Capacity Supply and Demand in Deregulated power systems

by Gerard Doorman

Introduction
One of the questions that arise when deregulation is introduced in power systems is if the market will provide sufficient generation capacity. The importance of this question is related to the fact that capacity shortage will not just increase prices, but may jeopardize power system security. This may in turn result in involuntary demand curtailment, which is unacceptable and costly in a modern society. In this work, I will take a closer look at the reasons why and under what circumstances capacity shortage may occur. An international comparison will be made between some deregulated and traditionally organized systems. The consequences of a potential shortage will be analyzed, and a number of possible policies to reduce the problem will be described. An important part of the work will be to analyze which role active markets for ancillary services can play.

Empirical Evidence
In the UK, investment in production capacity has been abundant since deregulation was introduced. This seems to be in contradiction with the hypothesis that investment may be sluggish. However, there are a number of special reasons for this: the obligatory use of domestic coal in the initial years after deregulation, and weak competition resulting in relatively high prices. Together with decreasing gas prices and great improvements in CCGT technology, it became very attractive for large end-users to invest in their own generation capacity.

In Norway, investments in new generation capacity have come down to a historically low level, in spite of increasing demand. The situation is actually worse than indicated by the figure, because several licensed projects may not realized, due to unfavourable market conditions. On the other hand, some projects would have been initiated, but have been stopped because they were politically controversial. This shows that also in Norway the picture is ambiguous. However, Norwegian generators have sold peaking power to companies in Germany and Holland, increasing demand with 2800 MW in the period 2001-2004.

Theoretical Evidence
In a traditionally organized power system, the planning of new capacity is based on forecasts of demand for capacity and/or energy use. Demand is in principal covered in a least-cost manner, but many political concerns come in. This procedure has several built-in properties that stimulate over-investment, most important that all costs can be transferred to the end-users. In deregulated systems, investments are made by market actors, based on their judgement of future prices. This introduces uncertainty to the investment decision. Future prices are uncertain for many reasons, and if a wrong decision (ex post) is made, costs cannot be transferred to customers. Several theoretical models are available for decisions under these conditions: the Capital Asset Pricing Model, Arbitrage Pricing Theory and real options theory. None of these can be readily used, mostly because they make some strong assumptions that are not valid in a power market. The more practical approach taken in most investment decisions under uncertainty is the use of a “hurdle discount rate”. From interviews I have had with a number of leading people in generation
companies, this appears to become normal practice in the Norwegian case.

**Investment in peaking capacity**

Generation capacity is necessary to cover normal demand variations over the day, week and year, to cover extreme peaks due to weather variations and to cover reserve requirements. How much excess capacity is necessary depends on: flexibility of the generation system, interconnection with other systems and especially the shape of the load duration curve.

The shorter the high-load periods, the shorter the time where peaking capacity is needed. So, given the cost structure (fixed/variable costs) for a certain technology, the shape of the load duration curve has a vital impact on the investments profitability. If the peaking periods are very short, and do not occur every year, profitability becomes highly uncertain.

**Available policies**

Several policies are available and actually in use in several parts of the world:

a) additional payment for used and/or available capacity during peak demand (UK, Chile, Argentina)
b) capacity obligation for supply to end-users (PJM power pool)
c) long-term contracts for keeping reserves

All these policies have their drawbacks, which have their origin in the fact that it is difficult to decide on the optimal level of payment (a) or capacity (b and c).

In addition, or even alternatively, the demand side can be used much more actively to provide "negawatts" and reserves. This can be obtained by creating markets for ancillary services beside or integrated with the established energy spot market, e.g. like in California, with active demand side participation.

**Markets for ancillary services**

A model has been developed for the simulation of an integrated market for energy and ancillary services. The intention of the model is to analyze prices and the effects of demand side participation during high-load periods.

**Further work**

There are two areas I will probe deeper into in the course of 1999:
- get a better understanding of the factors that decide the profitability of investment in peaking capacity
- do a quantitative analysis of the need for peaking power in the Norwegian system
- apply the simulation model on a number of representative cases to analyze effects of introducing short term markets for ancillary services

Finally, I have the intention to be able to come with recommendations for the Norwegian situation.

**Initiation and Funding**

I started this PhD study with some of the necessary courses in 1996. Funding became available from the middle of 1996, under the EFFEKT program, more specifically the project “Large Scale Power Exports”. This program is financed by the Research Council of Norway (NFR) and the Norwegian Electricity Federation (EnFO). Additional funding is provided by my employer, SINTEF Energy Research (SEfAS).

The supervisor for the work is Professor Øyvin Skarstein, and scientific advisor is professor Bjørn Nygreen.

**Status**

I have finished the obligatory number of courses, and have a good overview over the literature. A first version of the model simulating an integrated market for energy and ancillary services is completed, and a paper on this model has been submitted to IEEE. I hope to finish my thesis at the end of 1999.

**Personal background**

I received my M.Sc. in Electrical Engineering from the Norwegian Institute of Technology (NTH) in 1981. My career started as a research scientist at EFI. Later I worked at a power company with hydropower optimization, and as a consultant, among others with demand-side management. Since 1992, I have been at SINTEF Energy Research, working with hydropower optimisation and deregulation.