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ENERGY
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REFORM

ELECTRICITY MARKET REFORM

An IEA Handbook

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INTERNATIONAL ENERGY AGENCY

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The International Energy Agency (IEA) is an autonomous body which was established in November 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme.

It carries out a comprehensive programme of energy co-operation among twenty four* of the OECD's twenty nine Member countries.
The basic aims of the IEA are:

- To maintain and improve systems for coping with oil supply disruptions;
- To promote rational energy policies in a global context through co-operative relations with non-Member countries, industry and international organisations;
- To operate a permanent information system on the international oil market;
- To improve the world's energy supply and demand structure by developing alternative energy sources and increasing the efficiency of energy use;
- To assist in the integration of environmental and energy policies.

**IEA Member countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States. The European Commission also takes part in the work of the IEA.*

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Pursuant to Article 1 of the Convention signed in Paris on 14th December 1960, and which came into force on 30th September 1961, the Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

- To achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
- To contribute to sound economic expansion in Member as well as non-Member countries in the process of economic development; and
- To contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The original Member countries of the OECD are Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries became Members subsequently through accession at the dates indicated hereafter: Japan (28th April 1964), Finland (28th January1969), Australia (7th June 1971), New Zealand (29th May 1973), Mexico (18th May 1994), the Czech Republic (21st December 1995), Hungary (7th May 1996), Poland (22nd November 1996) and the Republic of Korea (12th December 1996). The Commission of the European Communities takes part in the work of the OECD (Article 13 of the OECD Convention).

FOREWORD

The electricity supply industry is under reform in nearly all IEA countries. The new framework is characterised by the introduction of competition in electricity generation and end-user supply, new access to electricity networks and a redefinition of the regulatory function of governments.

This study describes the changes that are taking place in the industry and its regulatory structure, surveys the experience acquired so far, and identifies some key issues and lessons for the market-oriented reform of electricity supply.

Available evidence on liberalisation confirms the expectation of an improved economic performance of the sector, including lower costs and prices and increased consumer choice. However, along with economic efficiency, governments have to meet other public objectives, including security of supply and environmental protection. This study provides insights into how governments can successfully address this complex array of objectives in the new regulatory environment.

"Electricity Market Reform" is an update of a study conducted jointly by the OECD and the IEA as part of an overall project on regulatory reform. It was previously published as a chapter of "The OECD Report on Regulatory Reform" (OECD, 1997). The primary authors are Caroline Varley and Gudrun Lammers of the IEA. I thank IEA member countries for their helpful co-operation in providing and verifying factual information.

Robert Priddle
Executive Director

TABLE OF CONTENTS

LIST OF TABLES

LIST OF BOXES

INTRODUCTION

This study forms part of an overall project on regulatory reform initiated by the OECD, as well as part of the ongoing work programme of the IEA. A main purpose of the OECD project is to disseminate some of the "lessons learned" in earlier reform experiences.

Electric power is essential to modern life. It fuels much of industry, the incubator of the new-born, the computers of the commodity trader and the railways of the commuter. It is an input to almost all goods and services. At the same time, power generation and its end use have negative environmental effects and may be implicated in global warming.

Since the middle of the century this central importance of electricity has been recognised by governments. Until very recently, most governments have also considered the whole power sector to be a natural monopoly and therefore that it should be closely regulated.

Regulatory reform of this sector offers significant potential benefits in terms of improved efficiency in the production of electricity and in the allocation of resources across the economy, lower prices for consumers, improved risk allocation, and stimulus to economic growth and competitiveness. If it is done well, these potential benefits are enormous. As with some other basic infrastructure and capital-intensive industries, investments made in the sector and by electricity users are long-lived; decisions made today have far-reaching and long-lived effects.

The central focus of recent regulatory reform has been the introduction of competition into the generation and supply sub-sectors of the electricity sector through market liberalisation. Market liberalisation critically shifts decision making from the state — or state-influenced entities — to the market and, often for the first time, gives consumers a choice. The evidence to date supports the strong expectation of a much better economic performance of

the sector; it also shows that reform can result in lower costs and a broader array of choices to consumers. However, there are other public policy objectives underlying liberalisation. It is important that these objectives, such as security of supply, environmental performance and social equity are met — hopefully bettered — in the new conditions. Evidence to date shows that these objectives can be met under the new competitive market conditions, but it is critical that they be included in liberalisation efforts at the beginning of the process.

Gas regulation is not addressed here. Gas and electricity are substitutes for many end-users and gas is an input into the generation of electric power. Hence, the regulatory status of one sector influences the other sector. A more complete analysis was not possible within the constraints of this study.

