

Deregulation of Electricity Markets: The Norwegian Experience

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# Deregulation of Electricity Markets

## The Norwegian Experience

*This paper describes the approach to and experience of the deregulation and liberalisation of the Norwegian electricity sector from 1991. The Norwegian electricity market was subsequently integrated with the Swedish, Finnish and Danish markets to become the Nordic electricity market: the first common, integrated, intercountry electric power market in the world. The article discusses the background to electricity market reform, the analytical and legal foundations for reform and the chosen market and regulatory design. It finds that the market has performed well in terms of economic efficiency and market functionality, even when exposed to severe supply shocks because of water shortages for a power system that relies heavily on hydropower. However, it also identifies issues and challenges that must be addressed to improve the performance of the Nordic electricity market and its regulatory system.*

TORSTEIN BYE, EINAR HOPE

### I Introduction

Following the enactment of the new Energy Act in 1990, which laid the legal foundation for Norway's electricity market reform, Norway was one of the first countries to deregulate and liberalise its electricity sector. The main motivation for electricity market reform was an increasing dissatisfaction with the performance of the sector, particularly with regard to investment behaviour, which caused capacity to exceed demand considerably (Section II). Simultaneous market liberalisation initiatives in other pioneering countries, such as New Zealand and the UK, increased awareness of the need for electricity reform and influenced its design and implementation. This was particularly the case within the Norwegian ministry of finance, which initiated the reform.

The market reform should be considered against the background of the structure and functioning of the electricity system before liberalisation [Hope et al 1992; Hope 2000], (Section VII). The generation of electricity in Norway is almost exclusively based on the hydropower. When the reform was launched, there were about 70 power-producing companies and 230 network owners in the system. There was some vertical integration between power generation and the network, particularly at the regional and local levels, but many power producers were not integrated. The largest of them, Statkraft, accounted for approximately one-third of total generation. About 85 per cent of the electricity system was publicly owned by local, regional and state-owned companies. The power production capacity of the hydro system in 1991 was approximately 108 TWh in a normal year, of which the energy-intensive industries consumed approximately one-third. Annual production could vary considerably from year to year because of the stochastic nature of water inflow to the hydro system.

On the consumption side, around 90 per cent of power was sold on long-term contracts, defined as contracts for "firm power". Those contracts were negotiated individually and were predominantly bilateral, non-standardised contracts. Power producers were obliged to deliver power within their concessionary areas

and to cover their firm power contract obligations through contracts with other power producers. However, the lack of an organised secondhand market for contracts made most of the electricity market inflexible. In addition, electricity prices and other contract terms were generally set by administrative or political decree. For example, the basic price charged by the state-owned company Statkraft, known as the Statkraft price, was an element of the annual regulation of the company determined by the Norwegian parliament. The Statkraft price functioned as a price signal to the market.

Because of the stochastic nature of hydropower production, a market for occasional or interruptible power developed. In 1972, this market was formally organised as a spot market in a power exchange, or pool, among the power producers, known as *Samkjøringen*. Spot market transactions were carried out at a market-clearing price on an hourly basis determined by bids sent in by the generators to the power pool based on expected demand and supply schedules. This wholesale, producer-based spot market, comprising approximately the remaining 10 per cent of annual power production, met its objectives efficiently. The market is interesting as a forerunner to the design of the organised market system produced by Norwegian electricity market reform. In addition, for almost 20 years before market reform took place in 1991, it represented a "training ground" for market participants in market-based transactions. Thus, because of the market experience gained from the spot market for occasional power, the learning-by-doing curve for market-based operations was not as steep in Norway as in most other countries that implemented power market liberalisation.

The rest of the article is organised as follows: In Section II, we provide a brief review of the relevant background to deregulation. In Section III, we describe the main elements of market reform. In Section IV, we discuss market design issues. In Section V, we describe market development following deregulation. In Section VI, we discuss how effectively the new market dealt with extreme supply-side shortages in 2002-03. In Section VII, we discuss market and regulatory challenges. Section VIII concludes the article.

## II Background to Deregulation

During the regulation period, all investments in production and transmission capacity were reimbursed through direct market prices, cross-subsidisation between utilities,<sup>1</sup> or direct public subsidies.<sup>2</sup> There was no direct link between market prices (since there was no functioning market) and investment or between market prices and operating cost efficiency. The government, when determining its budget, set the following year's prices in the electricity market.<sup>3</sup> The government equated prices to average costs until 1979, from when it set prices equal to long-run marginal costs (LRMC). It used LRMC as a price criterion rather than an investment criterion.<sup>4</sup> The market functioned as a cost reimbursement system and provided no incentives for utilities to be cost effective. During the regulation period, while cost minimisation (given output) was pursued, output maximisation was also used to ensure an adequate supply. In addition, the central government and municipality authorities set different prices for different consumers,<sup>5</sup> which created inefficiencies and welfare losses.

### *Inefficiencies in Production*

There was no systematic evaluation of potential inefficiencies in production before deregulation of the electricity market, except the imbalances between capacity and demand were evaluated. Statistics illustrate excess capacity problems. During the late 1980s, between 5 and 6 per cent of the inflow of water to the reservoirs was spilt annually (even in normal inflow years). The prices set by the central government restricted demand relative to the capacity of primary energy supply (water inflow). To eliminate excess primary energy supply, producers accepted overflow from the reservoirs despite sufficient generator capacity. In a free competitive market, generators would produce sufficient water because prices would exceed variable cost and would fall to equate supply and demand. Prices would eventually be too low to stimulate further investment.

Middtun (1987) outlines the political discussion of investment and pricing that took place in Norway from the 1960s to the 1980s. His main conclusions include the following: (i) production capacity in the state-owned companies has not increased following increases in marginal cost; (ii) the power price has never been high enough to cover the marginal cost of expansion; (iii) the expansion of capacity has led to excessive investments. According to Middtun, the bureaucracy wanted to equate prices and LRMC as an investment rule in the early 1960s, but they proposed a lower discount rate on investment projects to secure lower prices. Middtun also documents substantial cost overruns in the state-owned companies that were due to weak financial management (pp 102-09). However, some of the blame must be assigned to increasing environmental concerns, political intervention, changes to plans and development delays. Costs overran by 57 per cent on average. Project planning focused on technical issues rather than economic issues.

