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Security of Supply in Competitive Electricity Markets: The Nordic Power Market

by

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Abstract

It is well known that in the absence of a complete set of markets or under conditions of monopoly and imperfect competition, optimal provision of quality can not be taken for granted. Market set in the restructured electricity markets is not complete, physical networks per definition are natural monopolies, market-power issues are yet to be resolved, not all the services supplied through the restructured frameworks are private goods and risk of government intervention is high during the times when market prices signal shortages. Sole reliance on the energy-only markets for optimal provision of security of supply under such conditions is mistaken. On the other hand, centralisation of decisions for provision of reserve capacity, such as the gas-reserve capacity proposal in the Norwegian system is not an efficient substitute for missing or imperfect markets. The solution lies in the design of permanent market-mechanisms that enhance the ability of energy-only markets to handle the medium and long-term security of supply. A carefully designed reserve energy certificates mechanism is a viable alternative in this context.

Keywords: Liberalisation, supply security, capacity payments, reserve-certificates market

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0. Introduction

During the recent years much of the debate related to restructuring of network industries such as electricity, gas and telecommunications has focussed on development of efficient wholesale and retail markets for these services. In comparison, less attention has been paid on the development of efficient mechanisms for provision of quality of supply through the newly created markets. Quality can be seen as a multidimensional attribute of a commodity and quality differences map a given generic commodity into a spectrum of commodities that although being similar, are not perfect substitutes as not all consumers value these attributes equally. It is well known that in the absence of a complete set of markets or under conditions of monopoly and imperfect competition[3], optimal provision of quality can not be taken for granted. Market set in the restructured frameworks is far from complete, physical networks per definition are natural monopolies and market-power issues are yet to be resolved under the restructured frameworks. Provision of optimal level of quality in the restructured markets is one of the important challenges facing policy makers.

In the context of electricity, we may distinguish between two sets of quality attributes; commercial quality attributes and technical quality attributes where the former mainly refers to customer service issues while the latter is concerned with the security of supply in provision of electricity[4]. Security of supply is closely related to the installed capacity in the

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[3] Some of the early references include Spence (1975) and seminal work of Mussa and Rosen (1978). For recent discussion see Kim and Jung (1995). Also see Peluchon (2003) that addresses the issue of inadequacy of investments in peak capacity in the deregulated electricity markets.

[4] One may further distinguish between reliability and adequacy where the former refers to the attribute of an electricity system to meet demand in face of short-term contingencies, in other words reliability of supplies, while the latter refers to the attribute to meet demand at all times under “normal” conditions. See Oren (2000). In this paper we interpret security in a broader sense and distinguish between these two interpretations when relevant.

system. Particularly in the OECD countries, supply chain in the electricity industry was traditionally plagued with chronic over-capacity, and security of supply in the early phases of restructuring was a non-issue. One of the main achievements of restructuring has been a steady improvement in capacity utilisation and as capacity becomes scarce, issue of security of supply is increasingly gaining importance. Currently, there is growing concern about the ability of the electricity markets to efficiently provide adequate generation/network capacity or equivalent demand-side flexibility to ensure secure provision of electricity under the liberalised market frameworks.

In Europe, the importance of the issue is emphasized in the new electricity directive[5] that explicitly requires member states to develop institutional framework and measures to monitor and ensure security of supply in the member countries. This is in contrast to the earlier directive[6] where the issue was of secondary importance. In other regions, such as in the US and in a number of countries in Latin America, various forms of incentive mechanisms are already in use to enhance security of supply[7]. In most of these cases the focus is on *long-term* issues related to securing adequate investments in generation capacity.

In hydropower dominated systems, such as in Brazil, New Zealand, Norway and Scandinavia in general there is an additional focus on *medium-term* security; the so called "dry-year" energy security problem. In New Zealand, nearly half of the electricity production is from hydro resources with storage capacity limited to about six weeks of electricity consumption. Nordic market has a similar share of hydro resources in aggregate, although this varies across the member countries in this market. In this context, Norway represents one extreme being almost exclusively dependant on hydropower. Medium term supply security in these countries is related to ensuring adequate storage of water to balance inter-temporal deviations between water-inflows and load-profiles. The time frame in this case may extend across a season to few years depending on the nature of storage capacity in the system. In New Zealand, the government has recently established the Electricity Commission with a mandate for

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[5] Electricity Directive 2003/54/EC.
[6] Electricity Directive 96/92/EC.

[7] US, particularly in the northeast PJM, NEPOOL, NY, Argentina, Chile, Colombia. In Europe, Spain and UK are some of the examples of restructured markets in this context.

monitoring and ensuring dry-year security of supply. In Norway the, government has recently issued a white paper on the issue OED (2003).

In all the countries, the ability of the restructured electricity markets to maintain reliable deliveries in face of short-term contingencies; in other words the *short-term* reliability, is also a crucial issue[8]. The time scale in this case extends from seconds to minutes or few hours and failure to maintain balance can results in complete system breakdown. In almost all the restructured markets, this aspect of security continues to be the responsibility of the system operator who uses a mix of operation standards, protection devices, generation and load management resources that provide voltage support, spinning reserves and other ancillary services that are essential to keep the system in operation. So far, liberalisation, in this context has been limited to development of market mechanisms that improve the efficiency in procurement process for these ancillary services.

Figure 1 illustrates the different time frames and components that constitute the security of supply in power markets.