This study provides, first, an overview of the power sector (Section 2). The main part of the report (Section 3) considers the key issues in regulatory reform. It highlights the importance of identifying the underlying objectives of reform, before reviewing the mechanisms for introducing reform and competition. This section also considers the key public policy objectives of security of supply and protection of the environment and how these objectives can be met in the new conditions. Section 4 considers transition issues

In Section 5 a preliminary attempt is made to answer the question: What does regulatory reform and market liberalisation actually deliver? The report ends with conclusions and recommendations to governments.

OVERVIEW OF THE SECTOR

General Economic Characteristics

Electricity has a number of features which distinguish it from other energy products — and from most other commodities. First, electricity demand fluctuates in a daily and seasonal pattern, with superimposed random variations, largely (but not entirely) due to the fact that much of it is consumed in weather-related uses (heating and cooling). Second, it is not storable in large amounts and at low cost, which means that power at one point in time is not a good substitute for power at another point in time. Hence, power production and supply are multiple time-differentiated products. Third, the cost of load exceeding supply, brownouts or blackouts, is considerable. Taken together, these features create what is known as a "peak load (demand) problem": if all load must be supplied, then capacity must equal or exceed load at all times. Otherwise, random supply interruptions can occur in the form of brownouts or blackouts, causing considerable economic damage.

Another important feature of electricity demand is that it requires further transformation into the desired final form of energy: light, heat, cooling or motion power. This is due to the versatility of electric power. Hence, some of the input energies to electricity, e.g. natural gas, are also its competitors in end energy markets. Also, in many cases, demand is not very price elastic in the short term because a customer's transformation equipment (e.g. household goods like freezers) is relatively long-lived.

Electricity supply assets (including generating capacity) are also long-lived. The typical lifetime of nuclear plants is now expected to be 40 years, and hydro-electric plants, including dams, are expected to remain in service much longer.[1] Installed assets are accretions

1. Another example is Joskow (1983), for example, who illustrates the point by reference to a set of 588 large fossil-fuelled steam electric generating plants operating in 1979 in the United States. Of those for which the initial date of operation was given, 40 per cent began operation before 1950 and 17 per cent before 1940. He notes that most very old plants have been substantially modified in the intervening years.

over a long period of time during which technology, relative prices, beliefs about future demand and prices, economic and environmental regulation, population and industry have changed. Hence, actual installations are not those judged "optimal" under present conditions.

It is helpful to divide the supply side into four parts: generation, transmission, distribution and supply. Traditionally, the sector was considered as consisting of the first three parts: generation, transmission and distribution. These parts show clear differences in their functions, technology, and cost characteristics. More recently, however, power sector reform has encouraged the emergence of supply, or retailing, of electricity to ultimate consumers, as a separate and distinct function.[2]

■ Generation

Generation is the transformation of some other form of energy into electric energy, either chemically through the combustion of fossil fuel such as coal, oil or gas, or physically through the use of nuclear fission, or kinetic energy from wind or water in motion.[3] Different types of generating plants are characterised by different shares of fixed and variable cost: hydro-electric, nuclear and some renewable plants have high fixed cost (essentially capacity) and low variable cost (essentially fuel). Fuel cost in nuclear generation varies between 4 per cent (Canada) to 23 per cent (Japan) in OECD Member Countries.[4] In contrast, fuel accounts for 22 per cent (certain regions of North America) to 53 per cent (Germany) of total generating cost. The fuel share of gas-based generating cost lies between 46 per cent (Canada) and 75 per cent (parts of the United States).

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2. There are a number of additional functions, such as system operation/dispatch/network control and spot and contractual markets. However, the distinction according to the above mentioned four categories is the one that is most evident, due to the different functional and cost characteristics of those steps.

3. Many renewable energy sources actually use other processes. Fuel cells, for example, use fossil fuels, but the energy is extracted physically.

4. At a 10 per cent discount rate, 30 years lifetime and 75 per cent load factor. OECD Nuclear Energy Agency (NEA) / International Energy Agency (IEA): Projected Cost of Generating Electricity. 1992 Update. Paris, 1993.

This cost structure means that there is an order for plant dispatch, the so-called "merit order", which minimises total costs, bringing plant into operation as demand rises (*i.e.* no more than is necessary to meet demand at any given time). Hence, in a cost-based system, capacity with low variable and high fixed cost, such as nuclear, is operated as much as possible. This type of capacity is called base load. The reverse holds for the type of gas plants referred to above, which are operated at peak or intermediate load. Since load varies rapidly and unpredictably, so does system cost.

