1 Capacity mechanisms

1.1 Strategic reserve

Physical reserve owned by TSO

Another common proposal is for the system operator to acquire a strategic reserve (sometimes also called a mothball reserve) of power plants, which are used in emergency cases. Purchasing old units itself does not change the overall volume of generating capacity; the effectiveness in improving reliability depends upon the investment signal that is sent to the market. This depends upon the price at which the electricity from the reserve is sold. As the reserve dispatch price determines the investment incentive, a strategic reserve should also be considered as a price-based capacity mechanism.

Reserve dispatch price determines investment incentive

When the reserve capacity is dispatched, the market price will effectively be capped by the reserve price (until no more reserve capacity is available). The resulting reduction in price spike income reduces the average revenues of generating companies, as a result of which the equilibrium volume of generating capacity, which investors in the generation market provide, can be expected to be lower. The strategic reserve must make up for this deficit. Thus the lower the price at which the reserve is dispatched, the higher the volume of capacity in the reserve must be.

Optimal dispatch price difficult to determine

The difficulty with a strategic reserve (and with operating reserves pricing, the next capacity mechanism that we will discuss), is how to calculate the correct combination of reserve volume and dispatch price. As with all capacity mechanisms except capacity subscriptions (see Section 1.3), the regulator must first determine the optimal volume of generating capacity. Then it must be decided how large the strategic reserve will be. From this follows the volume of generating capacity that is to be provided by the market. With accurate load-duration data, it can then be determined how much time the marginal generator that is to be provided by competitive generating companies (not by the reserve) will operate on average. With an estimate of the costs of this generator, the correct dispatch price of the strategic reserve can be determined. The price must be such that the marginal commercial generator can just expect to make a profit during the hours that it runs (which are mainly the hours that the strategic reserve is being used). Errors in this process will either lead to an under incentive to invest or to electricity prices that are, on average, higher than necessary to fund the necessary generating capacity.

Trade-off

In choosing the size of the reserve, there is a trade-off to be made: a small reserve with a high price has a limited effect upon market power, while a large reserve would cause the system operator to become a major actor in the generation market. This may not be desirable with respect to his independence.

Effect upon investment cycles?

A strategic reserve is a modification of an energy-only market: investment is still driven by price spikes, only reliability is enhanced through an extra volume of generating capacity in the reserve. This means that the same tendency exists towards investment cycles, although a large reserve may reduce it. Similarly, the incentive to withhold generating capacity remains unmitigated until the reserve is dispatched (at which point withheld generating capacity is replaced by capacity from the reserve).

Problem with inter-system trade

Most relevant for individual European countries is that a strategic reserve is not robust against regional electricity shortages in a decentralized market. If consumers pay for a strategic reserve, for instance through an excise tax on electricity, they would expect the benefit of improved reliability of service. However, in a decentralized market, scarcity in a neighboring system will also lead to high prices in the system at hand. If there is sufficient interconnector capacity, trade between the two systems will cause the prices and the reserve margin will be about the same in the two systems. Contrary to systems with a mandatory pool, decentralized markets offer the system operator no possibility to direct electricity to its own consumers. Thus a strategic reserve is not effective in this case.

1.2 Capacity requirements

Government decides total volume of generation capacity

The PJM electricity market on the East Coast of the USA, one of the largest competitive electricity markets in the world, uses a system of capacity requirements to maintain generation adequacy (PJM Interconnection LLC, 2003). The principle of this system is that government requires the load-serving entities to purchase enough capacity credits from the generating companies to cover their own peak demand, so that the system as a whole is ensured of enough generating capacity to meet system peak demand plus a reserve margin.[1] The desired margin between generating capacity and peak demand is administratively determined. Based upon the expected total coincident peak demand of the loads served by each load-serving entity (retail company or large consumer), the system operator calculates how much generating capacity each load-serving entity must purchase (PJM Interconnection LLC, 2003).

Market mechanism for efficient allocation of capacity obligations

Reserve capacity may take the form of available generating capacity or interruptible contracts. Generating companies may sell capacity credits up to the volume of generating capacity that they have reliably available. To this end the regulator rates the availability of their generators. Capacity credits can be traded, so there is a secondary capacity market. Load-serving entities include the cost of purchasing capacity credits in the price they charge final consumers for electricity. The requirement for load-serving entities to contract generating capacity in excess of the projected peak causes the capacity market to become constrained before the energy market does. Consequently, the incentive to invest in new generating capacity develops before the electricity market becomes constrained. If the capacity margin is large enough, this leaves enough time to bring new generating capacity on line before an electricity shortage develops.