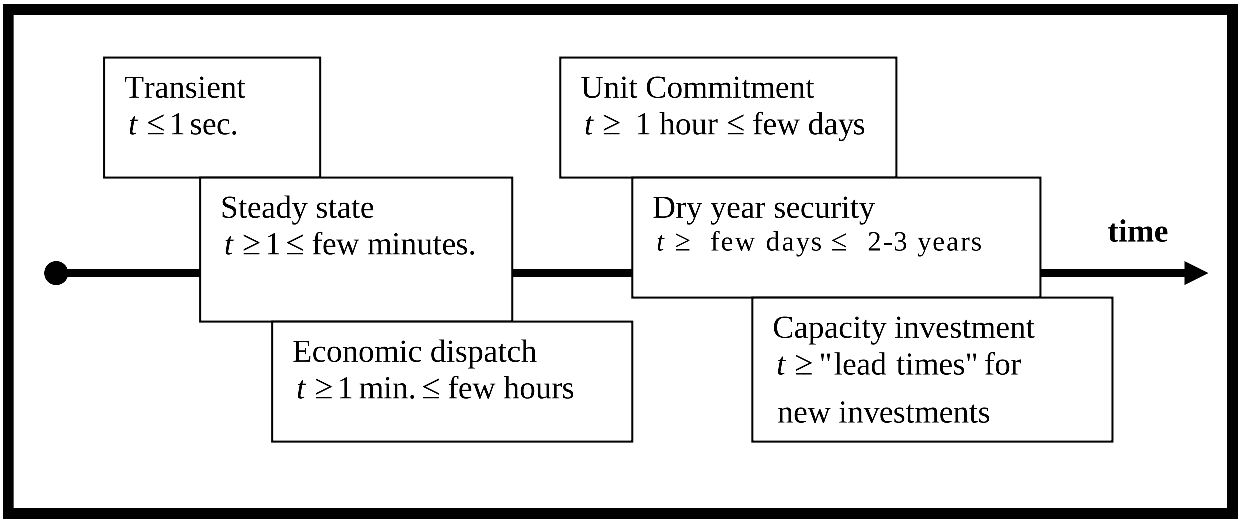

Figure1. Time structure and components of security of supply

[8] More recently in 2003, number restructured electricity markets experienced serious system failures. In Europe, these include Italy, Nordic market (eastern Denmark and Southern Sweden) and United Kingdom (London). In US and Canada the most recent major system failure occurred in the Northern eastern region (New York, Ohio and Toronto). Costs of these failures in terms of lost time and damage to equipment are substantial.

Technically, various time scales of security of supply are distinguishable though not necessarily separable[9]. The long-term issue is related to sufficiency of investment in generation, storage and network capacity to meet system load. In the medium-term the issue is of fuel sufficiency, which in a hydropower system translates into sufficiency of water in storage. In the short-term the security issue is concerned with the availability of buffer capacity to meet contingencies. The three technical dimensions of system security are closely interrelated. For example, a system with abundant generation and storage capacity also provides more flexibility in meeting medium and short-term random imbalances between load and generation. Alternatively, a system with stringent rules and operating reserve requirements for meeting short-term reliability criterion will promote larger installed capacity thus enhancing systems ability to meet the medium and long-term security criteria. Hydropower system in this context is an exception where dry-year characterised by low water inflows do not necessarily influence the ability of the system to meet reliability needs, unless of-course storage reaches the minimum levels.

The policy challenge in the restructured markets is to assure that the market institutions established under the restructuring process guarantee efficient provision of commodity spectre that is needed to maintain security of supply across all the relevant times frames. Failure of the restructuring process on this criterion would result in price spikes[10] and non-price rationing with associated economic and political adjustment costs that can easily jeopardise the regulatory commitment to the liberalisation process. Efficiency gains from restructuring may be overestimated if the liberalised markets provide cheap electricity at a level of security that is not in line with the consumer valuations.

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[9] See Alvarado (1993).

[10] It may be mentioned at the outset that prices are the most important signals for resources allocation in a market system and suppression of price peaks is not a legitimate policy goal in itself. In principle, if the markets function perfectly, security of supply from an economic view point is a non-issue. Price-peaks create the necessary incentives that maintain equilibrium in the electricity market. Policy interventions that impose exogenous constraints on price movements only delay the necessary adjustments to maintain the equilibrium and increase adjustment costs. On the other hand, if markets are imperfect, prices are distorted and so are incentives resulting from these prices. Policy responses around the world to the issue of security of supply are closely related to the beliefs that policy makers hold about the ability of the markets to provide efficient signals across all the time frames.

The main focus in this paper is on analysing the economic issues related to the handling of long-term[11] generation and network capacity and medium-term dry-year security problems in liberalised power markets. In particular the paper focuses on markets in which hydropower is an important generation technology, as in case of the Nordic power market. The paper is divided into four sections. In section one, we outline the various theoretical approaches to handling security of supply within a market framework. In section two, we relate the analyses in section one to the current proposals to handle security of supply in the Nordic market in general and the Norwegian price area in particular. It may be mentioned, that the Nordic market is one of the most mature electricity markets and consequently has also functioned as an important blueprint for a number restructuring frameworks in other countries. Section three, develops an alternative market architecture involving a "reserve energy certificates market" that provides the necessary incentives to handle medium and long-term supply security in a restructured electricity market. Section four concludes the analyses and outlines the main policy implications for the future.

1. Approaches to Security of Supply

The main economic motivation behind the concern for security of supply is driven by negative impacts on economic welfare that arise from the changes in prices and reliable supplies to the consumers[12]. In liberalised electricity markets, the prevailing paradigm is that well functioning markets are the most efficient delivery mechanisms for resource allocation. Additional instruments for assuring security of supplies are justifiable, either when all the necessary market institutions do not exist- the *incomplete markets hypothesis*, and/or those that do exist are imperfect- the *market failure hypothesis*. Current policy response or lack of response as reflected in the existing organisation of power markets ranges from non-intervention, to completely centralised solutions.

[11] In a companion paper we focus on the short-term system reliability issues and highlight the differences that call for different approaches to handling these issues.

[12] See Bohi and Toman (1996) for a detailed discussion.

Non-intervention: Energy only Markets

This is an approach that is based on the belief that market set is complete and the markets function perfectly. Generators and consumers submit bids in the day-ahead market. These bids that are often specific for each hour or half-hour form the basis for the physical merit-order of generation for the following day and determine the system marginal price SMP that equals the short-term marginal costs SMC of the marginal generator. In a hydropower system, if no storage facilities are available, SMC is negligible. If storage capacity is available, inter-temporal arbitrage results in a SMC - the " value of water" used in current generation; that is dependant on the prevailing SMP and its expectations for the future. System marginal price may include a mark-up if generation or storage capacity is constrained. The mark-up in the spot market provides the main economic signals for capacity expansion and consequently determines the security of supply across different time frames[13]. In case the energy spot and futures markets function perfectly, the price signals from these markets will reflect the consumer willingness to pay for security of supply and trigger necessary adjustments in capacity investments and storage that maintain market balance across the different time frames. Under such a scenario, any form of additional policy intervention to influence market equilibrium will result in a deviation from the market allocations and impose economic costs. The market-design in the Nordic market, UK and California is mainly based on this approach, although recent events in the Nordic market have led to rethinking on this "hands-off" approach to security of supply[14].