### *Inefficiencies in Transmission and Distribution*

Transmission and distribution are considered natural monopolies. Pricing of transmission and distribution network services can be non-optimal for two reasons: (1) the monopolist's profit maximising price is higher than the optimal price where marginal

price is equal to marginal cost; and (2) due to the inefficiencies in resource use by the monopolist.

Kittelsen (1993; 1994), and Førsund and Kittelsen (1998) estimated total annual efficiency losses in distribution network companies to be between 1.1 and 1.8 billion Norwegian kroner (approximately 300 million USD). This amount constitutes 25 per cent of the resources used for distribution per year. They found no evidence that mark-ups exceeded those necessary to cover cost inefficiencies. That is, they found no evidence of monopoly profits. Hence, distribution networks used their monopoly power to be cost inefficient rather than profitable.

There is no documented research on inefficiencies in the central grid.

### *Inefficiencies in the Market*

In a perfectly competitive market, one would expect different consumers to pay approximately the same price for a homogeneous good. Power at the wholesale level at a specific time is close to being a homogeneous good. Average reported prices for different consumers may be based on different types of contract (incorporating factors such as risk, security of supply, time of use, power and energy). However, during the regulation period, there was little risk of power shortages because a primary objective of the power suppliers was to ensure deliveries at any time.<sup>6</sup>

Bye and Strøm (1987) calculated the net prices at the power plant level (a homogeneous good) from purchaser prices (including transmission and taxes) for different consumers. Their results are reported in the table. Calculated prices for the energy-intensive manufacturing industry were between one-third and one-half of the prices for services and households. This substantial discrimination reduces social welfare. Differences in prices between households and services were less substantial. The averages disguise large differences between regions for the same consumer group. In the power plant regions, (net exporting) prices were kept low for local customers at the expense of those in net importing regions, where prices were high.

Bye and Strøm (1987), Bye and Johnsen (1991) and (Bye 1991) estimated the implicit annual efficiency losses because of this price discrimination at between 3.7 and 4.5 billion Norwegian kroner. This represents three times the loss in the distribution network described above. Since the calculations assume identical firms within a sector, the calculated efficiency gains are biased downwards.

## III Main Elements of Norwegian Market Reform

Based on the Energy Act of 1990, the main elements of the Norwegian electricity market reform were as follows.

– The government decided to build on the established spot market model for trade in interruptible power, while organising it as a

**Table: Power Prices – Net of Taxes and Transmission Fees**  
(Current prices Øre/kWh)

	1978	1979	1980	1981	1982	1983
Households	12.2	13.7	15.2	17.3	20.0	26.0
Services	14.2	15.2	16.9	19.2	22.3	28.1
Other manufacturing	12.4	13.4	14.5	16.8	19.9	25.4
Pulp and paper <sup>a</sup>	6.6	7.0	8.2	9.0	10.9	11.0
Power-intensive industries	4.3	4.5	5.3	5.8	6.2	7.7
Weighted average	9.5	10.3	11.6	13.4	15.6	19.8

Note: In 2004, 1USD = 6.7 NOK; i.e., 20 øre/kWh = 3 cents/kWh.  
Source: Bye and Strøm 1987.

regular spot market incorporating demand. The market was, in principle,<sup>7</sup> open immediately to all potential buyers, including households. Initially, the market was organised as a separate legal entity within the transmission company, Statnett, and was termed the Statnett Market.

- Common carriage principles requiring access to the network system on a transparent and non-discriminatory basis facilitated market-based trade.

- The dominant, state-owned and vertically integrated company, Statkraft, was split vertically into two separate legal entities: the generating company, Statkraft SF and the transmission company, Statnett SF. The other vertically integrated power companies were separated into generating or trading divisions and network divisions for accounting purposes, but were not split into companies with separate legal identities.

- The network companies were subject to natural monopoly regulations designed to achieve economic efficiency in network operations. The Norwegian Water Resources and Energy Directorate (NVE) regulate these entities based on rate-of-return regulation, later changed to income-frame regulations (1997).

- The market liberalisation reform was implemented without changes in ownership, because the privatisation of the power sector was politically unacceptable. This contrasted with the UK, where privatisation was implemented before market liberalisation. There, privatisation was considered a prerequisite for successful electricity market reform from an economic efficiency perspective.

The main events that have taken place in the deregulation and market liberalisation process since 1991 are described below:

Statnett Market began trading in the spot market for power (the day-ahead market) in 1991, when the NVE introduced the regulatory regime for network owners. In 1993, a financial forward market was established for the delivery of traded contracts. In 1994, this was replaced by a continuous trading system and standardised financial futures contracts were introduced.

To facilitate trade in the retail market while avoiding investment in expensive metering equipment for retail customers, in 1995, the load-profile demand measurement was introduced. In 1997, fees for consumer switching were also eliminated to stimulate consumer switching and market competition. In 1998, the Norwegian Competition Authority introduced a price information system for retail prices from power suppliers to improve market transparency. The time allowed for consumer switching was reduced to a week.

In 1996, a common Norwegian-Swedish power market was established to become the first intercountry integrated power market in the world. Nord Pool took responsibility for power exchange for the common market from Statnett Market. The Swedish transmission company, Svenska Kraftnät, became co-owner with Statnett. In 1998, Finland became an independent price area on the Nord Pool power exchange. Denmark integrated into the Nordic system in 2002, since when there has been a common Nordic integrated electric power market (excluding only Iceland).

#### IV

### Market Design and Market Operations

A complete market-based power system should be equipped with markets for the following five basic requirements or functions: (a) markets for trade in electricity; (b) markets and instruments for risk hedging in accordance with risk preferences;

(c) short-term markets for production capacity<sup>8</sup> and balancing supply and demand; (d) markets for investment in new capacity; and (e) markets for trade in environmental energy products (such as green-certificate markets). Nord Pool has organised markets for functions (a), (b) and (e). Function (c) is generally handled by the transmission system operators in the individual countries. There are hardly any organised markets for (d).

