Technical University of Denmark

# Security of supply secured by market forces: different stages and welfare prospects in relation to Danish and Nordic conditions

**Klinge Jacobsen, Henrik; Jensen, Stine Grenaa**

*Published in:*
Proceedings (CD-ROM)

*Publication date:*
2008

*Document Version*
Publisher's PDF, also known as Version of record

# Security of supply secured by market forces: Different stages and welfare prospects in relation to Danish and Nordic conditions.

***Henrik Klinge Jacobsen and Stine Grenaa Jensen***

Risø National Laboratory, Technical University of Denmark, P.O. Box 49, 4000 Roskilde, Denmark,

Ph: +45 46775109 Fax: +45 46775199

e-mail: henrik.jacobsen@risoe.dk

*9th IAEE European Energy Conference June 10-12 2007 in Florence*

**Abstract**

*Security of supply in electricity markets has been seen as a critical test for the functioning of the markets. This has been especially relevant for the existing spot and futures markets, and less explicit for the quality aspect of electricity, which has only to a marginal extent been covered by markets. This paper describes the possible steps and some necessary conditions for establishing markets for security of supply services in a Danish and Nordic perspective.*

*For the adequacy aspect of security concern has been raised that market prices are not sufficiently high to secure new generation capacity. In particular the peak power resources do not seem to be attractive without some capacity payments. Construction of such markets in an efficient way has been broadly discussed in literature, but the linkage with grid investment is less covered.*

*There are several possible benefits of having the security aspect covered by a market instead of by regulation. First step is to secure that a given level of security is satisfied at the least costs. To have this marginal cost in generation, transmission and distribution have to be at comparable levels. The argument is that consumers have identical cost of disruptions (Value Of Lost Load, VOLL) whether due to generation capacity constraints, capacity/ fault in transmission lines or faults in distribution equipment. Costs have to be equal across sectors operating in competitive markets and sectors that are directly regulated. If the regulator itself is demanding security of supply services from all three parts of the power sector the simplest form of a market would be implemented. This would not result in the optimal level of security as the final demand for security would not be reflected, only the regulators estimation of costs. If it is possible to reduce the public good property of security of supply a market might lead to a more correct level of security, but the largest benefits would be associated with possible differences in VOLL among customers.*

*Secondly the possibility of individualised security of supply exists. To the degree it is possible to exclude customers this would imply that different degrees of security can be supplied to customers with different costs of lost load. Examples of this possibility exist, but it is not a widespread practise in the liberalised power markets of today. The linkage to the flexible demand element in the existing power markets is discussed. Flexible demand and interruptible load share the property of having to individually affect the load of customers. If mechanisms are in place to have individual customers adjust their load with a warning time the step to having individual interruption is also possible. Special emphasis is given to relating the possible markets to the actual disruptions in Denmark.*

*As a majority of disruptions (frequency) are related to distribution grid faults the cost of reducing these faults relative to the cost of maintaining the capacity reserves that secures that almost no load has been lost due to capacity constraints is questioned. Would an integrated market for security services transfer resources from capacity reserves to distribution grid infrastructure? Finally is the*

*question of the supply of electricity to all residential customers at the same regional rate in line with having different prices for security of supply services to the same residential customers? As it is now, the security of supply is varying among the consumers without this being reflected in any difference in payments (and in the Danish case without compensation).*

### 1. *Welfare gain elements from construction of markets for security of supply*

Security of supply is one aspect of quality services associated with electricity supply. This aspect is not priced directly in the price paid for the electricity, neither in the wholesale markets nor in retail sale. The costs of securing supply are borne by consumers or producers, but it is not directly linked between their individual demand or supply for security of supply.

If markets for this kind of service is constructed what will be the possible gains?

**Cost minimisation in securing a given level of security of supply**

First it could be expected that a market with competition in the supply of electricity security would reduce the cost associated with reaching the level of security. Without a market it is not secured that all the possible technologies to increase security of supply are made available to the regulator and in particular not in the correct volume. If the regulator has all the information available it is however possible to reduce the error relative to the market considerably.