Success of the energy-only market approach is based on the assumed perfect functioning of the underlying spot and futures markets. The non-intervention argumentation is that electricity markets are no different from other industries and thus should be subject to the same market conditions as others. There are number of reasons, why such an approach may be inadequate. In electricity markets supply and demand conditions change rapidly, and so does the geographic and product definitions of the relevant market, market shares and structure of competition. Further, all the costs arising from insecure supplies may not be private and internalised in individual willingness to pay. At the current level of technology, not all of the

[13] To the extent the generators participate in other supplementary markets such as markets for provision of balancing or ancillary services, or green-energy markets, revenue from these markets may further enhance the economic signals.

[14] See the white paper on system security issued by the Norwegian Storting. OED (2003).

products delivered through the electricity markets are private goods and possibilities of rationing through price mechanism are limited. An example in this context is the short-term reliability attribute, where individual exclusion of consumers through a price mechanism is not possible and market-mechanisms will result in free riding and under-provision of this service. It is thus not surprising that in all the restructured markets, short-term reliability continues to be the responsibility of the system operator and cost are recovered through non-market levies embedded in network tariffs.

The medium and long-term security also has elements of public-good characteristics, though not to the same extent as in the case of short-term reliability. In addition, political debates that express concern about electricity supply security and its consequences for the business and wider community are sufficient to create market failures as market-actors internalise the risk of political intervention in their market behaviour. For example, during a dry year, expectation about market interventions can result in further deterioration of the supply situation. Liquidation of hydro storage would be accelerated as generators adjust their price expectations downwards due to risk of market controls expected as a result of the “concern” expressed by the policy makers. Regulatory interventions may also suppress market prices and influence investments in generation and storage capacity, thus also jeopardising the long-term security of supply in a system.

A relevant case in support of non-intervention would argue that the main economic impact of supply insecurity on the consumer results from the risk of high prices and outages resulting from physical shortfalls. Consumers should be able to share or transfer this risk to actors for whom the bearing of risk is less costly and/or reduce the total amount of risk by undertaking actions such as diversification of their energy use through changes in fuel mix or installation of back-up technologies. From the consumer point of view the main decision is concerned with arranging for adequate insurance cover or back-up capacity from the respective markets for these goods and services and any intervention in this process would distort consumer decisions.

Sole reliance on risk-sharing markets for handling supply security may be mistaken. The most important risk-sharing instruments that are available in the recently liberalised electricity markets are the various markets for financial derivatives. Most of these markets provide opportunities for short-term hedging and market liquidity falls as contract duration increases.

Derivative markets are not designed to generate price signals that can ensure long-term security. Even in case of medium-term security, experience indicates[15] that as the hydro resources dry, so does the liquidity in the derivative markets. In this context it is not the markets that determine prices but the prices that determine the very existence of the markets.

Further, as mentioned earlier, electricity supply and demand conditions change rapidly, and so does the geographic and product definitions of the relevant market, market shares and structure of competition. Imperfect spot-markets, further limit the efficiency of the derivative markets. Not to mention, the transactions costs associated with the use of derivative markets, particularly for small consumers who are obliged to use standard contracts that are designed for large traders and consumers. Consumers may buy "insurance" through fixed price contracts from electricity retailers, however firstly in this case insurance services tend to be bundled with energy supplies and neither insurance nor energy may be efficiently priced. In addition, with increase in vertical integration between generation and retailing, pricing of insurance and energy may be further distorted. Secondly, fixed price contracts themselves may further aggravate the situation during shortages to the extent such contracts result in a wedge between contract and spot prices and reduce consumer response to rising spot-prices.

Capacity Payments Approach

This approach starts with the argumentation that neither is the market set complete nor are the energy only markets perfect. To assure efficient provision of security of supply in restructured electricity markets there is a need to develop appropriate market mechanisms that supplement the energy-only market design. In principle, the main market mechanism envisaged in this approach involves a system of separate *per MW payments* to generators depending on their availability for generation in relation to the total resource availability in the market. Payments may be made in the form of a system-security mark-up[16] on the price in the energy-only market or alternatively as direct compensation for capacity held back to meet potential system shortfalls. In the context of medium-term dry year security in hydropower systems, the capacity payment mechanism may be formulated as *MWh payments* for water set aside or

[15] The first casualty of the dry autumn in 2003 in the Nordic market was the loss of liquidity in the options markets organised by the Nordpool power exchange.

[16] An example is the LOLP (loss of load probability) payments mechanism that existed under the pre NETA trading arrangements in the UK pool.

"ring-fenced" from the energy-only market to meet potential shortfalls. Volume of the ring-fenced capacity would normally be determined by the overall security standard[17] adopted for the system. Activation of capacity buffers created through capacity payments is at the discretion of a "central agent" such as the system operator appointed by the sector regulator. Costs associated with capacity payments in most cases would be recovered from the consumers through an additional charge on the energy prices/network tariffs or alternatively through public funding as was suggested in a recent proposal[18] in the Norwegian electricity market. As compared to the generators in the energy-only market design, the economic signal that determines the security of supply under this approach depends on the size of the capacity payments, in addition to the generator revenues from participation in the energy-only market.

Capacity payments imply compensation outside the energy market and raise important issues regarding their compatibility with restructuring ideology that relies on the market paradigm. An obvious conflict is related to the supply-side bias in this approach. Capacity payments are limited to promotion of generation capacity for improving security of supply and thus by design can exclude feasible demand-side options that may be more efficient. Further, determining the size of such payment is not trivial due to the information asymmetry that may exist between the suppliers and the central agent. Last and not the least important is the uncertainty related to the effectiveness of the payments in improving security of supply as effectiveness depends on how the market responds to the existence of the capacity buffers.