Nord Pool is a non-mandatory power pool that organises approximately 40 per cent of the total trade in electricity in the Nordic power market. The rest is organised on the basis of bilateral contracts. Nord Pool's share in total trade on the organised spot market is a useful indicator of the liquidity of the market. This is discussed in relation to the volume of trade in organised financial markets in this section.

Nord Pool also performs the functions of contract clearing and settlement and established a new environmental market for electricity certificates for renewable energy production (green certificates) in 2004.

#### *Nord Pool's Spot Market – Elspot*

Elspot is a contract spot market on which electricity is traded on a daily basis for physical delivery the following day (a day-ahead-market), with full obligation to pay. The bidding procedures are essentially the same as those adopted by Statnett Market in 1991. Market participants place bids in the Pool one day in advance for the next 24 hours of the following day. The Pool then aggregates the bids and prices for each hour based on supply and demand. The Nord Pool system price is the market equilibrium price for the aggregated supply and demand schedules for each hour. The spot-market system price functions as a reference price for Nord Pool's financial markets and the bilateral markets in the Nordic system. Currently, 280 participants trade daily on the Nord Pool spot market.

The system price is determined without taking into account potential capacity constraints in the transmission network system. If calculation of the system price indicates that the power flow between two or more areas exceeds capacity limits in the transmission grid, two or more area prices are determined. A capacity fee, defined as the difference between the system price and the area price, is then calculated. The transmission system operators in the Nordic countries set the capacity fee as an integral part of their operation of the system. Thus, the system operators are obliged to use the price mechanism in the spot market when adjusting power flows during periods of capacity constraints between bidding areas.

#### *Markets for Derivatives at Nord Pool*

The types of contract traded on Nord Pool's financial markets comprise electric power derivatives and electricity certificates. The financial derivatives are futures, forwards, options and contracts for differences. The contracts help market participants hedge and manage risk from market uncertainty and price volatility.

The reference price for those contracts is the spot-market system price for the total Nordic electric power market. The maximum trading time horizon is currently four years. For all financial derivative contracts, the principle of cash settlement applies; that is, there is no physical delivery of electricity on those contracts.



The basic distinction between futures and forward contracts is that the former are standardised contracts for a given quantity of power at a certain price in a specified time period, while the latter are typically non-standardised. A division of labour between futures and forwards has developed at Nord Pool. This is because the time horizon for futures has been reduced from three years to between eight and nine weeks, while forward contracts apply to periods of up to four years. Thus, the market seems to favour short-term futures near the due date and favours long-term forward contracts near the end of the time horizon. This may be because of the difference in margin calls between futures and forwards. Futures are settled daily on a market-to-market basis. This requires a considerable cash commitment upfront. By contrast, forwards only require cash collateral during the delivery period.

The option contracts traded at Nord Pool adopt the European convention that contracts can only be exercised at the stipulated exercise date. Options combined with futures and forwards offer interesting strategies for risk hedging and risk management in electricity power trading. They also allow greater flexibility in contract portfolio composition and administration.

Contracts for difference (CFDs) were introduced to allow market participants to hedge against the price area risk. When there are capacity constraints in the transmission network the system operators determine area prices that differ from the prevailing system price. Futures and forward contracts cannot hedge against this price area risk. Therefore, CFDs were introduced to provide a hedge even when the market is split into two or more price areas.

In 2004, Nord Pool began the trading of electricity certificates in Sweden, on contracts involving physical delivery. Nord Pool plans to introduce forward contracts for such certificates in 2005. A Norwegian market for electricity certificates is due to be created in 2007. The anticipated integration of the Swedish and the Norwegian markets is expected to increase liquidity and competition in the common market. In February 2005, Nord Pool also began trading in carbon emissions by using European Union Allowances (EUAs). Hence, it became the first regulated market in Europe to trade in and clear such contracts.

The volume of trade in financial derivatives markets is currently about five times the volume of physical trade in the spot market. This ratio, now increasing after a decline in 2003, is used as an indicator of market liquidity and their efficiency.

### *Balancing Markets*

Balancing markets are required to correct for imbalances between supply and demand due to three reasons: (a) deviations can arise between the planned supply and demand schedules on which prices are determined in the day-ahead market and the actual demand schedule prevailing at the time of delivery within each hourly time section in the spot market. (b) price deviations can arise because of transmission capacity constraints. (c) there can be imbalances or interruptions because of stochastic fallouts of generation or power line capacity. We focus primarily on (b).

If the power flow between two areas exceeds transmission capacity, the price is reduced relative to the system price in the surplus (low-price) area and is increased in the deficit (high-price) area. This continues until the power flow matches the capacity limits. The system operator responsible for capacity regulation on the grid does this when capacity constraints arise.

However, within the Nordic system, different principles and methods are applied to balance capacity. In Norway, transmission capacity problems are resolved by the price mechanism in the spot market according to the principle of delineation of price areas described above. This is the responsibility of the Regulating Power Market, which is operated by the Norwegian system operator, Statnett. Statnett divides the country into two or more geographical bidding areas and stipulates the maximum transmission capacity between these areas. Every week, based on data from Statnett, Nord Pool then informs all market participants of the bidding areas that apply for the following week. Currently, four price areas generally apply, but the number depends on grid conditions and the relationship between supply and demand in the system. Because of reduced investment in transmission capacity relative to demand, capacity constraints have gradually become more binding. This implies that price area delineations have become more persistent.

Sweden and Finland form one bidding area in the spot market, while Denmark is divided into two. In Sweden and Finland, the counter-purchase principle is applied to manage internal transmission bottlenecks. Counter-purchasing involves system operators in Sweden and Finland paying for the downward regulation of production in the surplus area and upward regulation in the deficit area until the capacity constraint is eliminated. The cost of counter-purchases is financed by tariffs on power production. The balancing mechanism used for Sweden and Finland is known as Elbas.

