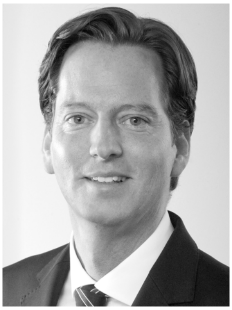
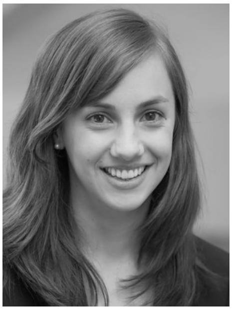
Risk Assessment of Investments in Energy-only and Capacity Markets





Christian Growitsch, Lisa Just and Burkhard Pedell

Capacity Markets, Electricity Generation, Electricity Markets, Investment Incentives, Market Design, Regulatory Commitment, Regulatory Risk, Risk Assessment

Investitionsanreize, Kapazitätsmärkte, Marktdesign, Regulierungsrisiko, Regulatorische Bindung, Risikobewertung, Stromerzeugung, Strommarkt

This paper addresses the long term challenges of electricity markets. First, the economic theory of the missing money problem is outlined. Additionally, a risk assessment of different market designs is pursued. Finally, we will conclude that both market and regulatory risks are important issues of the discussion. Due to the relatively high complexity of capacity markets it can be expected that there will be changes to the market design and to relevant parameters – in particular shortly after the first implementation of such mechanisms. This might increase the uncertainty perceived by investors. However, if the period of validity is long enough, i.e. the investors can calculate with a relatively stable revenue stream, a capacity market might be an instrument for reducing the risks perceived by investors and hence for facilitating the financing of investments in new energy generation capacity.

Der Beitrag thematisiert die langfristigen Herausforderungen für Strommärkte. Zunächst wird die ökonomische Theorie des ‚missing money problem' erläutert. Anschließend werden die Markt- und Regulierungsrisiken verschiedener Marktdesigns analysiert. Aufgrund der hohen Komplexität von Kapazitätsmärkten ist zu vermuten, dass gerade unmittelbar nach deren erstmaliger Implementierung Änderungen am Marktdesign sowie an einzelnen Stellhebeln vorgenommen werden, was das von Investoren wahrgenommene Risiko erhöhen kann. Können die Investoren jedoch aufgrund einer ausreichend langen Gültigkeitsdauer mit einem relativ stabilen Erlösstrom rechnen, können Kapazitätsmärkte ein Instrument sein, welches das von den Investoren wahrgenommene Risiko reduziert und die Finanzierung von Investitionen in Stromerzeugungskapazität erleichtert.

1. Introduction

A reliable electricity supply is crucial for any modern economy. In recent years, retained investment in new power plants and increasing shares of renewable energy sources have raised a large debate about the ability of energy-only-markets to guarantee a sufficient level of reliability. At first glance, basic energy economics do not indicate these problems. On a perfect market, prices have a coordination function in the short as well as in the long term. In the short term, prices assure an efficient dispatch of electricity generation. In the long run, the expectation about future prices should create sufficient rents to cover fixed costs and induce new investments in generation capacity (*Hogan* 2013). If generation capacity is fully utilized and there is excess demand, prices will rise until consumers reduce their electricity consumption and demand equals supply. The price of the market clearing determines the efficient market outcome including scarcity rents and should induce the efficient amount of investments.

However, current electricity markets are far from being perfect markets and thus market outcomes might not yield efficient results. Various flaws and market failures, reaching from regulatory price caps to inelastic demand might prevent electricity prices from rising sufficiently. This "missing money problem" (*Cramton/Stoft* 2006) would lead to non-sufficient investments and might thus endanger the political goal of a high level of security of supply.

In the debate about electricity markets functioning, two counterparties can be identified. The one side argues in favor of the performance of energy-only markets and the occurrence of sufficient price spikes. The other side states that to ensure security of supply the current market design has to be complemented by a capacity market which guarantees generation investments' long run profitability by compensating generating capacities through fixed payments, irrespectively of whether capacity is used or not. Empirically, this problem seems to be yet unsolved. However, the changing structure of electricity price formation with a high share of stochastic generation of low variable costs technologies – renewables as wind and PV – might jeopardize the business case of conventional power plants. Nevertheless, economic theory and empirics have not yet finally provided answers on the necessity of capacity mechanism. However, an analysis of different market designs' risk structure might give indications for economic policy advice.