**Establishing the social optimal common level of security of supply**

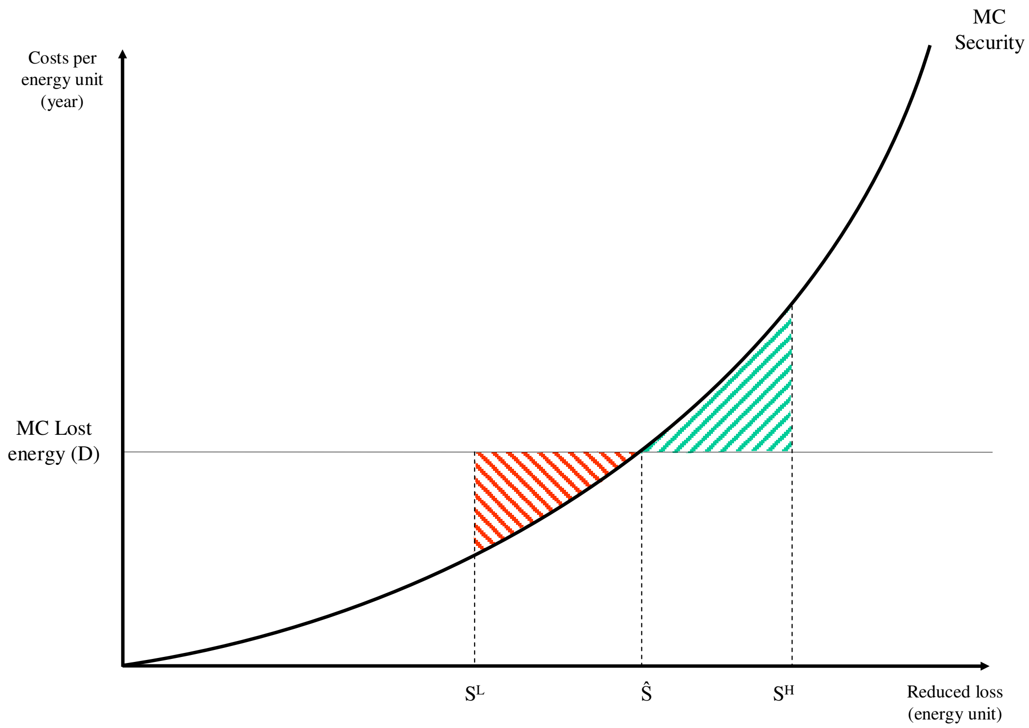


**Figure 1 Possible loss if incorrect level for security of supply**

For the elements of costs also involving consumers and their costs of supply interruptions we start by examining one common level of security of supply.

For simplification it is assumed that:

- Cost of interruption per energy unit is independent of duration and timing of the interruption
- All consumers are identical with respect to cost of interruption
- Marginal cost of limiting the expected loss of energy per year is increasing with reduction in expected loss

In Figure 1 there is a possible welfare loss if the arbitrarily chosen level of security is too low $S^L$ or too high $S^H$ relative to the level $\hat{S}$ where consumer's real cost of interruption are equal to marginal costs of supplying additional security. If security is a pure public good it is likely that consumers will express an opinion favouring high levels of security as that is not seen as affecting their costs. If authorities and regulators are adjusting to these opinions it is possible that we are having too high levels of security and thereby are experiencing a welfare loss. The opposite situation can arise if individuals are asked to actually pay additional for security and they understate their willingness to pay to enjoy the free ride on this service.