The Regulating Power Market in Norway is organised as a bidding market in which a 15-minute time span applies to price determination. For imbalances, which cannot be handled within this period, Statnett can impose downward or upward capacity regulation on market participants at short notice (less than 15 minutes). Initially, market participants comprised a relatively small number of large power producers with considerable regulating capacity. Now, however, the market has been opened to participants from the demand side. These include firms in power-intensive industries and other large consumers able to reduce their load.

### *Retail Market*

While the wholesale markets in Nord Pool are integrated, the retail markets are national markets due to differing national regulations, but developments are under way to integrate retail markets also.

Regulatory measures such as the abolishment of switching fees and the retail price information system have stimulated retail market competition in Norway. However, competition only takes place on the electric power price, which in Norway accounts for roughly one-third of the total consumer price, the remaining two-thirds is divided roughly evenly between grid user price and taxes and fees.

The obligation to report retail prices to the Norwegian Competition Authority (NCA) applies to around 170 suppliers, of which 50 to 60 operate regularly in the market. The number of consumers switching suppliers has increased steadily since the retail market was opened in 1995. During the first quarter of 2005, around 65,000 household consumers changed supplier, which represents 3 per cent of all households. In April 2005, 25 per cent of household consumers used a power supplier other than the dominant supplier in the area. However, the absolute number

of consumers switching suppliers is not necessarily an appropriate indicator of increased competition. What matters is whether the number is sufficiently large to cause suppliers to set prices competitively.

Approximately three-quarters of Norwegian retail consumers have entered into some form of variable retail-price contract (such as a spot-market contract or a standard variable power-price contract). This exposes them to variations in the Nord Pool system price on the wholesale spot market. By contrast, in Sweden, 80 per cent of retail consumers pay a fixed price. This difference may have arisen because Norway depends totally on hydroelectric power, whereas Sweden only depends on hydroelectricity for 30 to 40 per cent of its total production. Consequently, price volatility has traditionally been higher in Norway than in Sweden. In a fully integrated market, however, price volatility should converge. Tradition, contract types and risk preferences may also explain the difference in contracting behaviour.

The retail market has become very transparent, in part because of the price information system of the NCA. However, perhaps the market has become too transparent. Perhaps competition has reduced the difference between the highest and lowest prices without reducing the average price. Since price information is widely available, the retail market may be vulnerable to the exercise of collective market power or tacit collusion between suppliers and, therefore, vulnerable to higher prices. Information on retail prices is readily available to everybody in the market. The Nord Pool system price, which is the reference for retail prices, is also widely known. Moreover, suppliers learn from data on past prices and market behaviour as they meet each other frequently in the market. This hypothesis has not yet been tested empirically by using data on the retail market.<sup>9</sup>

### *Regulatory Policy for Electricity Markets and Networks*

The regulatory policy for the electric power sector comprises a competition policy for electricity markets and a regulatory regime for network activities. In both cases, economic efficiency is the policy objective.

Norwegian competition policy has mainly been concerned with improving market transparency through the retail-price information system and eliminating the abuse of market power by dominant firms that have resulted from mergers and acquisitions among electric power companies. The NCA investigates mergers and acquisitions. It prevented the acquisition of Agder Energi by Statkraft on competition grounds. However, an appeal against the NCA's decision was made to the ministry, to which the NCA is subordinated. Although the ministry agreed with the NCA's analysis of competition, it allowed the merger to go through, albeit with modifications. Recently, the NCA has been preoccupied with the implications of transmission capacity constraints for competition in electricity markets.

A new regulatory regime for network companies was introduced in 1997 based on a revenue-cap incentive mechanism,<sup>10</sup> The initial control period was defined for intervals of five years, but revisions could be undertaken during the period. Annual revenue was set *ex ante* by the regulator (the NVE) for each network company. The revenue cap was based on the total cost coverage of network activities. An efficiency improvement factor was defined for each network owner, based on a data envelopment analysis (DEA) of the efficiency improvement potential for each company. For the first year, the efficiency factor was set

at 2 per cent for all network owners. The regulator subsequently modified the efficiency factor in relation to the DEA-efficiency frontier. The highest annual efficiency requirement has been 4.5 per cent.

Although the regulatory regime was supposed to be evaluated and revised in 2001 it was extended on more-or-less the same basis for the five-year period from 2002 to 2007. The NVE has commissioned much research and consultation on the design of the new regime to be implemented in 2007. An important and challenging issue facing the new regulatory model is the design of an incentive mechanism for optimal investment in the network that enables the market-based electricity system to function efficiently.

## **V Development of the Market Following Deregulation**

Deregulation of the electricity market was expected to lower investment, reduce and equalise prices between consumers, lower net tariffs, and raise the rate of return on investment.

### *Prices*

In a virtually completely hydro-based electricity market, we would expect increasing LRMC because of a scarcity of resources. Because efficient private investment results in price being equal to LRMC, we would also expect prices to rise in the long run. In the short run things could be different due to excess capacity.

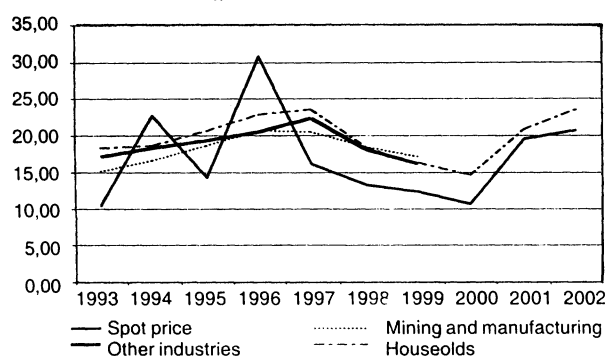
In the pre-restructuring era, even though there was an attempt to have prices equal to LRMC, there was an excess capacity which was indicated by three clues: (1) the energy-intensive industry which consumed one-third of the energy paid prices that were only 25 per cent-33 per cent of the LRMC with higher prices for other consumer classes; (2) prices for Norwegian consumers were kept high while the excess energy was sold on the international markets at very low prices; (3) during the late 1980s to the early 1990s, almost 5 per cent of the water was split indicating excess capacity.