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[1] 'Load-serving entity' is PJM's term for parties that are licensed to provide electricity to PJM consumers. An load-serving entity may be thought of as a retail company or a large power consumer.

Mandated reserve margin compensates for uncertainties

The main advantage of capacity requirements is that they provide a robust way to maintain a certain capacity margin. The investment incentive does not depend upon the generating companies' forecasts of future electricity prices, but upon the regulator's projections of peak demand and the resulting capacity requirements. As a result, this system is less affected by information deficiencies and other sources of investment risk than an energy-only market, as long as the regulator's capacity requirement is reasonably well chosen.

Complex system

Capacity markets are complicated and need to be designed carefully. PJM has experienced several design problems. One is that a firm reserve requirement creates a perfectly inelastic demand for reserve capacity. Not only does this increase investment risk, it also provides a venue for the exercise of market power. Stoft (2002) suggests to make the penalty to load-serving entities who are short of their capacity obligations elastic: it should increase with the magnitude by which a load-serving entity does not meet its capacity requirement. This would reduce both the volatility of the capacity credit prices and the incentive to withhold generating capacity.

Gaming

Another practical problem in the initial PJM design was that generators could 'delist' their capacity on short notice (Hobbs *et al.*, 2001a). Thus they could earn revenues in the capacity market when electricity demand was low, and sell at high prices in the (neighboring) electricity market when that was more profitable. The solution was to increase the minimum duration for which a capacity credit may be sold, so generators need to decide for a whole season at once whether to offer capacity credits, and to require a longer notice for de-listing reserve capacity. However, the strength of these rules depends upon the penalty for non-compliance.

Goal is not installed but operational capacity

A related issue is that the system can be gamed by providing reserve capacity that is not actually operational: it rewards 'iron in the ground'. In PJM the penalty to generators that have sold capacity credits but that are not available apparently is too low, given the probability to be caught, so the expected revenues from selling capacity credits exceed the expected amount of penalties to be paid (Hobbs *et al.*, 2001b). Reliability contracts, a capacity mechanism that will be discussed in the next section, are specifically designed to provide generators with a better incentive to be available.

Effective but complicated solution

We may conclude that capacity requirements perform reasonably well on most of the criteria that were presented in Section **Error! Reference source not found.**, as solutions have been developed for most of the problems that were encountered in PJM. The main issue that has not yet been discussed is implementation in decentralized markets (without a mandatory pool) that have significant exchanges with neighboring markets that do not have a similar capacity mechanism in place. As mentioned above, PJM experienced problems with generators who sold capacity credits but exported their power when prices in neighboring systems were higher, so they did not actually contribute to the reliability of the PJM system. In a mandatory pool like PJM, the pool operator has the ability to 'recall' exports; this possibility does not exist in decentralized markets such as in Western Europe. This issue will be addressed in the Section **Error! Reference source not found.**.

1.3 Capacity subscriptions

Consumers contract for peak capacity

A fundamentally different capacity mechanism, which promises to be the most market-oriented of all, is the system of capacity subscriptions (Doorman, 2000). This capacity mechanism directly involves consumers by requiring them to purchase electronic fuses which, when activated, limited their electricity consumption to a predetermined capacity. As a result, a capacity market develops between generating companies and consumers, which has the triple advantages that it provides consumers with an incentive to limit their peak consumption, that it produces a clear signal that indicates the volume of generating capacity that consumers wish to have available reliably, and that it provides a steady revenue stream with which to cover the costs of generating capacity.

Inter-system trade a problem?

The original proposal does not appear robust against inter-system trade in a decentralized market. Generating companies who have sold capacity subscriptions to consumers within the system could still sell their output outside the system. A solution could be a financial version, which again uses option contracts (De Vries, 2004). To ensure that peak consumption is indeed within the contract limits, real-time meters would be required. Both variants have significant implementation requirements, as a result of which they do not appear feasible in the near term. Therefore we will not discuss them further.

1.4 Conclusions

'Best' options not tried in practice

As was mentioned in the introduction to this section, capacity mechanisms that provide a capacity signal are preferable over those that provide a price-related investment signal. Not surprisingly, the most effective capacity mechanism that has been tried in practice is PJM's system of capacity requirements. Unfortunately, it appears that this system cannot be implemented in its current form in most European markets. There would be a risk of 'leakage' in case of unilateral implementation: if one country implements a capacity requirement, its reserve capacity could be sold outside the country in case of a regional shortage, so that the net contribution to the reliability within the country would be diluted. Reliability contracts could be designed to be robust against this effect, both a central and a bilateral variant. This would be an innovative, untried option, however, which entails a higher risk of policy failure.