**Possible loss due to not serving different levels of security to different consumers**

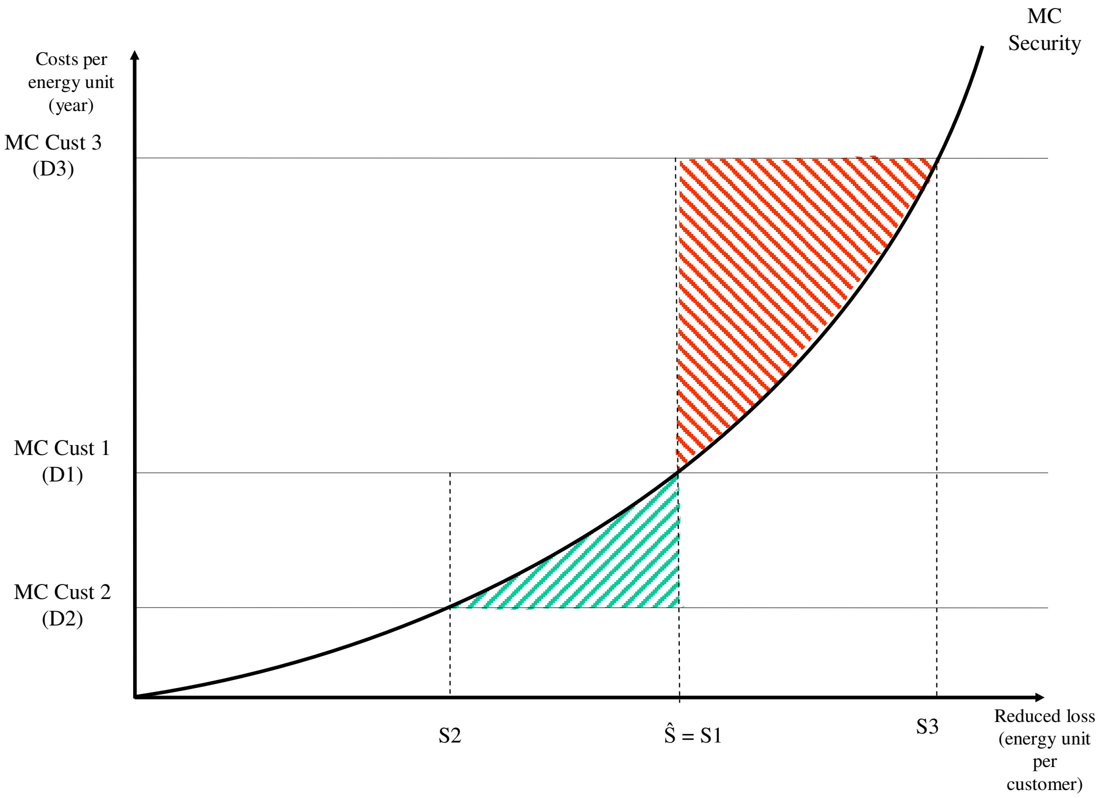


**Figure 2 Different interruption costs for consumers**

In this case we now relax the assumption of consumers having the same costs of interruptions. In some studies it has been found that industry is experiencing costs of being interrupted than do private households. For households it even plausible that there are quite large differences, for example, dependent on whether their heating is dependent on electricity supply or even more basic if they are actually at home during the hours where interruptions occur.

The demand part of the market for security of supply is particular important for possible welfare losses if the costs of lost energy are different among the consumers. In Figure 2 without a market Customer 2 will be supplied too high security and Customer 3 too low security. Only Customer 1 is experiencing a level of security that corresponds to her interruption costs. The loss will therefore be the sum of their individual losses.

A market with consumers included will imply having different levels for security of supply for different consumers. Still this seems fine in the case where there is assumed no difference in supply costs for different consumers as in the case in Figure 1 and Figure 2.

Another problematic issue in this simple representation is the difference in costs of establishing security of supply to the individual customers. We don't deal with this here.

## *2. Public good characteristics of security of supply and changes as a necessary precondition for construction of markets*

Security of supply is in the literature regarded as a pure public good and by others as not characterised as a public good. It is a necessary precondition that security of supply is not a pure public good to have a well functioning market without having to use regulate.

