that there is no universally correct model but rather that the needs of each country need to be analysed to establish the objectives. The state of development and size of the sector, the need to encourage inward investment and finance large projects are all relevant issues that will influence the optimum design.

Looking to the future it is difficult to see how all of the challenges can be met with some market structures. A key weakness of market based structures over a central planning approach is in the coordination of investment. The market will have a tendency to keep plant margins low when shortfalls can be expected, driving up prices. This can also result in insecurity with a higher probability of loss of supply when multiple failures result in insufficient generation to meet demand. The other area that presents problems is in coordinating the developing mixture of plant to maintain diversity and some hedge against fuel supplies being interrupted. The Single Buyer model does address these issues and allows the Buyer to place tenders for new capacity,
thereby controlling the volume and type of generation. There are a number of other concerns as outlined below.

- The development of renewable sources has been subject to government intervention in the market and it would not have happened without incentive schemes.
- The Emission Trading Schemes have so far failed to deliver the target reductions.
- The absence of price stability is a problem for industry that has led to the establishment of consortia to establish long term supply contracts.

It remains to be seen if governments will tolerate these adverse effects in the hope that the market structure will eventually deliver or if they will seek to exercise more direct control.