This paper addresses the long term challenges of electricity markets. First, the economic theory of the missing money problem is outlined. Additionally, a risk assessment of different market designs is pursued. Finally, we will conclude that both market and regulatory risks are important issues of the discussion – and that capacity markets suffer from the risk of wrong design but can be a device for regulatory commitment and, by that, reduce regulatory risk for investors.

2. Theoretical Background

The electricity market price is the coordination instrument to balance demand and supply in the short as well as in the long term. As electricity cannot – or at high costs only – be stored, demand has to equal supply at all times. However, this is a challenging task because the load profile is characterized by high volatility. Nevertheless, generating capacities always have to be able to cover the varying demand. This implies that a small part of the power plant fleet will maybe run just a few hours during a typical year. During these operating hours, these plants have to earn sufficient net revenues to cover their fixed costs which implies that prices have to be sufficiently high during these hours. In theory, during those scarcity hours where generating capacity is fully utilized, prices will rise to the value of lost load, reflecting the opportunity costs of involuntary load shedding for consumers

(*Joskow/Tirole* 2007). Thus, in a perfect market, prices should yield the efficient level as well as the efficient mixture of different capacities in the market (*Joskow* 2008). In conclusion, perfect markets (with sufficient demand participation) would induce the adequate capacity level that optimizes the occurrence of blackouts (*Cramton/Stoft* 2008).

However, there are diverging views about the ability of energy-only markets to generate sufficiently high prices to incentivize new investments as there might be market imperfections. There is a broad strand of literature showing that there might be reasons why electricity markets in the form of energy-only markets suffer from various imperfections and are thus not able to ensure resource adequacy and an efficient outcome without regulatory intervention (e.g. *Cramton/Stoft* 2006; *Joskow* 2008). However, from an economic perspective, a regulatory intervention is only justified in case of an actual or potential market failure, i.e. the inability of the market to balance demand and supply. Thus, it has to be proven that market failure is existent in energy-only markets.

The main causes of the problem are basically two demand side flaws which imply low demand elasticity (*Cramton/Stoft* 2006). First, due to a lack of smart metering and real time billing the majority of consumers is not able to monitor current prices and their electricity consumption. Even if smart metering is available it can be doubted that industrial and household consumers are willing to switch to real time billing to a sufficient extent. That is, most of the consumers have contracts with a fixed average electricity price and thus they have no incentive to adjust their consumption behavior in times of high prices when generating capacity is scarce. In addition, in times of scarcity also the supply side becomes very inelastic, as the marginal supply bid includes the incremental cost of capacity (*Cramton et al.* 2013). Thus, during scarcity and an excessive demand any adjustments to clear the market, i.e. a balancing of supply and demand, have to be made by the demand side resulting in high prices. These scarcity prices are necessary for generators to cover fixed costs and to induce sufficient investment incentives in the long term (*Cramton et al.* 2013). However, this combination of supply that is (nearly) fully utilized and an excessive demand creates also large incentives for generators to exercise market power (*Joskow* 2008). Concerns about the exercise of market power cause regulators to intervene in the market by setting price caps (*Cramton/Stoft* 2006). However, these price caps are often set too low so that not only the possibility to exercise market power is reduced but also net revenues are reduced below the level necessary to cover fixed costs. This again inhibits scarcity rents for generators and thus an overall profitable plant operation. This context is called the "missing money problem" meaning that market prices are too low to enable fixed cost recovery and thus to generate sufficient investment incentives (*Cramton/Stoft* 2006).

However, even if prices would be sufficient and the market would achieve the economically efficient level of reliability, it might not be the socially or politically wanted level of reliability (*Spees et al.* 2013). In order to maintain a high level of reliability and to be able to cope with unlikely weather conditions, extremely high load or unexpected plant outages regulators hold a reserve for those unlikely events. An energy-only market might not be able to determine an – from a political perspective – sufficient level of this reserve margin and thus of reliability (*Spees et al.* 2013).

Thus, due to the missing demand side participation the consumers' willingness to pay for reliability is not reflected in market prices and the market fails in determining the adequate level of reliability and the associated level of generating capacity (*Cramton/Stoft*

2006). The missing money problem is less a regulatory problem than a problem of missing demand side participation. Would there be sufficient demand side participation, markets would be reliable and would always clear with only voluntary but no involuntary load shedding (*Cramton et al.* 2013).