After restructuring, the excess capacity competes on the market and lowers the price. Efficiency gains from competition and price equalisation between consumers also lower prices. This will last until the demand increase and the production capacity constitutes a constraint on further growth. Then prices will increase again and trigger further investments.

Figure 1 shows changes in the spot price and average prices among consumer groups in 2002. First, the spot price is low in comparison to the end-user prices prevailing in 1993. This is mainly because of excess capacity and the splitting of the market. Neither the end-user market nor the spot market were fully developed after two years of deregulation. Second, there is almost no correlation between the spot price and end-user prices after four to five years of deregulation, although there was an increasing trend in all prices. In this period, end-user prices were similar among consumer groups, which suggests that the market eventually functioned as expected.

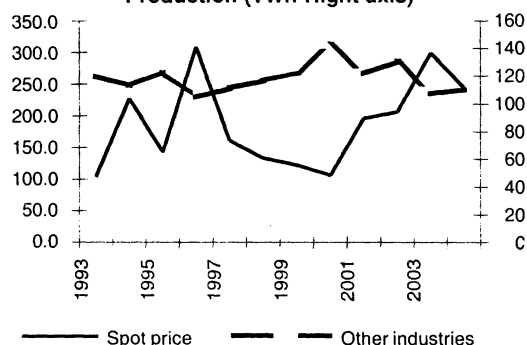
Since 1997, the Nord Pool market was extended when Sweden and Finland deregulated their markets.<sup>11</sup> The fee on contract switching for small consumers, which was introduced in 1991, was eliminated in this period. End-user prices then followed spot

**Figure 1: Spot and Consumer Prices, Nøre/kWh Fixed 2002 Prices**



Source: Statistics Norway (<http://www.ssb.no>) and NordPool (<http://nordpool.no>).

**Figure 2: The Spot Price (NOK/kWh Left Axis) and Hydropower Production (TWh-Right axis)**



Source: Statistics Norway (<http://www.ssb.no>) and Nord Pool (<http://nordpool.no>).

prices on a downward trend. Nevertheless, end-user prices remained above the spot price. When the spot price increased in 2000, the gap narrowed.

As expected, Figure 2 shows that fluctuations in the spot price were negatively correlated with those in hydropower production. Since demand elasticities are low [Bye et al 2003], a modest change in supply may have a large impact on the spot price.

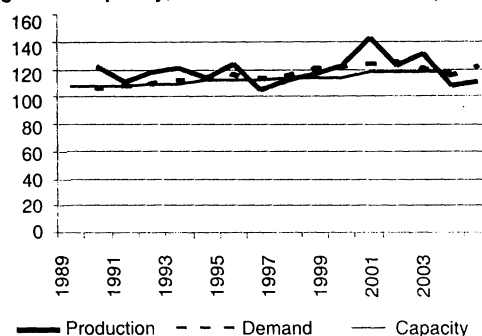
Hence, deregulation did put a downward pressure on the electricity price, seem to have reduced price differentials between consumers and have closed the gap between end-user prices and market equilibrium prices.

### Investment in Power Production Capacities

During the regulation period and in the six years after the deregulation of 1991, production capacity in Norwegian hydropower plants exceeded demand (Figure 3); that is, under normal inflow conditions, Norway was a net exporter.<sup>12</sup> After 1997, production and capacity has been lower than demand, except in 2002-03, when inflows were well below normal. Prices increased dramatically and demand responded.

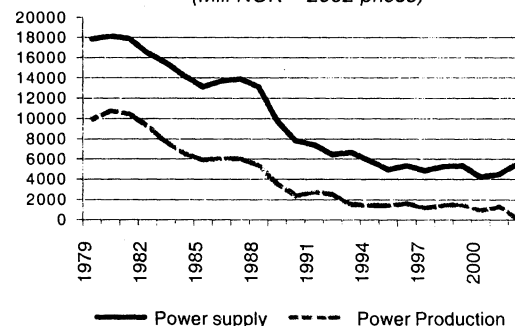
Investments in new production capacity began to fall in the early 1980s (Figure 4) long before deregulation. This was mainly because of a sharp increase in the marginal cost of expansion and a continuing increase in environmental concerns. These concerns made expansion politically unacceptable. After deregulation, investment continued to fall and reached a low level. As demand increased, Norwegian capacity was restricted and prices increased. However, when Sweden, Finland, Denmark and other northern European countries deregulated, excess capacity in these countries kept prices low and imports to Norway high.

**Figure 3: Capacity, Production and Demand (TWh)**



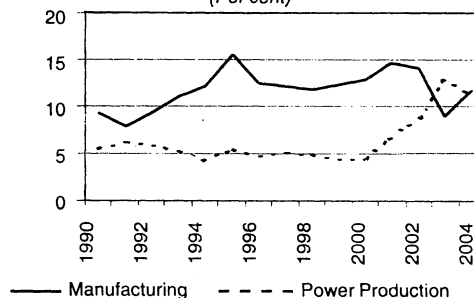
Source: Statistics Norway (<http://www.ssb.no>) and NVE (<http://nve.no>).

**Figure 4: Investments in Power Supply and Power Production (Mill NOK – 2002 prices)**



Source: Statistics Norway (<http://www.ssb.no>).

**Figure 5: Rate of Return in Manufacturing and Power Production (Per cent)**



Source: Statistics Norway (<http://www.ssb.no>).

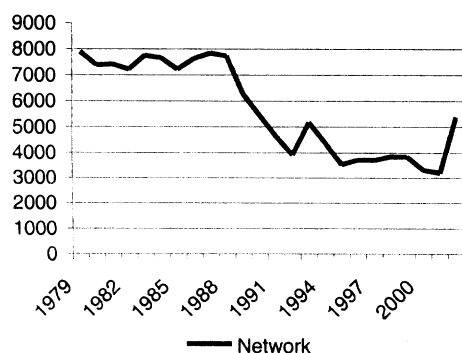
It remains to be seen whether in the deregulated regime there will be sufficient incentives for investing in additional capacity. The public debate on these issues is complicated by concerns about the environmental impact of capacity expansion. Politicians seem to be opposed to new investments in large new hydropower plants, new gas fired power plants, nuclear and other thermal plants. The supply side seems strangled resulting in price increases. The only feasible alternatives seem to be renewable technologies that are very costly. The market price has not reached the level to trigger such investments unless vigorously financially supported.