Financial and Fiscal Measures

A third approach, that has been discussed, relies on the use of derivative markets and tax incentives that provide the necessary signals for handling security of supply in restructured electricity markets. The financial approach would envisage the use of MW or MWh one-way call-options held by a central agent to meet the capacity or energy needs to maintain security of supply. The options may be standardised products with a price or an information based trigger. The option could be triggered when the market price or some proxy information

[17] Security standards are often stated in terms of "*1 in n years*" which means that the quantity ring-fenced should be such that it ensures adequate supply to meet demand without need for rationing even in a year with inflows as low as in last *n* years that in some systems ranges form 20 to last 60 years. In reserving capacity, the central agent would for example estimate the volume and time path in (GWh) of hydro-short fall in a dry year and also take into account the expected behaviour of the rest of the generation in the market during such a year.

[18] EBL proposal

variable (for example; precipitation, temperature or storage levels in the context of a dry year problem) that is related to resource availability reaches a certain level. Options which use information triggers that are directly or indirectly based on weather data are quite similar to weather derivatives[19]that have been used by some energy companies in the recent past. Needless to say, the efficiency of these instruments is closely related to the efficiency of the derivative markets. Practical implementation of such instruments will depend on the regulators beliefs about how mature are derivative markets to handle system security. As mentioned earlier, recent experience in the Nordic market indicates that as the hydro resources dry, so does the liquidity in the derivative markets and this may limit the security enhancing potential of such measures.

Fiscal measures have been discussed in the context of handling dry-year security problems in hydropower systems. The measures mainly envisage the use of differentiated rates for resource-rent taxation. Rates are differentiated to influence the storage decisions of hydropower generators such that post-tax rents are higher for generation during peak season as compared to the non-peak season. As in case of the financial measures, peak and non-peak periods may be identified on the basis of a price or information based criterion. The proposal has a supply side bias as it is focussed on use of hydro generation alternatives to improve supply security at the exclusion of other supply and demand side alternatives that may be more efficient. In addition it calls for a change in fiscal regimes that may be difficult to implement. Information based criterion relies on continually changing market fundamentals that reflect resource situation and may be difficult to implement in a fiscal regime.

2. Security of supply in the Norwegian price area and the Nordic market

The current organisation of the Nordic power market is a result of liberalisation process that has its origin in the Norwegian Energy Act 1990 that led to the establishment of a competitive power market in Norway. The main elements of the Norwegian Energy Act that came into operation in January 1991 were functional unbundling of the sector into generation, retailing, distribution and transmission where transmission function was allocated to Statnett SF; the

[19] The American multi energy company ENRON was one of the first and leading companies that developed these derivatives. The first weather derivative was entered into between ENRON and Koch in September 1997. See Ku, A. (2001).

Norwegian power grid company that was formed through divestment of the incumbent vertically integrated state-owned utility Statkraft. To assist trading of electric power by the market actors, a day-ahead spot, futures and regulation markets were established through the power exchange Statnett Marked AS, a wholly owned subsidiary of the transmission operator Statnett SF. Further, regulatory functions were divided between the Norwegian Competition Authority and Norwegian Water Resources and Energy Directorate NVE where the former institution focussed on promotion of competition in the newly established markets while the latter was entrusted with the task of inducing efficient operations and development of transmission and distribution networks in particular and system development in general. The liberalisation in Norway was followed by similar policy changes in Sweden in 1996 and establishment of a common market for electricity comprising of both Norway and Sweden. To accommodate the changes, the power exchange, Statnett Marked AS was restructured into the a Nordic power exchange – Nord Pool ASA , a company jointly owned by the Norwegian transmission operator Statnett SF and Swedish network operator Svenska Kraftnat. Later round of liberalisation of the electricity sector in other Nordic countries resulted in Finland joining the Nord Pool in 1997, followed by Denmark West in 1999 and Denmark East in 2002.

At present, Nord Pool operates the Nordic wholesale electricity market where electricity producers, retailers, large industrial users and grid companies, trade electricity. Nord Pool operates a day-ahead spot market for physical contracts ELSPOT, a set of financial derivative markets offering futures and options contracts and provides clearing services related to these contracts and bilateral contracts entered between the parties. During the recent years, Nord Pool has accounted for approximately a third of the consumption in the Nordic market, whereas the rest has been traded through standard bilateral contracting which remains the main instrument for electricity trades in the Nordic market.

An important characteristic of the production structure in this market is that, although diversified at the Nordic level, the same is not true for individual countries. Norway in this context is the least diversified, being almost exclusively dependant on hydropower generation with installed capacity of 27596 MW. There is a small amount of thermal (271 MW) and wind (13 MW) power capacity. Traditionally Norway has had ample access to hydropower generation capacity where some of the largest hydro capacity additions were made up until 1985. One of the specific objectives of the liberalisation process set into motion by the Energy

Act 1990 was to correct the excess capacity situation and promote efficient scale and order of new generation investments in the system. On this count, the liberalisation process has been quite successful. During the 1990s there has been limited addition to new generation capacity mainly in the form of upgrading and expansion of existing hydro generation plants. At present the production potential of the Norwegian system is estimated at 119 TWh in a normal year based on the period 1970-1999 while the current consumption levels are around 126 TWh thus making Norway a net importer of energy. The current cross-border network interconnection capacity is around 4000 MW, which is used to maintain supply demand balance demand during normal years. With a steady 2-3% annual growth in demand and limited additions in domestic generation capacity, the Norwegian system will be increasingly dependant on cross-border to cover both power and energy needs in the system. Currently, the main Norwegian cross-border interconnections are to the other countries within the Nordic region; a region where the power and energy situation is fast approaching its capacity limits. Concern for security of supply in Norway thus is not surprising.

In addition to the tightening generation capacity situation, the Norwegian system also faces a vulnerable *medium-term* supply security situation that arises due to the exclusive dependence on storage-based hydropower. The normal pattern of water availability in Norway is cyclical over the year. Starting with the minimum storage level by the last week of March/beginning of April that marks the end of winter, the level starts rising as inflows increase and consumption falls during summer. Storage levels peak by the beginning of September before they start falling during autumn and again reach the minimum by the end of winter. Inflows are highest during June to September; the summer months when the snow melts and load is highest during November to beginning of April which is the heating season. Given that water inflows to the system can vary plus/minus twenty five percent around the average levels and with limited access to alternate fuels or technical substitution possibilities on the demand side, the Norwegian system is particularly vulnerable towards the end of the winter as inflows dry-up and loads reach their maximum.

