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Policy Brief No. 062

Germany's Electricity Market Reform Should Harness the Power of Efficient Spot and Forward Trade to Foster Innovation, Investment, and Resiliency

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September 2024

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Funding by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under Germany's Excellence Strategy – EXC 2126/1-390838866 is gratefully acknowledged.

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The forward energy market is a capacity mechanism built for the future, avoiding mistakes of the past

Peter Cramton and Axel Ockenfels[1]

4 September 2024

Decarbonization requires expanding renewable power generation, phasing out coal, and growing electricity demand. Significant investments in flexible, climate-friendly generation capacity are needed. However, due to market design failures, the investment incentives in Germany are insufficient. Sources of market failure include political and regulatory uncertainties, time inconsistencies and constraints on energy supply and pricing, incomplete markets, and market power. These market failures distort spot energy prices, leading to what is often called 'missing money', a situation where the costs of electricity production exceed the revenue generated, creating financial challenges for the market participants.

In July 2024, the Federal Ministry for Economic Affairs and Climate Action (BMWK), representing the German government, released a pivotal document titled "Strommarktdesign der Zukunft" (Electricity Market Design of the Future). This 'options paper' presents alternatives for the investment framework and sets the stage for the future of the electricity market in Germany. The debate is welcomed. The options paper is a significant milestone in the ongoing discussion about the future of the German electricity market. Mistakes in the design of the electricity market can have devastating consequences for the entire economy and the energy transition. They must be avoided.

The fundamental thrust of the options paper focuses on creating a new electricity capacity mechanism to strengthen investment incentives. We agree that a capacity mechanism is needed. However, based on our extensive experience designing capacity markets, *we urge German regulators and policymakers to avoid the capacity mechanism pitfalls seen in the last twenty years and adopt a capacity mechanism that encourages innovation and resiliency*. A capacity mechanism built on efficient and transparent trade in a forward energy market, a variant of Option 1 in the options paper, and built on an efficient spot market, provides a reliable and resilient capacity mechanism, as well as the information and incentives for continuous improvement in investment, operation, and policy so that Germany may enjoy least-cost and sustainable electricity in the long run. On the other hand, the currently preferred combination of centralized and decentralized capacity markets, as outlined in Option 4, will be costly but will not provide the reliable price signals and resilience needed for the energy transition, especially if the deficiencies of the spot market are not addressed.

Germany should fix its spot market *and* adopt a forward-looking capacity mechanism

Germany stands at a critical juncture. The spot energy market is in dire need of repair. The question that looms large is: what is the most effective policy response?

One approach is to give up on the spot market for investment. Cost-based regulation could determine the operation of generating resources, and central planning could be used to acquire the needed generation through competitive procurement. This approach has been used in Brazil and China.

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However, such an approach is unlikely to perform well during the energy transition, which requires substantial innovation, especially on the demand side.

More generally, using capacity markets to cover up spot market flaws is a bad idea. Since a capacity market restores poor investment incentives, the flaws can remain indefinitely, regardless of the spot market flaws. Consumers pay more for electricity, but the better path forward is hidden.

In this context, it may be worth repeating what we wrote more than a decade ago in an article about the economics and design of capacity markets for the power sector in Germany (Cramton and Ockenfels 2012; Cramton et al. 2013):

> *Reliability concerns in Germany are mostly rooted in the transition process of Germany's electricity market, away from nuclear power and towards renewables. This transition comes with strong and hard-to-predict growth of renewables, time-inconsistent and drastic interventions of energy politics and regulation, ambiguous grid development, and concern that existing capacity may exit the market and not serve as a power reserve. The reason we only marginally speak to these challenges is that capacity markets cannot be part of the solution to these problems. No capacity can mitigate the risks implied by time-inconsistent politics (although it can mitigate the large price risks already inherent in stable markets). Rather, a capacity market makes the corresponding costs for long-term reliability transparent. […] Finally, in times of rather emotional public discussions, ambitious (or even illusionary) goals on future technologies and demand, and a financially strapped electricity sector, it may seem unlikely that the market design will be based on rational economic arguments only; yet flawed designs likely do more harm than good. We thus recommend, in the current phase of transition in Germany, giving the highest priority to building a stable and reliable political and sound market framework. […] In fact, given the current state of Germany's electricity market, the contribution from building a stable and more flexible market environment will likely exceed any contribution to reliability from well-designed capacity markets.*

This statement is even more valid today amid the transition to a renewable energy system.