The term 'Security of supply' refers to the likelihood that electricity will be supplied without disruptions. Thus, often the terms security and adequacy are distinguished so that (Oren et al, 2000):

- *security* is the ability of the system to withstand sudden disturbances, e.g.,
- *adequacy* is the ability of the system to supply the aggregate electric power and energy requirements of the consumers at all times, e.g., have enough power capacity, enough network capacity, and system functionality.

In recent years, the main argument for regulating of power market with focus on security of supply has mainly been the reading of security of supply as a public good. Several papers view security of electricity supply as a public good, e.g., Abbott (2001) "This means that security is non-rival in public good terms. Security of supply also appears to be nonexclusive in that it is difficult to exclude people from benefiting from that reduced risk associated with the construction of additional capacity.." Counter wise, Rochlin (2004) states that "The market provision of an adequate reserve margin does not fail the rivalry or the exclusionary principles and does not qualify as a public good".

In order for us to evaluate these two contradicting statements we start out by the economic definition of public goods. Public good are often defined as goods that are non-excludable as well as non-rival. This means, it is not possible to exclude consumers from consumption of the good and at the same time the consumption of the good will not reduce the amount of good available for consumption by others. The definition of a public good results in a different demand for good than seen with private goods. Demand for private goods is found by adding up the quantities demanded by each individual, whereas, demand for public goods is found by adding the individual marginal benefits at each quantity. This fundamental difference in demand for goods, results in different problems in the market place. Often, public goods traded in market places have to be regulated in order for the output to be efficient. This comes from the free rider problem that typically arises in markets for public goods.

The first conclusion to derive form this, is that markets for public goods typically needs regulation in order to reach the efficient level of output. That is, if the security of electricity supply is seen as a public good, then we need to have regulation in order for us to reach the social optimal level of security of electricity supply. But before we decide on whether or not we are dealing with a public good, we spend a little more time analysing the two requirements non-rival and non-excludable.

Abbott (2001) states that security of electricity supply is *non-exclusive* because, once a unit of capacity is added to the system all consumers benefit from the increased reliability that it provides. Stoft (2003), finds it non-exclusive because, of demand side flaws. He argues that since there are no real-time metering and, at the same time, lack of technology required to disconnect consumers individually in case of an inadequate supply, security of electricity supply is non-exclusive. Counterwise, Rochlin (2004) finds that it is exclusive because, even though, it is not possible to exclude consumers ex ante, it is possible to use ex post payment. That is, the mechanism to collect charges for using reserves.

According to Stoft (2003), security of electricity supply is also *non-rival* because, once produced it is unaffected by the amount of consumers that obtains a benefit. This corresponds to Abbott (2001) who means that security is non-rival because, "any expansion in capacity designed to meet growth in demand not only reduces the risk of black-outs for those being supplied from the new plant but also reduces everyone else's risk at no extra cost". Counter wise, Rochlin (2004) finds that this is not the case since, using reserves decreases the reserve margin, and hence, reduces the level of reliability. And when the reserve margin is sufficient low, the use of one unit more leads to load shedding.

The conclusions regarding non-rivalry and non-exclusion are therefore not straightforward. Hence, if we should treat security of supply as private instead of public good, we need a controversial shift from an 'obligation to serve' to 'obligation to serve at a price'. And following we need to see a quality differentiation where security of supply are not externalized from the market via, e.g., back-up systems. Finally, we need systems operations based not only on supply side flexibility but also demand side management.

The lack of technology to meet these requirements are partly mentioned by Stoft (2001) with lack of real-time metering and real-time billing, which causes a lack of demand elasticity in the market and inability to disconnect individual consumers. But recent technological developments have enabled individual billing and disconnection excluding free riders, wherefore, we find that security of electricity supply does not fail the exclusionary principle, and hence, does not qualify as a pure public good. With respect to non-rivalry we find all three statements credible and not contrary. If we turn to the definition of congestible public goods, we find goods for which congestion reduces the benefits to existing consumers when more consumers are accommodated. That is, the marginal cost of accommodating an additional consumer is not zero after the point of congestion is reached.

