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## Term Paper

# The Need For Capacity Mechanisms And Their Limits At Solving Issues Of 'Energy-Only'–Markets

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# 1 Introduction

As many developed countries around the world have been liberalizing their wholesale electricity markets to different degrees during the last three decades[1], their governments, regulators and customers had to make the experience that not all the hoped-for benefits of these steps did materialize[2]. Economic theory had predicted that competitive markets should lead to cheaper electricity as prices would eventually converge towards marginal production costs. The market mechanism was thought to provide the necessary price signals to give generators enough incentive to invest in new capacity so supply and demand could be matched in the future[3].

Alas, market designers didn't pay enough attention to intrinsic imperfections of electricity markets leading to insufficient investments in generation capacity. Inelasticities on supply as well as demand side and the difficulty to store larger amounts of electricity for later use results in high price volatility on the wholesale market[4]. Together with regulators' unwillingness to allow spot prices to climb too high fearing that firms exercise market power, new investments became unattractive to power companies thus leading to what became called the 'missing-money problem'[5].

This issue particularly concerns so-called peak power plants[6] whose short-

[1] Chile and UK were the first countries to abolish generation monopolies and opening up their markets to private companies introducing supply-side competition. Several US states and EU countries followed in the 1990s and 2000s

[2] see IEA (2002, 2003)

[3] Finon & Pignon (2006), p.3

[4] ibid (2006), p.9

[5] The 'missing-money problem' refers to the issue that so-called peak power plants which are in use only for a small part of the year (during peak demand periods) need high prices to cover their considerable fixed costs. If there are price caps in place, these prices will not come about which in turn results in under-investment in capacity.

[6] Böckers, Giesing, Haucap, Heimeshoff & Rösch (2012a) p.4

term response times to sudden increases in demand make them indispensable for the system operator to ensure system reliability avoiding involuntary rationing by shedding load.

Aggravating the situation is the increasing share of intermittent renewable sources especially in the German electricity market. Spot prices experience a downward pressure as renewables feature marginal production costs near zero and their bids on the wholesale market have to be taken according to German legislation[7]. This development makes it even more difficult for peak power plants to recoup investment costs. As a result from the year 2020 on, several authors predict a lack of peak capacity[8].

Capacity adequacy, defined as supply security in the long-run, can arguably be considered a public good, being non-rival but also non-excludable[9]. System failure caused by insufficient generation imposes heavy losses on all market participants be they users or suppliers of electric power. Having the characteristics of public good, private actors will not provide system reliability unless incentivized or forced to, government intervention could be a solution to the problem of capacity shortages.

[7] Matthes (2012), p.36

[8] ibid (2012), p.25 as well as Grave, Lindenberger & Paulus (2012)

[9] Finon & Pignon (2006), p.3

# 2 Structure & Research Question

This paper looks into the issue whether capacity instruments[1] can solve the aforementioned 'missing-money problem' in the long-term. This has to remain largely a theoretical discussion as the results and unintended effects of market liberalization[2] have become fully visible only during the past decade in most markets[3] and capacity mechanisms are a fairly new approach to the problem. Empirical data are rather thin and Germany which is to provide some exemplary illustrations for the questions at hand does not have any capacity market to date. On the other hand recurring brown-outs and even black-outs in the wake of California's electricity market reforms in the 1990s[4] show that concern about how to guarantee future generation adequacy is not merely a theoretical thought experiment.

Germany's generation parc for example has not run through a complete investment cycle since market deregulation[5] in the late 1990s and neither did

[1]This paper will employ the terms *capacity instrument*, *capacity mechanism* and *capacity market* interchangeably. Being linguistically accurate the expression *capacity market* should refer to the entire market system, whereas *capacity instruments* are the individual tools interacting with each other via *capacity mechanisms* to constitute the *capacity market*. For reasons of readibility I will use the three terms analogously.