■ Transmission

Transmission is the high-voltage transport of electricity. Most modern transmission systems in industrialised nations are more or less densely meshed, allow power exchanges over large distances and, thereby, establish an electricity system featuring power trade, least-cost operation of geographically dispersed plants, bundling of demand and pooling of reserve capacity. These features mean that in most locations, electricity traded over the grid is vastly cheaper than locally generated power.[5]

A modern, synchronously interconnected transmission system also requires minute-to-minute co-ordination among generators and grid owners in order to protect it from damage. Voltage and frequency fluctuations have to be maintained within a very narrow band. In the wires, electricity flows along the lines of least electrical resistance, not along contractual paths, and towards "load valleys". This means that the technical problems one generator experiences, or the transactions he carries out with a consumer, may affect third parties not involved in the transaction. That is, there are significant externalities which make the transmission grid a natural monopoly over a relatively large geographic area. For these reasons, and in order to avoid breakdown in all or part of

5. There are, however, some thinly populated areas in OECD Member countries where grid electricity is more expensive than decentralised generation. These are seen to be important niche markets for renewable energies.

the system, generators are required to deliver so-called ancillary services, which can consist of voltage or frequency support, "spinning reserve",[6] or "black start" capability to re-start the system after a breakdown. This requirement for close co-ordination among operators of the transmission grid and generators gives rise to economies of vertical integration between these two parts of the industry. Such co-ordination is a key constraint on possible structural change in the sector. However, reformers — in, for example, the United Kingdom and the state of Victoria, Australia, as well as independent power producers elsewhere — have found mechanisms for the co-ordination of generation and transmission under separate ownership or management. This separation has been shown to be feasible. The issue remains whether total costs are lower under vertical separation (this is explored later).

■ Distribution

Distribution is the low-voltage transport of electricity, generally from the transmission system to the end-user, or between generators and end users. Distribution often shows strong economies of density in urban agglomerations but diseconomies in remote areas. Distribution is a natural monopoly over given geographic areas.

■ Supply

Supply is the contracting for, and selling of, electricity to end-users. Supply also includes metering and billing, and can comprise activities such as customer information, advice and financing. Supply is not a natural monopoly. It can be wholesale or retail. This report does not clearly distinguish these categories since they are subject to further research at the OECD and IEA.

To give an idea of relative cost magnitudes, generation in the United Kingdom accounts for about 65 per cent of total cost of

6. Power plants where the (gas or steam) turbine is rotating but not the generating unit. They thus consume fuel as if they were producing but are not. However, run in this mode, they can be brought into operation very quickly.

the supply chain; transmission, 10 per cent; distribution, 20 per cent; and supply, 5 per cent (Newbery and Green, 1996, p. 59).

■ Related Financial Markets

Where markets for electric power have been established, new financial markets have also become established. Electricity contracts range from long-term (e.g., 20 years) requirements contracts to short-term (e.g., one-half hour) supply contracts. Built upon these underlying assets are futures contracts and options. In dynamic commodity markets, like those for grains and petroleum, financial markets enable the risk of price volatility to be shifted away from the parties least able to manage them (the end-user) to intermediaries. Electricity, as has already been demonstrated in the American gas market, is conducive to such intermediation. In certain liberalised electricity markets, this risk intermediation already includes the availability of futures contracts, options and their derivatives.

The different parts of the electricity supply industry are vertically or complementarily related but their relationships are, in fact, more complex. For example, transmission and generation are complements, since in most cases, transmission is necessary to connect generators to end users. However, increasing transmission capacity can also be a substitute for additional generating capacity, since it may allow power to be obtained from a distant generator. As mentioned above, transmission allows merit order dispatch, but it also amalgamates demand and thus allows the use of larger plant and the exploitation of economies of scale. Demand patterns vary between regions. The larger the interconnected area, the more individual demand fluctuations offset each other, leading to greater use of (comparatively) low-cost base load capacity, and increased sharing of peak and reserve capacity. Transmission makes possible greater exploitation of economies of scale in generation and risk-sharing of load fluctuations. The larger the interconnected area, the cheaper (on average) the supply, until the cost reductions are outweighed by rising transmission cost, including grid losses.

These cost and demand relationships between generation and transmission, along with the economies of vertical integration between transmission and generation, give rise to a complex relationship between the two activities.

Another example of the complexity of relationships among the four main functions of the sector is that between generation and supply, where interruptible supply contracts can be a substitute for additional transmission or generating capacity.

Box 1

Structure of the Power Sector Supply Chain

Function	Fraction of total cost (in the United Kingdom)*
1. ***Generation:*** transformation of other energy into electric energy. Potentially competitive	***65 %***
2. ***Transmission:*** High voltage transport of electricity. Natural monopoly features (at present)	***10 %***
3. ***Distribution:*** Low voltage transport of electricity to end user. Natural monopoly features for given geographic area	***20 %***
4. ***Supply:*** Retailing of electricity to end users. Potentially competitive	***5 %***

**Source for cost estimates: Newbery and Green, 1996, p. 59.*

Economic Importance and Security of Supply

The electricity sector in itself is an important part of a modern society's economy, leaving aside its importance as an input to other goods and services. In the United States, for example, annual sales of electric power total over $200 billion. The electric power industry accounts for about 3.2 per cent GDP and about 5 per cent of gross capital stock (1994). In France, Electricité de France,