### Rate of Return on Power Production

A low rate of return hinders investment in new capacity. Unlike in the manufacturing industry, the rate of return in the power sector in Norway has been low since deregulation (Figure 5).<sup>13</sup> However, the rate of return has recovered since 2000 because



**Figure 6: Investments in Network Capacity**  
(Mill NOK - 2002 prices)



Source: Statistics Norway (<http://www.ssb.no>).

hardly any investment in new capacity has occurred while demand has increased by, on average, between 1 and 1.5 per cent per year for the last 10 to 15 years.

In a hydropower-based system, one should expect the average rate of return to be higher than in other industries (such as manufacturing). This is because the basic resource is scarce and marginal costs are increasing.<sup>14</sup> Scarcity is not yet a problem, but will become one as the market develops.

### Investment in Networks

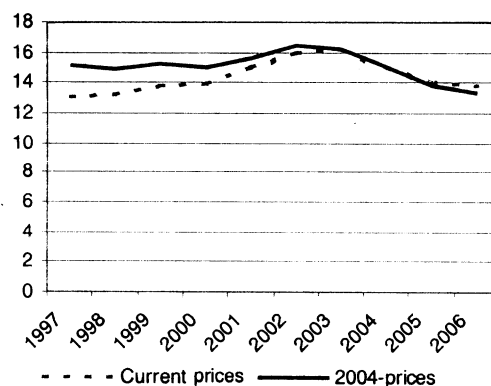
In the 1950s and early 1960s power projects and energy-intensive manufacturing were developed together at the same location. Manufacturing industry was located near power plants to minimise transmission costs and benefit from the cheap energy based on the resources from large waterfalls, mainly on the western coast of the country. Over time demand from services and the residential sector in the densely populated areas in the east also grew.<sup>15</sup> The location of hydropower in the west increased the need for transmission capacity from west to east and, to a certain extent, from north to south. Higher fuel oil prices in the 1970s and increasing fuel taxes because of environmental concerns triggered a massive substitution of fuel oil with electricity. Along with the aggregate economic growth, this raised demand for capacity investment in the distribution network. Once this large infrastructure project had been completed, investment in network infrastructure capacity decreased (Figure 6).

This story partially explains the sharp decrease in network investment in 1988-93 pictured in the figure. The new regulatory regime for tariff setting also reduced the profitability of new investments. Investments in network increased again in 2002-03 because of upgrading of existing networks and instalment of new capacities to handle temporary constraints in the network.

### From Rate-of-Return Regulation to Income Regulation

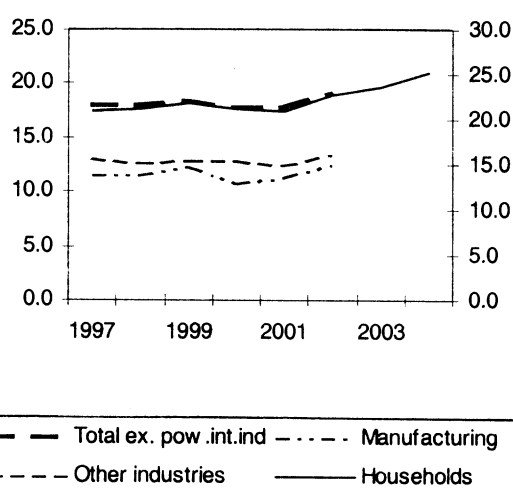
The introduction of the new Energy Act implied a firm specific rate-of-return regulation for network companies. In 1997, income regulation replaces the rate of return system. An important aspect of the regulation is the efficiency rate, which reduces the annual allowable network-specific income. The efficiency rate includes both a yardstick competition and a catching-up-period rule.<sup>16</sup> On average, this should cause the network tariff in Norway to fall by about 20 per cent between 1997 and 2005.

**Figure 7: Regulated Total Income in Networks Current and Fixed (2004) Prices**  
(Billion NOK)



Source: Statistics Norway (<http://www.ssb.no>).

**Figure 8: Net-Tariffs (2004) Prices**  
(Nøre/kwh)



Source: Statistics Norway (<http://www.ssb.no>).

Figure 7 shows changes in total income and Figure 8 shows the development of the network tariff in this period. Income was on an upward trend before 2003, when it fell. Over the whole period, real income fell by 1.5 per cent, which is less than the fall in the efficiency rate. This was mainly because of an increase in transmission capacity, as income per transmitted kWh fell by about 18 per cent in this period. Operating costs drove tariffs up, while the fall in interest rates reduced them.

Because regulation is more sophisticated and because supply and demand are stochastic, transmission tariffs and regulated income per transmitted unit may behave differently in the short run. However, in the longer run, transmission and distribution networks must pay back excess income and may add accumulated, but insufficient income to future regulated income. The regulatory regime allows this adjustment to take time (several years). According to the regulatory authority, this fully explains the increase in tariffs over the last three or four years. As tariffs had previously been low, tariffs had to increase to make up the income shortfall. Since precipitation and inflow were low in 2002 and 2003, and the resulting high prices in the market reduced demand substantially, income regulation resulted in higher tariffs per



transmitted and distributed kWh. According to the regulatory authority, *ceteris paribus*, tariffs are expected to fall over the next two years.

In the longer run, interest rates, operating costs and the spot-market price (the price of transmission losses) are expected to increase. This may offset the downward bias that is due to the yardstick efficiency gain measure.

Another important issue is whether the new regulatory regime provides sufficient incentives to invest in infrastructure capacity in this sector. This is a widely debated issue in Norway and represents a further challenge.

### *Market Structure and Concentration*

The dominant producer of hydropower in Norway, Statkraft, is a state-owned company. Before deregulation of the electricity industry, Statkraft produced around 30 per cent of Norway's power. However, much of its output was delivered to the energy-intensive manufacturing industry on the basis of long-term contracts. Statkraft's share of the remainder of the market was less than 15 per cent. Private firms provided about 10 per cent of Norway's production capacity, while municipalities and counties owned the rest.