[2]The term liberalization refers here to reforms to national electricity markets that attempted to introduce competition. Measures taken included vertical unbundling by which incumbent energy firms had to separate different business activities along the value chain (generation, transmission, distribution to end-customers), granting access to monopoly network infrastructure to third parties and creation of independent regulators. Liberalization often went along with full or partial privatisation of state-owned electricity assets. Market liberalization has been implemented to varying degrees in different countries, and this paper will take the developments on Germany's electricity market as an illustration. Nonetheless the conclusion drawn should be applicable to a certain extent to any deregulated electricity market

[3]see IEA (2002)

[4]see Jurewitz (2002) as well as Woo (2001)

[5]The terms *deregulation* and *liberalization* will be used synonymously here, although dereg-

other markets even if liberalization started earlier in some cases. So empirically no final judgment can be made whether 'energy-only'–markets[6] provide sufficient incentives to build new plants or not. Some authors even express doubts over the existence of a 'missing-money problem'[7]. After an overview of some of the specific characteristics of electricity and electricity markets the paper will describe the 'missing-money problem' and why liberalized 'energy-only'–markets may not be able to guarantee sufficient investment in capacity for ensuring adequate supply in the future.

In the third part I will present the challenges to the established 'merit-order' from the massive increase in renewable electricity generation and how this aggravates the 'missing-money problem'. This paper does not have to scope to expore advantages and disadvantages of different capacity schemes, but will rather highlight general shortcomings of this solution. For a thorough discusion on the effectiveness of specific design see Battle & Peréz-Arriaga (2008), Matthes (2012) and Siegmeier (2012).

My paper will argue that capacity mechanisms will fail to address the deficiencies of 'energy-only'–markets if regulators inhibit the free functioning of market mechanisms via upholding caps on spot prices. Secondly I attempt to show that the objective of expanding renewables' market share will make it more difficult to ensure supply adequacy while at the same time reaping the potential welfare gains of a deregulated market.

ulation, the removal of sector specific regulation, can be considered a subset of a more complex liberalization effort (see Sioshansi 2006a)

[6] On an *'energy-only'–market* solely electrical power is traded, generation and transmission capacity are not part of the transactions

[7] see Hogan (2005)

# 3 The Need For Capacity Mechanisms

## 3.1 Electricity As A Good Unlike Others

Electric power is unlike other goods or commodities in that it is expensive to store for later use. Given the current technology level only pump storage plants allow this on a large scale, geographic conditions permitting, which limits the feasibility of the approach to mountainous areas. Electricity markets thus require continuous and above all instantaneous balancing between supply and demand[1], as there is only a very limited amount of stored power available to make up for generation shortfalls.

Failure to balance supply and demand at any given time will put the system's stability at risk. This can result in disruptions for the entire electricity network due to involuntary load shedding as customers are forcibly cut off from power supplies by the system operator. As only in rare instances it is technically possible to suspend deliveries to specific end-consumers their willingness to pay higher prices to continue the service or else forego supply cannot be acknowledged by the market.

In addition most households have fixed-price contracts with utilities making them unresponsive to price spikes caused by supply scarcity[2]. This renders the demand side very inelastic in the short- as well as in the long-run. The 'traditional' function of market mechanisms to restore the equilibrium between demand and supply by price swings as classic economics would have it cannot be provided by the current market design.

On the supply side we also find short-term inelasticities since lead-times for the construction of new power plants are considerable, ranging from between

[1] Creti & Fabra (2007), p.259/260
[2] Hughes & Parece (2002), p.32

2-3 years for gas-fired installations to 10 years or more for nuclear reactors[3]. The lump-sum nature of investments in generation capacity with hefty upfront costs for new infrastructure also leads to slow decision-making processes by power companies. By implication the system operator has to estimate future demand for specific time frames and then make sure that sufficient capacity will be available during that period.

If capacity supply is inflexible and highlty used at a certain point in time, even small changes in available capacity or demand can result in huge price swings[4]. This inherent price volatility in the electricity sector is unwelcome to generation companies since it makes estimating future revenues from new capacity very tricky thus making these investments less likely to be undertaken.