Winter 2002-2003 illustrated the medium-term supply security problems in the Norwegian power system. During this period, the storage levels in the Norwegian system fell well below the minimum observed since 1990 and the prices peaked to historic levels. Interconnections with the neighbouring countries were used to their full capacity to supplement domestic production and the Norwegian regulator issued warnings for rationing through planned outages. To reduce the probability of recurrence of the situation the government set into motion number of measures and has issued a white paper that outlines the government strategy to handle medium and long-term security of supply in the Norwegian system.

The strategy in brief, outlines a ten-point program involving a mix of supply and demand side measures to meet the security objectives. The main measures on the supply side include upgrading of existing hydro capacity and new capacity mainly through development of green energy alternatives that include small and micro hydro projects and wind power. In addition, development of gas-power remains an important objective however the imposition of carbon dioxide emission constraints on these projects makes the projects commercially unviable under the current expectations of price structure in the Nordic market. An investment subsidy for low emission gas power plants is planned for introduction from 2006, however in the absence of the details of such subsidies large scale developments in gas power are unlikely in the near future. Supply security in the Norwegian system is also closely related to the conditions on the demand side where electricity dominates the fuel-mix in stationary demand for energy. Large share of final demand consists of heating processes in industry, services and residential sector, all with limited access to alternate fuels or technical substitution possibilities. The strategy outlined in the white paper thus includes number of measures to reduce the rigidity in the structure of demand through development of district heating and gas network infrastructure and various investment subsidies to accelerate efficiency improvements in use of electricity.

An important element in the government strategy, is the mechanism that is outlined to handle medium term dry-year security problem in the Norwegian system. The mechanism is expected to function as a supplement to the energy-only market and involves establishment of gas turbine reserve capacity of 600- 1200 MW with an expected potential of generating 3,5 TWh of electricity assuming a production period lasting 4 months. The reserves are to consist of 2-4 mobile or stationary gas power facilities each in the range of 150-300 MW. Reserves are to be to be hired or *owned* by the grid company Statnett, although the decision to draw on these reserves will be at the discretion of the regulator. No particular details are outlined about financing of these reserves, however given that the responsibility is placed on the grid company, most likely, costs of maintaining the reserves will be included in the grid operators revenue caps[20] and socialised through the transmission tariffs.

In principle, the mechanism outlined in the white paper reduces to a mechanism of capacity payments for mothballed gas-powered generation capacity to be used during the dry-years. Capacity payments were analysed in section two and much of the general discussion also applies to the mechanism outlined in the white paper. In addition, the efficiency and effectiveness of the proposed mechanism is further questionable.

Demand Response and Efficiency

An important weakness of the proposed gas reserve capacity mechanism arises from the lack of neutrality in treating supply and demand side measures. It ignores demand side alternatives to improving security of supply. To understand the importance of demand side measures we may draw on the experience from the situation in winter 2002-2003.

From the end of November 2002 to end of January 2003, the daily average spot price in the Nordic market varied in the range 0.5-0.8 Nkr./kWh, and from January onwards the prices were in the range of 0.25-0.3 Nkr/kWh. For the first half of the year 2003, the average price was 0.32 Nkr/KWh. All these price levels implied increase in prices by a factor of two as compared to the levels that were achieved during the same periods in 2002. During the first half of 2003, aggregate demand was approximately 4TWh lower as compared to the same period during 2002. Most of the reduction in demand came from consumers in the power intensive industry and industry in general and residential and commercial demand also contributed to this reduction although not as much as the other groups. While it is difficult to ascertain exactly the share of price responsive reductions in the total reductions[21], the effect of increase in prices on electricity demand cannot be ignored in this respect. The gas capacity buffer currently recommended has a potential of making a net contribution of about 3.5 TWh. In case the situation in winter 2002-2003 is considered sufficiently serious to call for activation of such buffer capacity, activation of such reserves would have resulted in

[20] Network operators in the Norwegian system are subject to a performance-based regulation involving annual revenue caps

[21] It has been argued that some of the reductions, particularly in the power intensive industry were due to the general depression in their product markets

crowding-out of efficient price responsive demand reductions. Not to mention, the negative impact such activation will have on market prices and market-driven investment in supply and demand side alternatives that improve the security of supply in the system.

Efficiency of the mechanism is also doubtful as compared to the other supply side alternatives. Focus on gas power turbines, excludes other supply side alternatives such as renovation of marginal hydro and green electricity projects that could be profitable as compared to the new gas capacity. Further while it is true that gas turbines have low investment costs, the variable costs for use of these turbines should not be underestimated. The current estimates for variable costs of gas turbine based power are estimated to be in the range of 0.12-0.3 Nkr/kWh and are based on current expectations of average gas prices. It may be noted that the turbines will be used during winter when gas prices peak and use of average prices is misleading. In addition, current gas prices are based on long-term contracts with substantial base load supplies. It is unlikely that “spot” gas required during the peak season would be priced at the same level as that available under long-term contracts.

Producer Response

Effectiveness of the reserves critically depends on the response of the generators to the existence of the gas capacity reserves. The simplest assumption is that generators decisions are unchanged and even in this case analysing the effectiveness of the reserves is not trivial. However if we allow for a more realistic assumption that generators would factor-inn the buffer capacity in their production and storage decisions, potential impacts of the buffer on improving the dry-year security can be minimal.

Storage decisions in a market based power system are not exogenous but driven by producer expectations about the term structure of the market prices. Norwegian producers engage in both spatial (trade) and inter-temporal (storage) arbitrage activities and a change in conditions in one activity would influence the level of the other activity. Ignoring transport and storage costs for the moment, for example, a fall in expected gain on the marginal unit put in storage would lead to an increase in current consumption or exports depending on the market conditions. Buffer reserves constitute a credible threat for regulatory intervention and factoring-inn of these reserves would result in downward adjustment in producer expectations about future prices and consequently storage, thereby neutralising the additionality impacts of the buffer mechanism.

