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Security of supply in electricity markets: Improving cost efficiency of supplying security and possible welfare gains

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ABSTRACT

In liberalised markets the ability to maintain security of electricity supply is questioned because security is characterised as a public good. We discuss if this property can be modified with changing technology. Furthermore, we examine if construction of markets for security can be justified by possible welfare gains. From a welfare perspective it is possible that security levels are too high and obtained with too high costs. Adjusting the effort so that marginal cost for securing supply is at similar levels in generation capacity and in network maintenance could increase welfare even without the need to construct markets. Secondarily, a consumer defined average level of security might improve welfare. Finally, different willingness to pay among customers and construction of advanced markets might increase welfare further. We argue that several cost and welfare improvements can be achieved without constructing complete markets for security.

1. Introduction

Security of supply in electricity has received widespread attention in light of the liberalisation of electricity markets [1,2]. The basic question is whether liberalised markets will secure that adequate capacity is available and whether tight efficiency regulation of electricity networks will result in deteriorating quality of network reliability. Maintaining security of supply in liberalised 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 included in markets. This paper describes the possible steps and some necessary conditions for establishing markets for security of supply services. In a European perspective increased focus has been put on maintaining quality of supply in a liberalised power market with cost reducing incentive regulation of network monopolies. CEER [3] refers to eight countries out of 19 European countries covered in their analyses having specific quality elements included in the incentive regulation for distribution (network) companies. The inclusion of quality is mainly based on the concern that quality would deteriorate in a liberalised and tighter incentive regulated environment.

For adequacy of generation capacity, concern has been raised that market prices are not sufficiently high to secure investment in new generation capacity. In particular the peak power resources do not seem to be attractive without some capacity payments. Construction of such capacity markets in an efficient way has been broadly discussed in literature including [4,5], but the linkage with grid investment is less covered. In this paper we argue that investment in adequacy in generation and transmission capacities should be balanced with the costs of reducing interruptions in the distribution grids.

There are several possible benefits of having the security aspect covered by a market instead of by direct regulation. The first step in improving efficiency is to secure that a given level of security is provided with the least costs. A requirement for this is that marginal costs of supplying security in generation, transmission and distribution are at similar levels. The argument is that consumers have identical cost of interruptions (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 with suppliers and a single buyer. 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 average interruption 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. Some evidence suggests that there are large differences in interruption costs. de Nooji et al. [6] finds large differences between sectors, regions and in time

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for the Netherlands. They also refer to the issue of actually providing a level of supply security that is at too high levels especially concerning the adequacy part. A solution would not necessarily mean shifting funds from generation to grid, but may imply that capacity cost in generation is reduced slightly to the benefit of consumers with an absolutely marginal reduction in reliability from adequacy.

A second step is to individualise security of supply. If it is possible to exclude customers; this would imply that different degrees of security can be supplied to customers that have 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 contracts both involve the ability 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. Even though interruption cannot be controlled by the grid operator through advanced metres it can be ex post verified that there was no consumption for the requested time interval.

As a majority of interruptions (frequency) are related to distribution grid faults, the cost of reducing these faults should be evaluated against the cost of adequacy in generation capacity. We question if maintaining in the Nordic market a capacity reserve level that secures that almost no load has been lost due to capacity constraints is optimal. Would an integrated market for security services transfer resources from capacity reserves to distribution grid infrastructure? Of concern is also the equity question. Will we accept discrimination among residential customers regarding their supply security and the price they pay for a given level of security? In most countries it has not been allowed to discriminate among residential customers for their connection costs, network charges and the electricity price within a supply area. However as it is now, the security of supply is varying among the consumers without this being reflected in any difference in electricity price or network charges.

This paper is organised with a section presenting the public good property discussion for electricity supply security and the modifications required for creating a market for supply security. The next section examines the possible welfare gains from creating markets in different situations with regard to interruption costs and costs of supplying security. It argues that complete markets are only necessary if there are large and unsystematic differences between costs of interruptions for different consumers. Following this a section suggest the possibility of gradually moving in the direction of markets by first improving the contribution of resources providing security of supply and later by involving consumers when this becomes possible by individual excludability. The last sections include conclusions and comments.

2. Security of supply and the public good argument

This section discusses public good characteristics of security of supply and changes in this characteristic as a necessary precondition for construction of markets for this ancillary service.

Security of supply is in the literature regarded by some as a pure public good, and by others, not characterised as a public good. A pure public good is non-rival at all times and non-excludable for all its elements and is illustrated with point A in Fig. 1. It is a necessary precondition for a well functioning market that security of supply is not a pure public good.

Electricity is not valued by consumers solely through its quantitative dimension, but rather through services that it provides. Most of such electricity dependent services are based on pre-planning that assumes a stable supply of electricity to be available at request in real-time. Following, security of supply expresses the system's ability to ensure continuous supply of electricity at a stable frequency and voltage, and can be seen as the qualitative dimension of the electricity good.

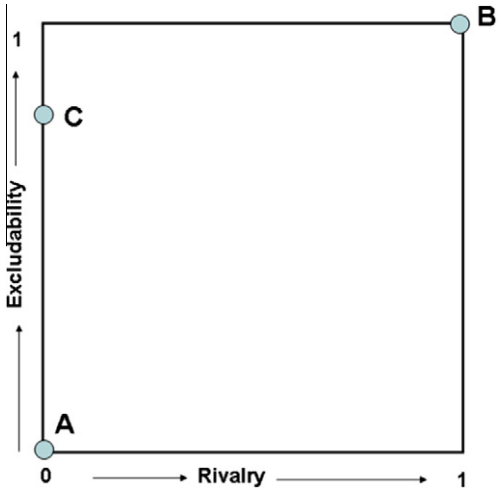

Fig. 1. Classifying goods according to the degree of rivalry and excludability. (A) Pure public good, (B) pure private good, and (C) non-rival good.

The term 'security of supply' refers to the likelihood that electricity will be supplied without interruptions. Thus, often the terms security and adequacy are distinguished so that [7]:

- *Security* is the ability of the system to withstand sudden disturbances, e.g. disconnection of a distribution line
- *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

The security is provided firstly by the distribution and transmission grid, but also the system services with reserves and control ability from generators contributes to the security. Adequacy is provided by both generators and the grid with each components ability to meet regular peak demand levels under normal conditions.

In recent years, the main argument for regulation of power market with focus on security of supply has been the understanding of security of supply as a public good. Several papers view security of electricity supply as a public good, e.g. [8]. "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 the reduced risk associated with the construction of additional capacity". Counter wise, [9] 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 goods 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, consumption of the good will not reduce the amount of good available for consumption by others Mas-Colell et al. [10]. Following this, determination of social optimal equilibria in the case of public goods are found to be difficult, when the number of participants is large, as the amount of people knowing each other is relatively small, i.e. the possibility of ones actual marginal benefit being detected is