Examining the public good characteristics in relation to security of supply in power markets, we conclude that creating markets that involve also the customers demanding security is possible without extensive regulation if there are some elements present as:

- Exclusion from security is an available and affordable technical solution
- There is rivalry in this service because some capacities (production, transmission of distribution) are congested

It must be possible to exclude customers from the service unless they are paying for the service. At the same time the demand for power, transmission or distribution must be near the limit where additional demand for this capacity will affect the security of supply for other customers. In other words capacity restrictions must be more than only theoretically binding.

### *3. Individual steps in construction of security of supply market construction*

In this section we turn to the possible steps in increasing market forces influence on allocating resources to security of supply and setting the level of security.

Pre-establishing cost figures and comparability

**1. step** Securing that marginal costs of supplying security for a given customer is identical for possible suppliers of this service (first simplification for aggregated consumption) The level of security is "arbitrarily" set at a socially acceptable target. Cost minimisation in securing a given level of security of supply.

**System adequacy:**

- Costs of securing adequate power capacity
- Costs of securing adequate transmission capacity
- Costs of securing adequate distribution capacity

**Probabilities for failures:**

- Back-up short term – marginal cost of reducing probability
- Frequency etc. – marginal cost of reducing probability
- Transmission and distribution faults – marginal cost of reducing probability

All the system elements contributing to the probability of loss of load should have marginal costs for reducing the probability at similar levels. This can be achieved without creating a market.

One basic assumption for the above arguments is that failures and interruptions are independent, what will not always be the case.

In this case there is an option of allowing the supplier of security to supply different levels of security to individual customers based on difference in costs of supplying. This is relevant for networks

**2. step** Adjusting level of security of supply to average costs for consumers (value of lost load).

This does not necessarily involve the construction of a market. The costs for consumers (households as well as business) have been estimated from several studies in a large number of countries. This can be used for setting a less arbitrarily target for security of supply. This will not be as accurate as what would be established if a well functioning market could be constructed. This aims at reducing the welfare losses related to Figure 1.

**3. step.** Associating individual customer's costs of lost load with compensation payments, or different payments for security of supply.

This step is different from a construction with compensation payments identical for different customers. Such a scheme is one option as a regulatory instrument in the second step. If the objective is to reduce the possible welfare losses as described in the Figure 2, this step will require some kind of a market that involve consumers. The market need not necessarily be a separate market, but could be an integration of the security costs in ordinary power markets, but requires that individual consumers are charged and chose their level of demand based on different prices.

**4. step** This step involves customers even more as this targets the possibility of having different costs of interruption depending on the duration and the timing of interruption. This would involve a more sophisticated market, were it is quite unrealistic that customers should monitor price movements so closely, but automatic equipment following general set price parameters could make individual demand respond to price signals.

**How much can be achieved without relaxing the characteristics of a public good?**

Only step 1 and 2 is possible without relaxing the public good characteristics. If the real market from step 3 with participation of consumers is to be established it must be possible to exclude customers from security of supply to give them an incentive to reveal their willingness to pay for this service. Interruptible supply to customers and meetring equipment is needed.

***How much can changes in the functioning of existing power markets contribute***

There is much to achieve from improving the functioning of existing power markets rather than just creating new isolated markets for security of supply. The more markets that are created the less volume in each market, the higher transaction costs and the more risk for exemption of market power. Therefore improvements in the spot and regulating power markets should be emphasised.

Demand response is one of the most obvious ways of improving how we establish adequate resources. With increased price response in the existing market, the load duration curve would flatten and the profitability of new power (or transmission) capacity would increase. This adequacy part of security of supply is thus possible to influence by the existing markets to a large extent, whereas the problems caused by faults in transmission and distribution equipment is less directly influenced by the existing power markets.