An efficient spot market is essential

Instead of abandoning the spot market for investment, a much better approach is to fix the spot market in politically acceptable steps. *The spot market has to be the center of any long-run market reform*. The reason is that the spot market provides incentives for the efficient operation of resources. It is the anticipation of the spot market revenues that provide investment incentives. All forward products, *including capacity*, are derived from the spot products and the anticipated spot market outcomes. The spot market enables efficient performance for deviations from contractual positions. Forward positions are settled at spot prices. One cannot have an efficient long-run market design without an efficient spot market.

However, the options paper ignores critical flaws in the electricity market. For instance, despite consensus among independent energy economists that using local prices to manage congestion is vital, the options paper does not include local prices as an option to consider. Yet, it is an illusion that a transition to renewables can occur with a single German electricity price.

Other flaws need to be addressed in any long-run market reform. Consider the definition of capacity. In early capacity markets, capacity was defined as the nameplate capacity of a resource. There was no obligation to produce energy. Consumers were effectively buying "iron in the ground", which has no value to the consumer and would never be purchased voluntarily. Economists pointed out that the appropriate definition of capacity is energy during a shortage. Capacity resources were selling an option to supply energy during a shortage. The generator would receive a capacity payment per MW-month for the obligation to deliver the specified MW during shortage events. Failures to deliver would result in payment to the buyer at the shortage price. Once the flaw of the original capacity product was learned through practice, the markets introduced performance incentives based on this *pay-for-performance* logic (Cramton et al. 2013).

Any sensible capacity product and capacity mechanism are thus tied to the spot prices during a shortage or near shortage. Hence, *the market rules must be explicit* about what happens to prices in shortage or near shortage. Market pricing cannot work in shortage—all offers have been accepted and energy and reserves are still insufficient. Moreover, shortages come with enormous market power. Thus, the *shortage price*, or price cap, is set administratively. This single number is a necessary and fundamental regulatory instrument to address investment incentives. A higher shortage price strengthens investment incentives. In US markets, the shortage price ranges from $2,000 to $5,500 per MWh, depending on the market. Rather than jump discontinuously to the shortage price when a reserve shortage occurs, the US markets have adopted an *operating reserve demand curve* that prices reserves in a continuous way with an adder that goes from zero to the shortage price as the system moves from near-shortage to shortage. This approach leads to high spot prices near shortage intended to elicit a supply response to help avoid a shortage. The operating reserve demand curve and the shortage price are the core administrative parameters determining the profits enjoyed by firms that supply during shortage and near-shortage. Notice that the importance of these administrative parameters falls to zero when there is sufficient bid-in demand that shortages never occur—when all offers to sell are accepted there is always a bid to buy that can set the price. This is one more reason why consumer engagement is so critical. A market design for the future encourages this engagement by enabling consumers to benefit from being price-responsive (Bobbio et al., 2023).

In Germany, what determines the price during and near shortages is vague. There are 'technical' price limits of currently 4,000 EUR/MWh in the day-ahead market and 10,000 EUR/MWh in the intraday market, but these can be raised when reached and do not affect over-the-counter trading. The balancing energy price in Germany can also serve as a scarcity price, and it is regulated. However, the balancing energy price is not capped, and due to a scarcity component, it can also rise to 10,000 or theoretically to 100,000 EUR/MWh or even more. Moreover, it is unclear how to deal with simultaneous scarcity in several bidding zones intraday, with transmission capacity still available. As a result of these ambiguities, any capacity market transfers wealth to certain types of resources under enormous uncertainty about spot market incentives for investment. There is no reason to believe that capacity markets will find reasonable capacity prices or provide least-cost resource adequacy under these circumstances.

Germany should learn from the United States experience with capacity mechanisms

Even with a fixed spot market, we agree that more capacity and a new capacity mechanism are needed (Cramton and Ockenfels 2012; Cramton et al. 2013; Cramton and Ockenfels 2024). The United States is a valuable source of lessons from past mistakes when designing such mechanisms. With over two decades of experience in seven restructured markets, capacity mechanisms have provided a wealth of knowledge. The reasonably good governance has allowed for the identification and correction of flaws in early designs, a process that is still ongoing. Three different capacity mechanisms are currently in place, as shown in Table 1.