Following deregulation, many of the companies under local-government ownership were turned into limited-liability firms. Larger regional power companies were established, partly through acquisitions and mergers among local-government entities. The state-owned company, Statkraft, also grew through mergers, acquisition and the purchase of shares in other large and small power companies, partly encouraged by politicians, although there was some obstruction from the competition authority. Politicians focused on Norway as part of a larger Nordic integrated electricity market in which Statkraft was a minor player. That is, competition prevailed, and the authorities wanted to develop Statkraft as an important player in the international market. The competition authority accentuated changes in the regional markets, that is, when transmission was constrained and the market leader could exercise market power. Eventually, Statkraft was allowed to purchase companies, but was also forced to sell divisions to increase competition.

Bye et al (2003) report a Hirschman-Herfindahl concentration index for the Norwegian market based on direct ownership of 0.1634. One that incorporates inactive but incentive-based cross-ownership is 0.1980. A third index that controls for demand<sup>17</sup> and incentive-based cross-ownership is 0.3325. They concluded from the traditional measure (0.1634) that the Norwegian market remains unconcentrated. However, if we take into account cross-ownership, the market is reasonably concentrated (0.3325). For the whole Nordic region, they found a cross-ownership, an incentive-based index of 0.1138, which suggests an unconcentrated market.

The relevant issue is whether the Nordic market is an integrated market or a regionalised market. Hourly data on area prices indicate the scale of transmission constraints and allow a calculation of the scope of the relevant market. In 2001, the Nordic market was fully integrated 51.8 per cent of the time and regionalised otherwise, based on calculations for seven Nordic regions. The most populated area in Norway, the south, was classified as a separate area less than 10 per cent of the time, while the northern part of the country was a separate area nearly 20 per cent of the time. Thus, the issue of market power is relevant.

Generally, it is difficult to prove the abuse of market power, especially in a hydropower system in which the primary energy source and implicitly total production from a reservoir is determined by inflows (given that the regulators monitor any waste of water). However, concentration is not all that matters: any plant on the margin in a restricted price area, even a small firm, may abuse market power. Clearly, mergers or acquisitions that increase concentration should be prevented. Alternatively, transmission capacity between regions could be increased.

## **VI**

### **Market under Stress – A Real Test**

The Nordic electricity market was exposed to an extreme primary energy shock between 2002 and 2003. A short-term shortage of precipitation and inflow sharply increased prices and led to a vigorous discussion of the functioning of the deregulated market when exposed to such extreme situations. Policies that could relieve these so-called "infirmities" in the market were discussed. However, Bye (2003) showed that the market functioned remarkably well; producers tried to optimise the value of water, as expected; electricity trade followed anticipated patterns; and consumers responded as predicted by theory [Bye et al 2003; Fehr et al 2005].

During the period of regulation, a security-of-supply rule determined investment decisions; there should be enough capacity at any time to satisfy demand. Given the uncertainty in inflow and the variability in demand because of a very high electric heating load and extreme variations in outdoor temperatures, this rule resulted in excess capacity in normal situations – and spill of water in above normal inflow situations. Deregulation involved price and investment drops. Firm-specific profit maximisation reduced excess capacity over time. Stochastic supply and demand eventually increase price fluctuations. If the rain fails, as in the autumn of 2002, prices are expected to increase.

In order to maximise the value of stored water, hydropower producers equalise prices over time using the storage capacity of the reservoirs. In the Norwegian hydropower system, water typically flows into the reservoir during the snow-melting period from early May to mid-July and in the rainy season from mid-September to late October. The high-demand period is winter, from October to April, while demand is low in summer, from May to August.

In the spring of 2002, since the inflow to the hydro reservoirs exceeded the normal level, production increased and prices decreased. The water level was above normal. Producers had the incentive to produce to avoid an overflow in the rainy autumn season. However, the autumn rains did not come, which resulted in a 20 TWh (17 per cent of Norway's annual production) inflow shortfall within six weeks, relative to the normal inflow for this period. The probability of this happening was approximately 0.5 per cent. Prices in the spot market increased to an all-time high level (and quadrupled on average within two months). Over a period of 12 months, average spot prices increased by almost 50 per cent. Demand fell by about 5 per cent, despite many manufacturing companies having fixed-price contracts. Some companies even sold power back to the electricity companies under these fixed contracts.<sup>18</sup>

During this period, physical rationing of power was discussed because of a possible draining of the reservoirs during winter. Some focused on a possible malfunction of the market (because of abuses of market power, irrational behaviour by new firms and

the inadequacy of the market for dealing with extreme events). Politicians threatened to reregulate the market and proposed several measures for dealing with extreme situations. They were primarily motivated by public and media focus on the possibility of rationing and severe price effects on the income distribution.

At the request of the minister of administrative affairs, Bye et al (2003) evaluated the event and concluded that the market functioned as expected and that the market dealt with the extreme almost perfectly. The historic rate of return in power production explains low investment in production capacity and is not a consequence of malfunctioning or the abuse of market power. Moreover, between 2002 and 2003, expectations of futures prices (contract prices for hedging two or three years ahead) were low despite the high prices specified in physical contracts. Thus, short-term prices did not justify an expansion of productive capacity. High prices simply reflected a water shortage and the need to stabilise water values over time, which reflected great uncertainty. The water balance in the summer of 2002 was well above normal. This put downward pressure on prices to increase demand and generate a water balance that was low enough to accommodate the autumn rains. Because the rain failed and the water balance fell, the market had to adjust to restore the water balance in the spring of 2003. Since imports were restricted, domestic prices had to rise.

Although the market seems to have functioned well, Bye et al (2003) identified issues for further study and follow-up by the competition authorities. One issue is the future design of contracts. The market seems to have been competitive despite the fact that transmission was restricted between Norway and other countries almost 60 per cent of the time during the winter of 2002-03. However, there seems to have been a problem because of price differences in the contract market, both in the wholesale market [Bye et al. 2003] and in the retail market [Fehr et al 2005].