The second demand side flaw occurs from the fact that it is at the moment technically not possible to monitor and to curtail the electricity consumption of individual consumers in real time (*Stoft* 2002). Thus, in some instances, involuntary load shedding is necessary to balance supply and demand. However, at present only large areas can be disconnected technically from the grid. A curtailment of electricity consumption is thus independent of whether consumers have a high or low willingness to pay for reliability. In consequence, individual consumers consider the probability to be blacked out as exogenously given. Thus, consumers have no incentives to invest in reliability measures because whenever they invest neighbors would profit as well irrespectively of whether they also invest or not. That gives reserves the character of a public good, indicating that private investments would always be too low to ensure an adequate level of reliability (*Joskow/Tirole* 2007). In the future, technological progress, particularly in information technology, might enable system operators to reduce or cut off individual consumers, making this second demand side flaw possibly less of a problem.

In case of an imbalance of supply and demand and a resulting blackout more people than actually necessary are disconnected from the grid and the price for electricity is zero. However this does not reflect the preferences or the willingness to pay of consumers respectively generators. Thus, the market fails to reflect these preferences in adequate prices and thus fails in incorporating the social costs of a blackout (*Joskow* 2008). In systems with insufficient demand elasticity, markets are not able to determine the optimal level of reliability themselves and are thus not able to induce sufficient investments because markets do not know anything about the value of reliability to market participants (*Cramton/Stoft* 2006).

These arguments notwithstanding, the question of whether capacity markets are indispensable for future electricity systems to work has not been answered definitely by economic theory yet. Therefore, we analyze different market designs' risk structures to generate new insights from a management science perspective.

3. Risk assessment of investments under different market designs

In liberalized energy markets, the risks associated with investments in generation capacity lie predominantly with private energy generators. Expected cash flows and in particular expected prices must be sufficient to provide a risk-adequate return of and on private investments. Thus, to obtain private funding for new investments in capacity (and to avoid the abandonment of existing capacity) the risk-return estimates of investors are crucial. Therefore, the risk assessment of investments under different market designs is a major issue for the choice and consistent and credible design of a market.[1]

The risk assessment of investments might differ significantly between different market designs. In most instances, *energy-only markets* are liquid for a limited time period, as forward markets, where guaranteed delivery of energy is traded, usually only cover few years

1 For the pivotal role of consistency and credibility as regulatory principles with regard to perceived risk and investment incentives see *Kretschmer et al.* 2011.

into the future, in any case a much shorter period than the long economic lifetime of most generation capacity. Therefore, investors planning to invest in generation capacity have to form their expectations about future energy prices. In particular, they have to form expectations about whether potential price spikes in scarcity times will be sufficient to cover the fixed costs of additional generation capacity. Even without any regulatory interventions, their decision will depend on a number of uncertain (demand and supply side) factors that drive the frequency, length and magnitude of price spikes.

Furthermore, if investors are skeptical about the political acceptability of sufficient price spikes they will demand a very high risk premium for investments in generation capacity. In addition, regulatory interventions (in particular, due to concerns of market power as discussed above) would have to be excluded credibly which ultimately is not possible because of time-consistency problems (see *Kydland/Prescott* 1977). Due to his sovereignty the regulator – and ultimately the legislator – cannot completely credibly commit to not deviate from an announced course of action after investments have been made and thus the possibility of regulatory hold-up by changes of the regulatory system cannot be excluded. If investors expect windfall losses with a certain likelihood (but no corresponding windfall profits) they are exposed to an asymmetric risk that lowers the average expected rate of return on their investments.[2]

The advent of renewable energy sources tends to increase these risks for investments in generation capacity. In particular, when the feed-in of energy from renewable sources is prioritized and guaranteed at fixed and subsidized rates as by the German Renewable Energy Sources Act (EEG), the operating time of (marginal) conventional power plants tends to decrease and also will be more volatile. In addition, the level of (peak) prices is lower due to the merit order effect (i.e. the crowding out of fossil generation by lower variable cost renewables) and prices also will be more volatile. Higher price spikes would be necessary in the remaining operating times increasing the risk of regulatory interventions in the form of price caps. As the treatment of renewable energies is subject to continuing discussions they induce high uncertainty about prices, the energy mix and regulation (see also *Cramton et al*. 2013).

With *capacity markets* and other capacity mechanisms, investments in generation capacity draw cash flows from two sources (see also Monopolkommission 2013), revenues from the energy-only market being supplemented by revenues from a capacity mechanism. In principle, we would expect that risk is considerably higher in energy-only markets than in case a capacity market is implemented (clearly when capacity payments are guaranteed), because in energy-only markets the profitability of generating capacities depends on rather uncertain and unsteady revenue streams. If a capacity market with fixed payments is implemented, only part of the revenues still comes from the energy-only market. Hence, the risk in total is reduced as capacity mechanisms are guaranteed over a certain period and thus tend to reduce uncertainty. This general reasoning applies to both contracts and auction-based mechanisms. Contracts can be assumed to be particularly risk-reducing when they determine capacity payments that are cost-oriented. Auctions also reduce uncertainty as they give investors whose bids are accepted price information for a certain period (see *Spees et al*. 2013).