Three capacity mechanism approaches in the US ISO markets

Market	Independent System Operator	Resource Adequacy	Capacity Requirement of Load-Serving Entity	Reserve Shortage Price	Scarcity Pricing
PJM	PJM Interconnection	Capacity auction	Three-year forward purchase in capacity auction	$5,500	Operating reserve demand curve
ISO-NE	ISO New England	Capacity auction	Three-year forward purchase in capacity auction	$3,500	Pay-for-performance
NYISO	New York Independent System Operator	Capacity auction	Capacity auctions six and one month ahead	$4,000	Operating reserve demand curve
CAISO	California Independent System Operator	Capacity obligation	Bilateral contracts for system, local, and flexible resource adequacy	$2,000	Operating reserve demand curve
MISO	Midcontinent Independent System Operator	Capacity obligation	Bilateral contracts and annual auction for seasonal planning reserve margin	$3,500	Operating reserve demand curve
SPP	Southwest Power Pool	Capacity obligation	Bilateral contracts for planning reserve margin and resource adequacy	$2,000	Operating reserve demand curve
ERCOT	Electricity Reliability Council of Texas	Reserve demand curve	None (voluntary response to spot scarcity pricing)	$5,000	Operating reserve demand curve

Table 1: Capacity mechanisms in the seven US restructured markets

Centralized capacity auctions are too administrative

The electricity markets in the Northeast US, PJM, ISO-NE, and NYISO, opted for centralized capacity auctions. Restructuring in these markets was more extensive, typically requiring the separation of generation and serving load. The initial designs all suffered from poor performance incentives. Procured capacity that did not deliver energy during shortages went unpunished. Strong performance incentives that tie capacity payments to energy delivery during shortages were introduced once this flaw was identified. The shortage price and the operating reserve demand curve are essential in linking the spot energy market to the capacity mechanism. The options paper does not discuss those crucial issues. Figure 1 compares the capacity auctions and the forward energy market, a variant of Option 1 in the options paper we briefly outline below (Cramton et al. 2024; Cramton and Ockenfels 2024b).

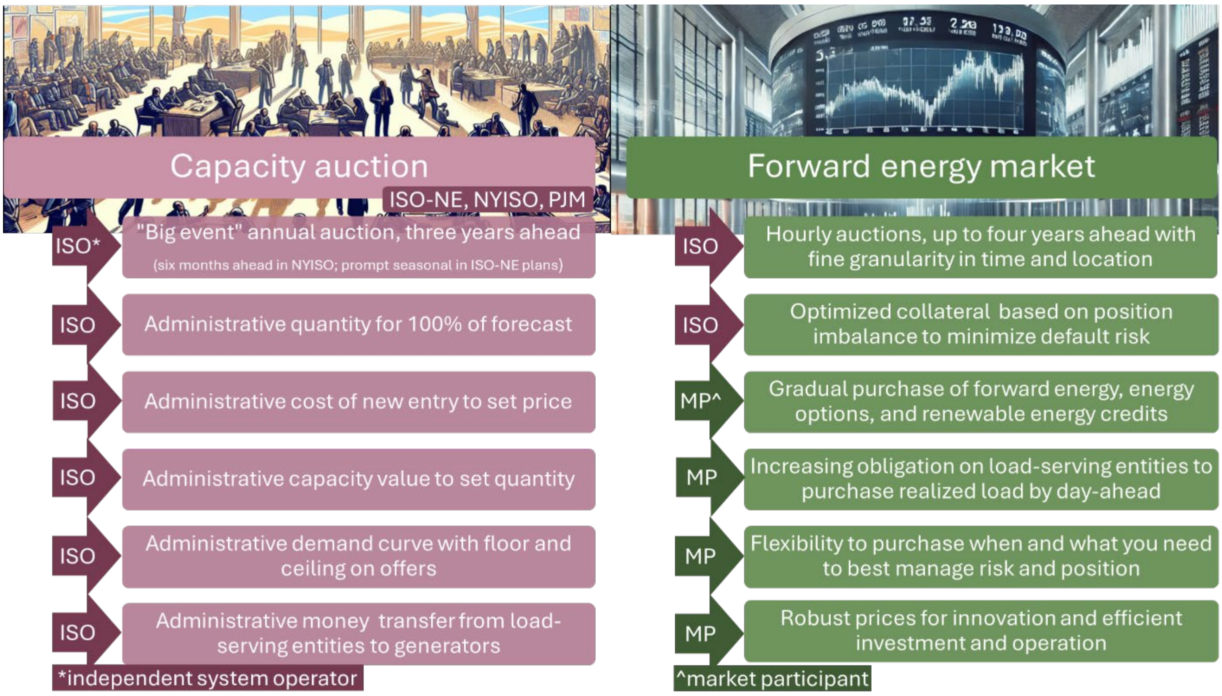

Figure 1: Comparison of capacity auctions and the forward energy market

Despite the fix in performance incentives, critical flaws remain in today's capacity auctions, especially during the energy transition when rapid innovation must occur to replace legacy resources. The main flaw is that capacity auctions are an administrative construct, where the independent system operator (ISO) plays a lead role in establishing the parameters of the auction, such as the quantity procured, the cost of new entry, the capacity value of each resource type, and the floor and ceiling on offers to address market power. The result is an administrative money transfer from the load-serving entities to generators. The size of the money transfer is determined in a lengthy and costly stakeholder process that determines these many parameters. Rent-seeking is the norm. A vital advantage of the capacity auction is that its prices and quantities are transparent despite its flaws. The transparency has led to a regulatory process of continuous improvement. However, the process is too slow and costly to address the challenges of the energy transition.