## VII Some Challenges

In a comprehensive EU-financed research project on European electricity reforms, known as SESSA,<sup>19</sup> the Nordic electric power market model was suggested as a potential benchmark for market organisation and the efficient functioning of electric power markets. However, even if the Norwegian and Nordic electric power markets and their regulatory systems performed reasonably well in terms of competition and economic efficiency, there is scope for improvement. Some issues and challenges in this context are as follows.

(1) *Market dominance and market power*: Investigations by competition authorities and research studies have not documented instances of the exercise of market power in the Nordic power market, either unilaterally or collectively.<sup>20</sup> However, market power is a recurring issue in the debate on the Nordic market. This is partly because of the characteristics of electricity as a commodity in market terms and partly because of the increase in market concentration following restructuring of the market through mergers and acquisitions between electric power firms. The issue of market power suggests the need for the design of a system for monitoring the market and its regulatory system, as argued by Hope (2005).

(2) *Design and operation of investment markets*: The Nordic market has performed reasonably well in terms of the efficient

operation of a market system with a fixed capacity, because the excess capacity that had built up before the market was reformed has meant that further investment is not required for capacity expansion. Now the excess capacity that had been built up before the market was reformed, has been absorbed and there is a need for investment in new capacity. However, there is no overall investment planning system for the Nordic electric power system and there is a lack of investment markets for optimal investment within the integrated Nordic market.

(3) *Network integration and system operation*: The Nordic transmission network system remains decentralised in the sense that national transmission companies are responsible for the operation of, and investment in, the national network, and for system operation. Cooperation between transmission companies takes place on a voluntary basis through NORDEL. The regulation of network companies and the handling of network constraints are not harmonised on a Nordic-wide basis, which results in potential inefficiencies in the functioning of the power markets. A common, independent transmission system operator for the integrated Nordic market is also lacking.

(4) *Integration of the Nordic market with the European electricity market at large*: Economic efficiency could be increased if the Nordic market were more closely integrated with the European electricity market. Although insufficient transmission capacity limits such integration, transmission investment is planned. For example, an undersea cable between Norway and the Netherlands is being developed. The more mature Nordic market in terms of market organisation, competition and regulation, may promote power market liberalisation in Europe.

## VIII Summary

During the regulation period, investment in production and transmission capacity was subject to cost reimbursement, through either direct prices in the market, cross-subsidisation between utilities or direct public subsidies. There was no direct link between market prices and investment or between market prices and operating cost efficiency. Several studies report substantial inefficiencies in the production, transmission, distribution and market distribution of electricity.

The new deregulated market built on the principles applied in an already existing spot market for interruptible power. Vertically integrated power companies were split into divisions on an accounting basis. A derivative market was opened to deal with hedging against uncertainty. Introducing common carriage and securing access to the grid on a transparent and non-discriminatory basis opened up the electricity network. The network companies were subject to regulation, the objective of which was to increase economic efficiency.

Following deregulation, electricity prices fell, prices between consumer groups became more equal, investment declined in both production and transmission capacity and the return on capital increased. In addition, market concentration increased and opportunities to exercise market power arose as the market became more regionalised because of transmission constraints. Market power does not seem to have been abused. The stochastic electricity market is occasionally tested by extreme events, particularly on the supply side. However, the market seems to have handled these events well.

Some challenges remain with respect to market concentration, the design and operation of investment markets, network integration and system operation and integration of the Nordic and European electricity markets. [PW]

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## Notes

- 1 This is made possible by the increasing marginal cost of expansion in firms.
- 2 This is achieved through either capital subsidy or relaxed requirements on the rate of return on investment.
- 3 In fact, the government set prices for state-owned companies. However, the municipalities and counties, which own almost all the rest of the power producing capacities, followed. Since the energy-intensive manufacturing industry had long-term contracts, they were exempted [Bye et al 1999].
- 4 In 1979, the government, in a green paper, St meld nr 54 (1979-80) 'Norway's Future Energy Demand and Supply (Norges framtidige energibruk og produksjon)', decided that the electricity price level in the long run should reflect long-run marginal cost. The escalation period continued until 1985.
- 5 The purpose was to distribute some of the local natural resource value to local consumers or to support energy-intensive industries and the local labour market.
- 6 There was a compulsory delivery standard in each region.
- 7 Small consumers had to pay a relatively high access fee when changing contracts in the first four or five years.
- 8 Capacity markets are needed to provide two kinds of service (Section 4). These are: (1) the instantaneous balancing of supply and demand to prevent system breakdowns or fallouts; (2) accounting for deviations between planned production according to the supply and demand schedules at the time when the price is determined and the production is needed to meet demand at the time of delivery.
- 9 For discussion of the relationship between market transparency and the potential exercise of collective and unilateral market power [Hope 2005].
- 10 In Norway, this is referred to as 'income frame regulation'.
- 11 Market expansion increased the amount of surplus power and prices fell.
- 12 We define capacity as the production potential in a normal inflow year, i.e. in TWh compared to a normal definition measured in MW. 'Normal' refers to the average over the period 1970-99.
- 13 In much of the manufacturing industry in Norway, the rate of return varies because of international business cycles (in, for example, aluminium, ferro alloys, chemicals and pulp and paper). This explains the low rate of return in manufacturing in 1991.
- 14 New investment will not occur unless prices cover the long-run increases based on marginal cost. This applies unless there is a backstop technology that limits increases in marginal costs or unless there is an unlimited import capacity at fixed prices.
- 15 Demand from the residential sector was five times higher in 2004 than in 1960, while demand from manufacturing industries was only about twice as high. The residential sector used almost the same amount of electricity as did the manufacturing industry in 2004.
- 16 The catching-up period in this rule is the period that firms are allowed for catching up with the leading firm.
- 17 That is, the index controls for demand according to ownership share.
- 18 These contracts represented a combination of price and volume contracts.
- 19 For documentation, see the SESSA webpage [www.sessa.eu.com](http://www.sessa.eu.com).
- 20 See the Nordic Competition Authorities (2003) and Hope (2005).

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