Medium term security of supply in Norway is a winter phenomenon, closely related to the hydro storage during summer and autumn. For example, during the period July to December 2002, there was a net export of 6.4 TWh from the Norwegian system to the rest of the Nordic market. Exports were mainly to Sweden and the direction of trade reversed only in January 2003, when the resource situation became critical. Until, December 2002, from the hydro storers point of view, gains for spatial-arbitrage through trade with rest of the Nordic market must have dominated expected gains from inter-temporal arbitrage through storage if the pattern of storage and trade was in line with the market incentives and producers were motivated by economic signals. Under such conditions, existence of reserve capacity mechanism as outlined in the white paper would have further reduced the incentives for storage and consequently also the effectiveness of a buffer capacity mechanism[22].

Administrative and Political Constraints

Implementation of the mechanism is also constrained by the current legal, sectoral and environmental policy constraints. The main legal constraints are related to the problem of compatability of such mechanisms with the Norwegian obligation under the European Economic Area agreement with the European Union. Some of the relevant *legal* constraints are those imposed by the Electricity Directives 96/92/EC and the New Electricity Directive 2003/54/EC, various Provisions related to economic freedoms and Competition Law in the EC treaty, the Rules on Public Service Obligations and the provisions of State Aid[23]. Under

[22] So far we ignore the problems associated with market power. At present a total of 156 companies are engaged in power generation in Norway of which the state owned Statkraft is the largest producer that also directly or indirectly has ownership interest in other companies. Depending on how these cross-ownerships are accounted for the Statkraft has around 40% of the Norwegian production capacity. The share gets significantly higher if we include the current acquisition plans of Statkraft in South and mid Norway. Statkraft share of storage capacity is even higher, if we take into consideration its operational control agreements on the jointly owned capacity. The dominant position of Statkraft is obvious; what is contested is whether the company has the incentive and the ability to exercise this position in its own interest. The answer depends on geographic and product definitions of the relevant market. There is no doubt that the ability is limited, when there are no bottlenecks on the inter-connectors between Norway and the rest of the Nordic market. However, when the Norwegian system is partitioned from the rest of the Nordic market and often into a number of separate price areas, the ability to use the dominant position is enhanced which if exploited results in distortions both in time path of prices and water storage. This may also jeopardise security of supply in the system.

[23] See Knops (2003) that provides a detailed discussion about the directive and the degrees of freedom that member states have to implement such measures under the current European legislation.

the New Electricity Directive 2003/54/EC, the member states are expected to ensure that security of supply issues are monitored -: Art. 4, implement measures to ensure adequate level of generation capacity-: Art. 7, designate public/private body that is *independent* of generation, transmission, distribution and supply activities, to organise, monitor, control of tendering process for establishing reserve capacity. In this context a Transmission System Operator TSO is eligible – *only* if it is pure system operator devoid of ownership of network assets.: Art.7(5). Statnett is both a system operator and owner and legality of the allocation of the responsibility to Statnett to acquire buffer reserve capacity through tendering process is doubtful. In addition, preferential treatment of gas turbines at the cost of exclusion of the other supply and demand side alternatives can be questioned. Lastly, financial support to the system operator for the purposes of establishing such reserves may conflict with the constraints imposed on state aid that favours certain undertakings.

The main sectoral constraint is related to the incompatibility of the mechanism with the basic tenets of the organisation model for the Norwegian electricity sector. An important characteristic of the restructured model is the functional separation of the network functions from generation. Opening up of ownership of generation capacity; reserve or regular, by the system operator Statnett conflicts with the functional separation that is basic to the restructured sector framework.

The main environmental policy constraint is related to the high levels of climate gas emissions associated with gas turbines, particularly when used as a source of regular supply of electricity. For example, mobile gas turbines have low levels of fuel efficiency (around 35%) and emissions levels from such plants are higher than those from conventional gas power plants. Given the controversy around the introduction of gas-power plants in Norway, the mechanism that envisages new capacity equivalent of 3 to 4 gas power plants would be in conflict with the stated policy of the government on the matter.

3. Expanding Energy only Markets -Reserve Certificates Market

The view that we subscribe to is that energy-only markets in their present form are not sufficient to provide optimal levels of medium and long-term security of supply in the restructured power markets. On the other hand, we also believe that centralisation of decisions through the office of a central agent is not an efficient substitute for missing or imperfect markets. The solution lies in the design of market mechanisms that enhance the ability of energy-only markets to handle the medium and long-term security of supply. In the absence of perfect revelation of consumer valuations for long and medium term security through well functioning energy only spot and derivative markets, a second-best approach would be to focus on achievement of a *target level* instead of an efficient level of supply security at the *minimum cost*. The difference is that instead of striving to attain an efficient level of security through the energy-only markets we may rather focus on a target level of security that is determined through an administrative process. The policy issue then is to develop an incentive mechanism that achieves the target level at minimum cost.

The approach is quite similar to the policy solutions used in other sectors for improving resource allocation when markets do not exist and/or when markets fail. Environmental policy instruments and mechanisms provide a spectrum of alternatives in this context. Although details may vary, the general modus operandi is as follows: A public regulator determines a single or a distribution of target level for a policy variable in a given jurisdiction. In principle, the target-level may be estimated through a mix of engineering and/or contingent valuation techniques that use well designed consumer surveys to estimate consumer preferences[24]. The chosen level is then assigned to a particular link in the supply chain through a predetermined rule. As the initial assignment is not likely to be efficient, a supplementary marked mechanism is established to facilitate economic exchange of initial assignments; the objective of the supplementary mechanism being to allow for cost efficiency improvements in the initial allocation

One current illustration of the approach in Europe are the green energy certificates markets that are being developed as a supplement to the energy-only markets, to promote integration of renewable energy RE technologies in restructured electricity markets. The central element of the mechanism is the target "percentage requirement" that is defined as the percentage of total energy consumption to be covered by renewable energy sources in the implementing countries. The main mechanism for cost efficient achievement of the RE target is the green certificates market. Supply side of the certificate market consists of generators who sell certificate entitlements that are "produced" as a by-product of the sale of electricity generated

[24] See for example, .(1994), Hanemann (1994).For a critique of the methodology see Hausmann (1993).

from authorised renewable technologies.[25] Demand side in this market are electricity consumers who face mandatory percentage requirement defined in terms of share of total electricity consumption to be covered by electricity produced from green sources. Mandatory percentage requirements lays the foundation for the existence of a market for green certificates and assures that the green electricity producers receive compensation through the certificate market in addition to the revenues received from the energy-only market. Consumers face prices that are a weighted average of the price in the certificate market and the energy market, the weights being dependant on the percentage requirement mandated in the mechanism.