## *4. Final comments*

What is discussed in this paper is based on an ongoing project and conclusions can not yet be drawn.

Is it possible to create new markets for security of supply and is it better than improving on existing markets? Technological developments will make it possible to create markets in the future, but it is probably advisable to increase effectiveness of existing markets as at least part of the possible welfare losses can be reduced by including different forms of demand response in existing markets.

## REFERENCES


*Ajodhia V., Petrov K., Scarsi G., Franken B. (2006) Experience with regulation of network Quality in Italy, the UK and the Netherlands. Electrical Power Quality and Utilization Magazine Vol. II, No. 1, 2006*

*Ajodhia V., Schiavo L.L., Malaman R (2006) Quality regulation of electricity distribution in Italy: an evaluation study, Energy Policy 34, p. 1478-1486.*

*Andersen, F.M.; Jensen, S.G.; Larsen, H.V.; Meibom, P.; Ravn, H.; Skytte, K.; Togeby, M.*, Analyses of demand response in Denmark. Risø-R-1565(EN) (2006) 100 p.

*Belmans R (2003) Liberalization of electricity market scrutinized Power Quality. A report from the World Forum on Energy Regulation.*

*Boisvert and Neenan* (2003) Social Welfare Implications of Demand Response Programs in Competitive Electricity Markets, LBNL-52530, Ernest Orlando Lawrence Berkeley National Laboratory, University of California Berkeley (omhandler bla. forsikringstankegangen)

CEER (2005) THIRD BENCHMARKING REPORT ON QUALITY OF ELECTRICITY SUPPLY 2005 C05-QOS-01-03 Final Version: 6-December-2005

*Egenhofer C. et.al*. (2004) Market-based options for security of energy supply NOTA DI LAVORO 117.2004

EUROELECTRIC (2006) Euroelectric's Views on: Quality of electricity distribution network services. Working Group on DISTRIBUTION, 7 December 2006, 2006-233-0012

Hamachi Kristina LaCommare, Eto, Joseph H. (2004) Understanding the cost of power interruptions to US electricity consumers. Ernest Orlando Lawrence Berkeley National Laboratory, LBNL-55718.

Hogan, William W. (2005) On an "Energy only" electricity market design for resource adequacy. Cambridge 02138.

Iyer, Ananth V. (2003) A Postponement Model for Demand Management. *Management Science* 49(8)

*Joskow P., Tirole J.* (2004) Reliability and competitive electricity markets. *MIT Department of Economics Working Paper No. 04-17*

*Joskow P., Tirole J.* (2006) Reliability and competitive electricity markets. revideret version

*Joskow P.* L. (2006) Incentive regulation in theory and practice: Electricity distribution and transmission networks, MIT January 2006

*Morthorst, P.E.; Jensen, S.G.; Meibom, P.*, Investering og prisdannelse på et liberaliseret elmarked. Risø-R-1519(DA) (2004) 114 p.

*Nordreg (2006)Nordic Market Report 5/2006*

*Oren Shmuel S and Doucet Joseph A. (1990)* Interruption insurance for generation and distribution of electric power Journal of Regulatory Economics Volume 2, Number 1 / March, 1990, p. 5-19.

*Oren, Shmuel* Priority pricing of interruptible electric service with an early notification option. *The Energy Journal*, April 1993

Ross Baldick, Sergey Kolos, Stathis Tompaidis Interruptible Electricity Contracts from an Electricity Retailer's Point of View: Valuation and Optimal Interruption *OPERATIONS RESEARCH* Vol. 54, No. 4, July 2006, pp. 627-642

Utilities Bulletin, Power cuts – know your rights. Martineau Johnson January 2006.

Energimarknadsinspektionen (2006) Utveckling av netpriser 1 januari 1997 - 1 januari 2006