2 For a discussion of asymmetric regulatory risks see *Kolbe et al*. 1993; and *Pedell* 2006.

Frequently, capacity mechanisms are combined with a *call option* that allows the responsible authority to collect the difference between the electricity spot market price and an exercise price fixed in the capacity mechanism from the energy generator. This element is based on the rationale to avoid double rents from the energy-only market and the capacity market (Monopolkommission 2013). As a consequence, an interdependence between the cash flow streams from both sources is induced. De facto, this element is equivalent to a price cap corresponding to the exercise price.[3] Ceteris paribus, the volatility of cash inflows is reduced (*Joskow* 2008). If this comes along with a reduction of the covariance with the overall market risk, systematic risk and the cost of capital are reduced as well. Furthermore the average level of revenues is reduced and the payoff structure becomes asymmetric. As just described, the upside potential of revenues is limited by a call option but there is no corresponding floor on the downside. These effects have to be taken into account when calibrating the entire capacity mechanism in a way that gives investors sufficient investment incentives.

In the following, the effects of the choice of some *elements of capacity mechanisms* on the risk of investors are discussed, i.e. the parameters that are fixed, the period of validity and the lead time:

- In principle, and without considering here all merits and drawbacks of different approaches, payments can be fixed or variable, either providing a fixed capacity premium or a guaranteed price for capacity that is used during peak times (*Joskow* 2008; *Cramton et al.* 2013). In the latter case, which is rather rarely suggested, the investor would be exposed to a quantity risk that is eliminated in the first case.
- Given the very long lifetime of most generation capacity, the period of validity of a capacity mechanism is a crucial factor for investment incentives. If the period of validity is relatively short compared to the economic lifetime of generation capacity and there is a relatively high perceived political or regulatory risk, the capacity mechanism runs the risk to be ineffective. For existing generation capacity this is less problematic; on these grounds, shorter periods of validity for existing generation assets seem justifiable.
- The overall (target) capacity that is covered by a capacity mechanism can be more or less stable beyond the period of validity of a certain contract or auction. The more unstable the capacity the higher tends to be the risk for the investor. Particularly, unilateral decreases of the target capacity covered by the capacity mechanism could be problematic for investors.
- A longer lead time between the implementation of a capacity mechanism and its period of application gives investors more planning reliability for the revenue side of their investment calculus.[4] This tends to reduce investment risks. However, there is a trade-off with higher uncertainty about the cash outflows (initial investment and operating expenditures) which can make very long lead times unfavorable.
- The inclusion of demand side management-activities in the capacity mechanism can reduce the price volatility (*Spees et al.* 2013).

3 It should be noted that despite the price cap, individual generators still have an incentive to provide additional energy as they will receive the spot market price for it (see *Cramton et al.* 2013).

4 Apart from that, a longer lead time facilitates the participation of new entrants in the capacity market (*Joskow* 2008).

- Another aspect can be a differentiated treatment of existing and new generation capacity with respect to the price. For example, the price for new capacity could be oriented towards full cost, whereas existing capacity is only granted a small premium on variable cost. As *Cramton et al.* (2013) point out, this is problematic as investors will anticipate that new investment potentially will be treated differently ex post and will ask for a contractual commitment covering this risk.

To sum up, investors in energy-only markets face significant market and regulatory risk. With the introduction of capacity markets, a major fraction of the market risk for investors can be eliminated. However, the introduction of a capacity market and its complexity can induce additional regulatory risk into the sector. For the individual investor, this regulatory risk can be mitigated at least partly in a capacity market design with a comparably long validity. Such a market can be interpreted as a means of increasing (regulatory) stability perceived by investors in an uncertain system.

4. Conclusions

Current energy markets may suffer from various imperfections, which prevent an efficient price formation and, thus, sufficient investment incentives. In particular the lack of proper demand response and the existence of explicit or implicit price caps may restrict necessary scarcity rents for peaking capacities. As long as it is not possible to monitor and restrict electricity consumption of individual consumers, investments in reserves have the character of a public good which implies that the private investment level would be below the socially wanted amount of reserves.

To give investors additional investment incentives the implementation of capacity markets is currently being discussed. Such markets ensure not only additional revenue streams but also reduce the market risks for investors.