Reserve capacity certificate market

The parallel in the context of ensuring supply security is the establishment of a *reserve capacity certificate market*. In brief, a public regulator determines a target level; a "percentage reserve requirement" specified in relation to the expected electricity demand in a given jurisdiction. The target reserve requirements are then assigned to a functional link in the electricity market supply chain, which procures the reserves in the certificate market. The reserves procured in the certificate market are placed at the disposal of the public regulator who authorises the activation of the reserves when deemed necessary. Activated reserves are compensated through the energy-only market.

Supply side of the certificate market consists of all the market actors who possess capacity that is relevant for meeting mandatory reserve requirement. All the market actors who possess relevant reserve capacity are allocated reserve certificates in proportion to their documented stock of existing and potential reserve "assets". The relevant reserve assets may consist of existing or planned generation capacity and interconnection capacity[26]. In the context of dry-year security problem the certificates in addition would also be supported by water in storage. Electricity consumers are eligible for allocation of capacity certificates depending on their documented ability to provide "negative" demand for the necessary duration. Obvious candidates in this context are large consumers with an ability to offer load-reductions on call.

[25] See Nielsen, L. and T. Jeppesen (2003) for a discussion of the mechanism

[26] Inclusion of transmission may pose problems in cases where definition of reserve interconnection capacity is ambiguous as in a meshed-network where presence of loop-flows may make definition of capacity difficult.

Consumers may supply “negative demand capacity” directly in the reserve certificates market or through the network entities who acquire demand flexibility through priority pricing contracts. Revenues from sale of the reserve certificates in addition to the revenues for activated reserves that are compensated through the energy only market forms the main market signal for handling of long and medium term security under this mechanism.

Demand side in the certificate market is the functional link in the supply chain that is assigned the responsibility of meeting the mandatory reserve requirements. Supply security is a system attribute and it is natural that responsibility is assigned to an actor best able to handle system wide attributes. In the electricity sector, this limits the choice to the various network operators at different levels in the network. In principle; the responsibility may be imposed on any of the network levels ranging from distribution to national grid entities. The main consideration for policy guidance is that the chosen alternative promotes transparency and competition in the certificate market and at the same time reflects the spatial nature of the shortages associated with the medium and long-term security issues.

In the first instance, spatially, both medium-term and long-term security issues in practice appear at the regional level. The phenomenon is true not only for electricity markets but also in other markets such as those for agriculture commodities[27]. Secondly, the prospects of achieving workable competition in the pricing of reserve certificates are much more at the regional level than at the distribution level where supply side may be quite concentrated. Thirdly, the reserve certificate market mechanism distinguishes between *estimation and activation of reserves* on one hand and the *procurement* of reserves on the other. In practice, the grid operator would be closely involved in the estimation and activation process. For the sake of transparency and to avoid perverse incentives it is important that the grid operator is free of the procurement process. All these considerations collectively call for the imposition of the percentage requirements on the regional entities.

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[27] A common conclusion that “famines” are regional in content but global in consequence applies as much to electricity as to agriculture markets which are one of the most closely analysed markets in the context of designing mechanisms for handling shortages. For example, the recent system failure in the Nordic market-Eastern Denmark and Southern Sweden on September 23, 2003, was a result of a combination of network and generation capacity shortage in Southern Sweden, although its consequence was much beyond this region.. Similarly, the risk of non-price rationing that emerged during the dry-year autumn winter 2002-2003 was mainly limited to the Norwegian system and in particular to Western Norway than the whole Nordic system.

The regulatory framework

Establishment of a market for reserve certificates and allocation of responsibility on the regional network entities by itself does not guarantee that the reserve requirement obligations will be fulfilled in the most efficient manner. A crucial issue in this context is the regulatory framework for implementation of the mechanism. In this context, three factors are important: rules for reimbursement of costs incurred in the reserve certificates market by the regional network entities, penalty mechanism for non-compliance and the geographic expanse of the mechanism.

As regards cost recovery; if the certificate market functions efficiently, then conduct regulation that imposes mandated procurement through this market would secure efficiency, and the regulator may allow full pass-through of costs incurred in the certificate market. The regulatory challenge however under a full pass-through regime is to assure that certificate market works competitively. Almost all the restructuring models require some form of vertical disintegration between network and generation activities. In practice, in most of the restructured markets, there is still a substantial amount of common ownership of generation and network assets although the latter are organised as independent entities. Such an ownership structure creates incentives for strategic behaviour in certificates market and can jeopardise the efficiency of the certificate markets and the full pass-through framework.

The alternative framework to conduct regulation implicit in the mandatory procurement process is to allow for free bilateral contracting in procurement of reserves certificates. This is particularly a relevant alternative in cases where restructuring process is in infancy stages and energy markets are not mature. However with existing common ownership of generation and network assets, the framework would have to be supplemented by some form of a performance-based regulatory regime[28], to avoid self-dealing and gaming by the network entities through bilateral contracting with preferred reserve suppliers[29]. Regulatory regimes in this context include ex-ante or ex-post reviews of procurement contracts and various administrative or market-based benchmarks for reserve certificate prices. It may be emphasised that allocation of procurement responsibilities at the regional level also allows

[28] See Blumstein (1999)
[29] For a discussion of some relevant issues related to pass-through of costs see Littlechild (2003).

greater opportunities for a comparative assessment of the performance of the responsible entities and assist in effective regulation of the entities.