While scarcity of supply makes the available generation capacity very valuable when wholesale prices are high, it renders it utterly valueless in case the whole system collapses and no electricity can be sold anymore[5]. The mere possibility of extreme cases where the system collapses under too much load or when the system operator resorts to involuntary load shedding to prevent this happening gives capacity adequacy the character of a public good. No customer can be excluded from the benefits of a functioning electricity system since it is nearly always impossible to cut off individual consumers. By implication providing the good 'supply security' is not a profitable business in itself and will thus not be made available by an 'energy-only'–market.

Joskow and Tirole deem regulatory action all the more warranted as a single power plant no supplying the contracted for amount of electricity could potential cause a system failure. This would impose a severe negative externality on all market participants[6] since they would all be immediately affected.

[3]CITATION NEEDED!!!
[4]Hughes & Parece (2002), p.32
[5]Joskow & Tirole (2007), p.63
[6]ibid (2007), p.78

## 3.2 Electric Power Markets And Their Specific Nature

To serve peak loads almost at any time there needs to be idle reserve capacity available, which does not earn any income when not supplying electricity to the system[7]. Therefore, peak power plants have to make high returns when called upon in order to recover not only marginal costs but also their long-term fixed costs which only high spot prices on the wholesale market could ensure. Operators that provide peak capacity will not bid their marginal costs as in that case thdunkelgrau.60e assets would not profitable[8] without additional capacity payments to fund their investment expenses.

At the same time most electricity markets feature caps for wholesale prices imposed by regulators. Market supervisors fear that high prices are less a signal of scarce supply but rather the result of strategic behaviour by energy firms using their market power. By withholding some of their capacity, artificial scarcity can be induced which would in turn lead to higher prices if the price mechanism was totally flexible and free.

As policy makers and regulators impose upper price limits on electricity, the chances of peak power plants becoming sufficiently profitable to give incentives for new investment[9] are significantly reduced. Thus peak power plants, although essential to ensure adequate generation capacity during periods of high demand, pose substantial investment risks for private actors[10]. Adding to that problematic situation, construction of new conventional power plants is rarely feasible in incremental small-scale steps. Lump-sum investments imply higher risks and by easing undersupply via extra capacity may paradoxically undercut their initial economic rationale[11]. *As long as generators cannot be certain to recover their fixed-costs, the prime objective of market liberalization, to drive down prices to marginal costs in the long-term will not be realized.*

[7]Hughes & Parece (2002), p.33
[8]Ni, Wen & Wu (2004), p.366
[9]Keller & Wild (2004): *"Investment only makes sense (i.e. is profitable) when the discounted value of revenues from sales of new [. . . ] capacity exceeds investment and operation costs"*, p.244
[10]Finon & Pignon (2006), p.4
[11]Keller & Wild (2004), p.244

# 4 The Effects Of Renewable Energy Sources

The existing system of selecting supply offers according to the merit-order[1] gets disrupted as renewable energy sources (photovoltaics, wind & tidal power) increase their market share. These technologies combine high fixed-costs (in relation to the specific generation potential for an individual plant) with the advantage of very low marginal costs since their input factors are provided free by nature.

Bidding with very low offers renewable energy pushes all other generation capacity rightwards in the merit-order. Thus the previously most expensive conventional plants (regarding marginal costs) are not contracted for by the system operator anymore, leaving this capacity unused and thus unprofitable. In general, spot prices, reflecting only marginal prices, are pushed lower during non-peak times. All participating plants are affected by this structural shift in the wholesale price level. Final unique wholesales price are insufficient for expensive power plants to recover their fixed costs via the difference between their marginal costs and spot prices. Conventional capacity thus earn lower returns, making it more difficult to pay off investment expenses. Some plants will be rendered entirely unprofitable since they get called upon too rarely for their revenues to cover fixed costs[2].