Due to the relatively high complexity of capacity markets it can be expected that there will be changes to the market design and to relevant parameters – in particular shortly after the first implementation of such mechanisms. This might increase the uncertainty perceived by investors. However, if the period of validity is long enough, i.e. the investors can calculate with a relatively stable revenue stream, a capacity market might be an instrument for reducing the risks perceived by investors and hence for facilitating the financing of investments in new energy generation capacity.

As the implementation of a capacity market is likely not to be easily reversible for political reasons, its advantages and drawbacks have to be weighted very carefully and particular care has to be taken when designing a capacity mechanism. Our analysis contributes to providing a sound economic base for the consistent design of capacity markets.

References

Cramton, P./Stoft, S. (2006): The Convergence of Market Design for Adequate Generating Capacity with special attention to the CAISO's Resource Adequacy Problem, White Paper for the Electricity Oversight Board, 25. April 2006.

Cramton, P./Stoft, S. (2008): Forward reliability markets: Less risk, less market power, more efficiency, in: Utilities Policy, Vol. 16, pp. 194-201.

Cramton, P./Ockenfels, A./Stoft, S. (2013): Capacity Market Fundamentals, in: Economics of Energy & Environmental Policy, Vol. 2, No. 2, pp. 27-46.

Hogan, W. (2013): Electricity Scarcity Pricing Through Operating Reserves, in: Economics of Energy & Environmental Policy, Vol. 2, No. 2, pp. 65-86.

Joskow, P.L. (2008): Capacity payments in imperfect electricity markets: Need and design, in: Utilities Policy, Vol. 16, pp. 159-170.

Joskow, P.L./Tirole, J. (2007): Reliability and Competitive Electricity Markets; in: RAND Journal of Economics, Vol. 38, No. 1, pp. 60-84.

Kolbe, A.L./Tye, W.B./Myers, S.C. (1993): Regulatory Risk: Economic Principles and Applications to Natural Gas Pipelines and Other Industries, Boston / Dordrecht / London.

Kretschmer, T./Küpper, H.-U./Pedell, B. (2011): Bedingungen und Prinzipien einer konsistenten Regulierung, in: *Müller, Ch./Pedell, B.* (eds.): ZfbF, Special Edition 2/2011, pp. 1-31.

Kydland, F./Prescott, E. (1977): Rules Rather than Discretion: The Inconsistency of Optimal Plans, in: Journal of Political Economy, Vol. 85, pp. 473-491.

Monopolkommission (2013): Energie 2013: Wettbewerb in Zeiten der Energiewende. Sondergutachten 65, Bonn.

Pedell, B. (2006): Regulatory Risk and the Cost of Capital. Determinants and Implications for Rate Regulation, Berlin.

Spees, K./Newell, S.A./Pfeiffenberger, J.P. (2013): Capacity Market – Lessons Learned from the First Decade, in: Economics of Energy & Environmental Policy, Vol. 2, No. 2, pp. 1-26.

Stoft, S. (2002): Power System Economics – Designing Markets for Electricity, IEEE Press & Wiley-Interscience.

Christian Growitsch, PD Dr., ist Direktor am Energiewirtschaftlichen Institut der Universität zu Köln und Privatdozent an der Wirtschafts- und Sozialwissenschaftlichen Fakultät der Universität zu Köln.

Anschrift: Energiewirtschaftliches Institut an der Universität zu Köln, Alte Wagenfabrik, Vogelsanger Straße 321a, D-50827 Köln, Tel.: +49 (0)221/22729-400, E-Mail: christian.growitsch@ewi.uni-koeln.de.

Lisa Just, ist wissenschaftliche Mitarbeiterin am Energiewirtschaftlichen Institut der Universität zu Köln.

Anschrift: Energiewirtschaftliches Institut an der Universität zu Köln, Alte Wagenfabrik, Vogelsanger Straße 321a, D-50827 Köln, Tel.: +49 (0)221/22729-400, E-Mail: lisa.just@ewi.uni-koeln.de.

Burkhard Pedell, Prof. Dr., ist Inhaber des Lehrstuhls Controlling an der Universität Stuttgart und Senior Fellow am Risk Management and Decision Processes Center, The Wharton School, University of Pennsylvania.

Anschrift: Universität Stuttgart, Lehrstuhl Controlling, Keplerstr. 17, D-70174 Stuttgart, Tel.: +49 (0)711/685-83170, E-Mail: burkhard.pedell@bwi.uni-stuttgart.de.