By contrast, the forward energy market limits the key administrative component to determining the operating reserve demand curve. This approach keeps the pricing incentives where they belong—in the spot energy market. Market participants then use efficient and transparent forward trade to manage risk and needs. Because of the information it provides, the forward energy market makes the management job much easier for regulators, system operators, and market participants.

The system operator's task is to conduct an efficient and transparent market for forward energy and energy options. The energy options are like reliability options in a traditional capacity market, except they do not include a tie to physical capacity. The lack of a physical tie does not harm reliability since the system operator will still conduct seasonal resource adequacy assessments. Its absence means that generators take positions based on their best assessment of their resources.

The forward energy market is readily accomplished with frequent auctions up to four years ahead with fine time and location granularity. The approach extends what US system operators do in today's day-ahead and real-time spot markets. Efficient trade further forward is straightforward because it is a convex optimization problem (Cramton et al. 2024). The approach emphasizes gradual and flexible trade among market participants. Participants trade what they need when they need it to manage risk better, limit trading costs, and avoid market power. The robust price information—essential to innovation, investment, and operation—is formed from the consensus of market participants with the information and incentives to make good decisions. Supply security comes from an increasing obligation on load-serving entities to purchase their realized load a day ahead. The load-serving entities must also maintain sufficient collateral with the system operator to limit default risk. Collateral increases with position imbalance.

Decentralized capacity obligations are too opaque

The restructured markets that did not require unbundling of generation and load serving, CAISO, MISO, and SPP, opted for a 'decentralized' approach, imposing capacity obligations on the load-serving entities.[2] Monopoly utilities prefer a capacity obligation because it is less transparent. A capacity obligation can discourage competitive entry without a transparent market to manage it. Incumbent utilities are at an advantage because their scale enables them to negotiate bilateral trades among themselves. Some markets introduced backstop auctions to address this difficulty, but this hybrid approach is imperfect.[3]

Figure 2 compares capacity obligations and the forward energy market. While capacity obligations may appear more flexible and market-friendly, the opposite is often true. The system operator

[2] The term "decentralized" is somewhat misleading because it might falsely suggest a more market-based approach. However, if a "decentralized" market imposes obligations without a competitive market platform, it can do more harm than good, while a well-designed "centralized" approach can reinforce decentralized decision-making based on efficient and competitive pricing.

[3] France, another market with a dominant incumbent, also opted for a decentralized capacity market, yet there is now a discussion of moving to a centralized approach.

administratively determines the capacity obligation, including a capacity value for each resource. Then, the system operator must audit each participant and establish penalties for violations or poor performance if there are any performance incentives. The most glaring weakness is the lack of transparency. The rules for audits and penalties are too often vague and poorly executed, tempting participants to use inadequate resources to ensure reliability and resiliency.