It may be mentioned that costs of assuring a given level of supply security through a reserve certificate mechanism are largely dependant on the valuations of the market participants. Energy reserve certificates derive value from the conditions in the energy market. To illustrate; in the context of dry-year security, the shadow-price associated with the percentage requirement is dependant on the resource situation. Prices in the reserve certificate market would move in line with the resource situation, falling as resource availability rises and rising as resources availability falls. An important factor affecting this process is the *penalty* level chosen by the regulator to penalise non-compliance by the regulated network utilities. Low penalty levels will reduce the effectiveness of the mechanism. It is important that the penalty levels are determined in relation to the rationing costs facing the consumers, to assure that the mechanism does not suppress investment signals originating from the resource situation in the energy market.

Effectiveness of the reserve certificate mechanism is also dependant on the *geographic expanse* in relation to the level of interconnection in the system. It is important that the geographic expanse internalises the major interconnections to avoid “leakage” of supply-security to the neighbouring systems[30].

Temporary or permanent reserve requirements

Underlying much of the debate related to market intervention to handle supply security is the implicit assumption that policy measure should be taken when resource situation calls for the intervention; in other words measures should be temporary. In contrast, it is important that the energy reserve certificates mechanism is established on *permanent* basis. The rational for establishment of the mechanism is the missing and imperfect markets. The solution involves development of market institutions that assist continuous price formation in the capacity market as distinct from temporary measures that may be introduced at the discretion of the regulator during dry-years. Permanent mechanisms also signal regulatory commitment.

[30] Stoft (2000) provides a discussion of the problem in functioning of a similar mechanism in the PJM market in the US.

An inherent characteristic of the issue of supply security is uncertainty and once the uncertainty is revealed, utility of additional temporary mechanisms is quite limited. For example, in case of a dry-year problem, once the precipitation has failed, temporary actions that can be taken to assure secure supplies through the season are limited to a choice of price or non-price rationing of water in the remaining part of the season. In systems with multi-year storage capacity, this approach does not allow efficient use of multi-year capacity in the context of assuring dry-year security issues. Another drawback of temporary measures is that it places information burden on the regulator to unveil uncertainty and act prior to the market actors to correct the market allocations. A priori, there is no reason to assume superiority of the information set of the regulator over that of the market participants. Besides, temporary regulatory intervention may itself introduce an additional uncertainty in the market environment and introduce costs on the market participants. Lastly, in case of long-term security, installation of new generation and interconnection capacity is subject to time-lags and temporary interventions that promote generation or interconnections at best will be effective after a lag and can generate investment cycles of over and under capacity that are typical of capital intensive industries.

4. Conclusions

It is well known that in the absence of a complete set of markets or under conditions of monopoly and imperfect competition, optimal provision of quality can not be taken for granted. Market set in the restructured electricity markets is not complete, physical networks per definition are natural monopolies, market-power issues are yet to be resolved, not all the services supplied through the restructured frameworks are private goods and risk of government intervention is high during the times when market prices signal shortages. Sole reliance on the energy-only markets for optimal provision of security of supply under such conditions is mistaken. On the other hand, centralisation of decisions for provision of reserve capacity, such as the gas-reserve capacity proposal in the Norwegian system is not an efficient substitute for missing or imperfect markets. The solution lies in the design of permanent market-mechanisms that enhance the ability of energy-only markets to handle the medium and long-term security of supply. A carefully designed reserve energy certificates mechanism is a viable alternative in this context.

REFERENCES

Alvarado, F.L. “Technical Foundations for Pricing System Security”, in Oren, S.S, and S.A. Smith, eds, *Service Opportunities for Electric Utilities: Creating Differentiated Products,* Boston, Kluwer, 1993, 121-146.

Blumstein, C. “Pricing Electricity for Default Customers: Pass Through or Performance-Based Rates”, Working Paper PWP-066, Program on Workable Energy Regulation, University of California Energy Institute, Berkley, 1999. Available at www.ucei.berkley.edu/ucei

Bohi, D.R. and M.A. Toman. *The Economics of Energy Security*. Boston, Kluwer 1996.

Hanemann, W.M. “Valuing Environment through Contingent Valuation,” *Journal of Economic Perspectives,* Fall 1994, Vol. 8, number 4, 19-43.

Hausman, J.A. *Contingent Valuation. A Critical Assessment*. New York, North Holland, 1993.

Knops, H.P.A. “Securing electricity supply: What is the potential of national measures in the European market”, Paper presented at the Research Symposium on European Electricity Markets, The Hague, 26 September, 2003.

Kim, J-C., and C-Y. Jung. “Regulating a Multi-Product Monopolist.” *Journal of Regulatory Economics*, 1995, Vol. 8, number 3, 299-307.

Ku, A. “Betting on the Weather.” *Global Energy Business*, July-August, 2001, 28-32.

Littlechild, S.C. “Wholesale Spot Price Pass-Through.” *Journal of Regulatory Economics,* 2003, Vol. 23, number 1, 61-91.

Mussa, M., and S. Rosen. “Monopoly and Product Quality.” *Journal of Economic Theory,* 1978, Vol. 18, 301-317.

Nielsen, L. and T. Jeppesen. “Tradable Green Certificates in selected European Countries-Overview and Assessment.” *Energy Policy,* 2003, Vol. 31, 3-14.

“Om forsyningssikkerhet for strøm mv.”, *St.meld. nr18,* OED, Oslo,19the Desember, 2003

Oren, S. “Capacity Payments and Supply Adequacy in Competitive Electricity Markets.” Proceedings from the symposium of specialists in electric operational and expansion planning, Curitiba, Brazil. May 21-26, 2000.

Peluchon, B. “Is Investment in Peak Generation Assets Efficient in a Deregulated Electricity sector”, Paper presented at the Research Symposium on European Electricity Markets, The Hague, 26 September, 2003.

Spence, M.A. “Monopoly, Quality and Regulation.” *Bell Journal of Economics*, 1975, Vol. 6, 417- 429.

Stoft, S. "PJM's Capacity Market in a Price-Spike World." Working Paper PWP-077, Program on Workable Energy Regulation, University of California Energy Institute, Berkeley, 2000, Available at www.ucei.berkeley.edu/ucei