[1] *Merit-Order:* Sorting of power plant types according to their marginal generation costs in increasing order

[2] Böckers, Giesing, Haucap, Heimeshoff & Rösch (2012b) p.10

# 5 Shortcomings Of Capacity Instruments

As this paper mentioned in its introductory part, we do not have extensive empirical data so far to make a thorough assessment of how successful capacity markets really are in practice. In most countries capacity instruments have not been in place for long enough to judge their performance over the entire period of an investment cycle in the electricity sector (20-30 years)[1]. The original 'energy-only'–market structures and the solutions politicians in different countries have found to tackle the 'missing-money problem' are so diverse that a *most-similiar* or *most-dissimiliar* empirical research design would be very difficult and probably unreliable to apply.

Therefore I will limit the following discussion on capacity markets to a theoretical level, which should yield informative insights nonetheless. Even with the implementation of a certain capacity mechanism additional objectives policy makers may want the national electricity market to achieve cannot easily be squared with the aim to ensure future electricity supply. Low prices for industry to maintain international competitiveness and for households out of consideration for social policy purposes will barely provide the price signals we have seen are necessary to make investment in new capacity attractive.

Several important aspects of supply adequacy will be left aside due to the limits of scope of this term paper. The effects of an increasingly integrated European electricity markets are to remain unexplored as will be the issue of insufficient transmission infrastructure, an essential facet of overall supply security as well.

[1]see Matthes (2012)

## 5.1 Can Capacity Markets Live Up To Expectations?

Shortcomings of 'energy-only'–markets for electricity and unintended consequences of liberalization efforts were the motivations behind the idea to create separate mechanisms where operators would be remunerated not only for the amount of electricity they supply but also for their contribution to system reliability via generation capacity. In the section *The Need For Capacity Mechanisms* this paper has attempted to show why current market designs fail to deliver adequate levels of electricity supplies during peak loads not least because renewables disrupt the erstwhile merit-order.

The current market designs are marred by a lack of price signals due to price caps, be they grounded in regulatory or political motives. These curbs deny market mechanisms the ability to offer sufficient incentives for private companies to invest in new power plants as they are unlikely to recover their costs. In order for capacity instruments to provide these exact inducements they would at first have to come up with a different way to determine the appropriate level of generation capacity[2]. A single authority, be it the system operator or market regulator, would have to decide upon the quantity of reserve power to contract for or oblige distribution companies to do so.

Having arrived at an estimate about future load demands a price for capacity needs to be established either by the contracting authority itself or via a separate market where demand and supply for extra generation potential settle on a specific price.

The option of one institution deciding upon quantity and/or price of reserve capacity raises the basic question, whether a centralized decision process is able to accomplish this task. The same information asymmetries persist as in an 'energy-only'–market, and it is hard to imagine the responsible authority to correctly anticipate future demand and plant availability all the time.

[2] Hogan (2005), p.5

## 5.2 Obstacles To Capacity Markets' Effectiveness

The initial goal of capacity instruments was to come up with an alternative method to determine the appropriate amount of generation capacity other than a pure price mechanism. This is to be done by some sort of a central authority which, it is hoped will, will be able to overcome flaws of existing market designs as explained in earlier parts of this paper. The expectation is that this approach will be more effective in providing the common good of reliable electricity supply.

Then again, how is a capacity market to discover the quantity of installed capacity necessary for system stability? Price-based designs, see Battle & Peréz-Arriaga (2008), Matthes (2012) and Siegmeier (2012) for details, also try to harness market valuations of demand and supply for finding a cost-effective solution to the 'missing-money' problem.However with regulatory price caps still in place, capacity instruments will, like traditional 'energy-only'–markets, fail to ensure enough generation power is available. It would be somewhat illogical to allow price mechanisms on capacity markets while barring them on the wholesale market.

The other approach to the 'missing-money' issue is to administratively determine capacity requirements and then to directly contract private actors to meet them. This would mean moving back closer towards the old model of command & control supply policy via publicly owned generation companies.

# 6 Conclusion

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