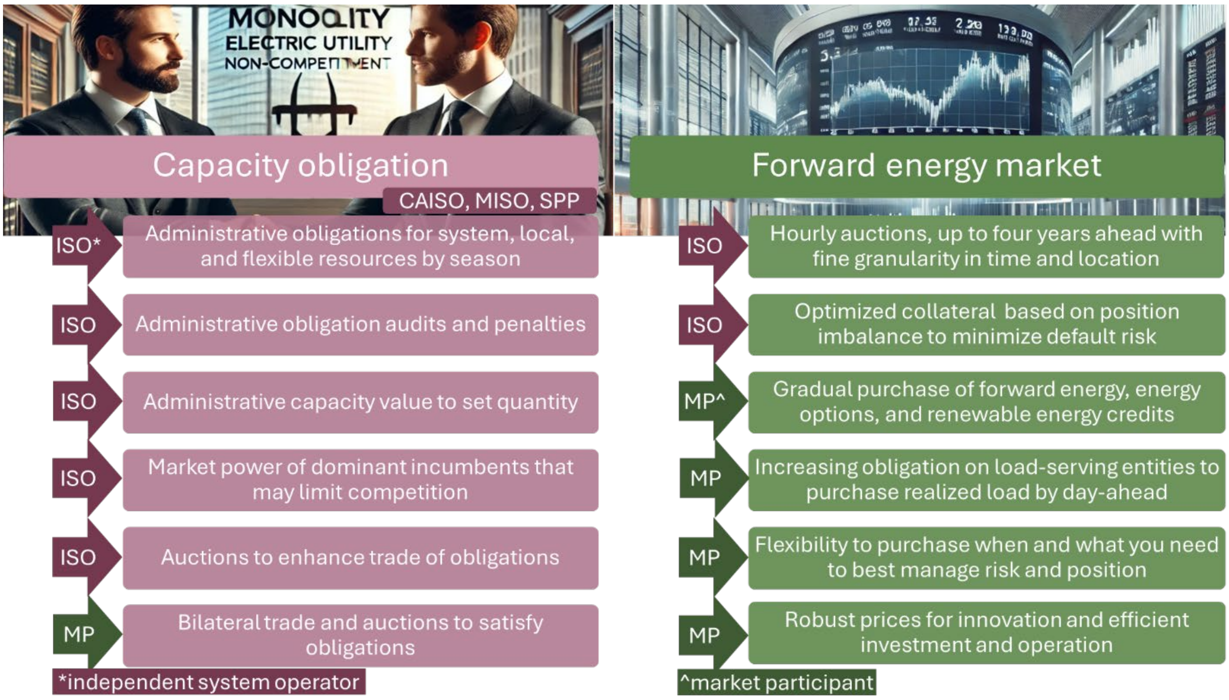

Figure 2: Comparison of capacity obligations and the forward energy market

Moreover, the decentralized market sketched in the options paper would further hollow out the energy market. Because it is supposed to run continuously until and beyond the real-time delivery of procured capacity, the capacity price will correlate with the energy price, weakening the spot energy price signal. As we get closer to real-time, the marginal cost of capacity will approach zero (for existing capacity) or infinity (for new capacity) since new capacity cannot be built in the near term. As a result, with competitive bidding, capacity prices will either be zero or close to the penalty for insufficient capacity certificates but not reflect the marginal cost of additional capacity. (As we noted before, a capacity product not tied to a performance incentive is unlikely to perform well.) The interaction of the centralized and decentralized capacity markets further complicates decision-making and price discovery. For example, the regulator may be motivated to respond to scarcity in the decentralized market by adjusting the capacity procurement in the centralized market, affecting prices and revenues in all capacity and energy markets. Taken these arguments together,[4] we conclude that the proposed combined capacity market design will fail to promote reliable price signals for energy and capacity.

Germany intends to have an efficient electricity market in the long run. This admirable goal is best realized by an electricity market design to push Germany through continuous improvement to that goal. Based on significant experiences, strengthening the energy spot market and encouraging efficient and transparent forward trade is the best path forward. Subsidies to special interests should be replaced with a market design that fosters innovation and investment through efficient pricing. The traditional capacity mechanisms, even when well-designed, are essentially an administrative negotiation process with stakeholders that is almost always subject to protracted disputes, leading to frustration among market participants, system operators, regulators, and policymakers (Aagaard and Kleit 2022a, 2022b; Cramton et al. 2024).

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[4] There are more concerns. See, e.g., Frontier Economics' statement from 26 August 2024.

Energy-only markets may be too weak without transparent capacity obligations

The third capacity mechanism used in the United States is the energy-only market in Texas' ERCOT market. An energy-only market forces the regulator and system operator to focus on the spot energy market. The spot market is the source of investment incentives. If investment incentives are insufficient, shifting the operating reserve demand curve northeast is the primary means of strengthening incentives. If the reserve margin is uncomfortably low, the regulator can increase profits for those providing energy during near-shortage conditions. The system operator still conducts seasonal resource adequacy assessments. Still, these inform the regulator of potential issues, including adjusting the reserve demand curve or finding other means to encourage entry, such as streamlining the interconnection process.

Unsurprisingly, the energy-only market in Texas is characterized by significant growth and a substantial industrial load. Growth creates a more favorable investment environment, and industrial load implies a louder demand-side voice in the stakeholder process. While this approach has worked well for decades, it proved vulnerable to extreme weather during Winter Storm Uri in February 2021. The rare storm resulted in outages of up to 3.5 days for 25 percent of the Texas market. The dollar cost was over 100 billion dollars; 262 Texans died.

Although traditional capacity mechanisms would not have prevented the disaster, Texas had ample capacity throughout the event. The problem was that much of the capacity could not generate energy during the storm because of a lack of fuel (Cramton 2022). The forward energy market would have helped Texans by encouraging bid-in demand to provide essential demand response (Bobbio et al. 2023) and avoiding defaults from imbalanced positions. Figure 3 compares the energy-only market and the forward energy market.

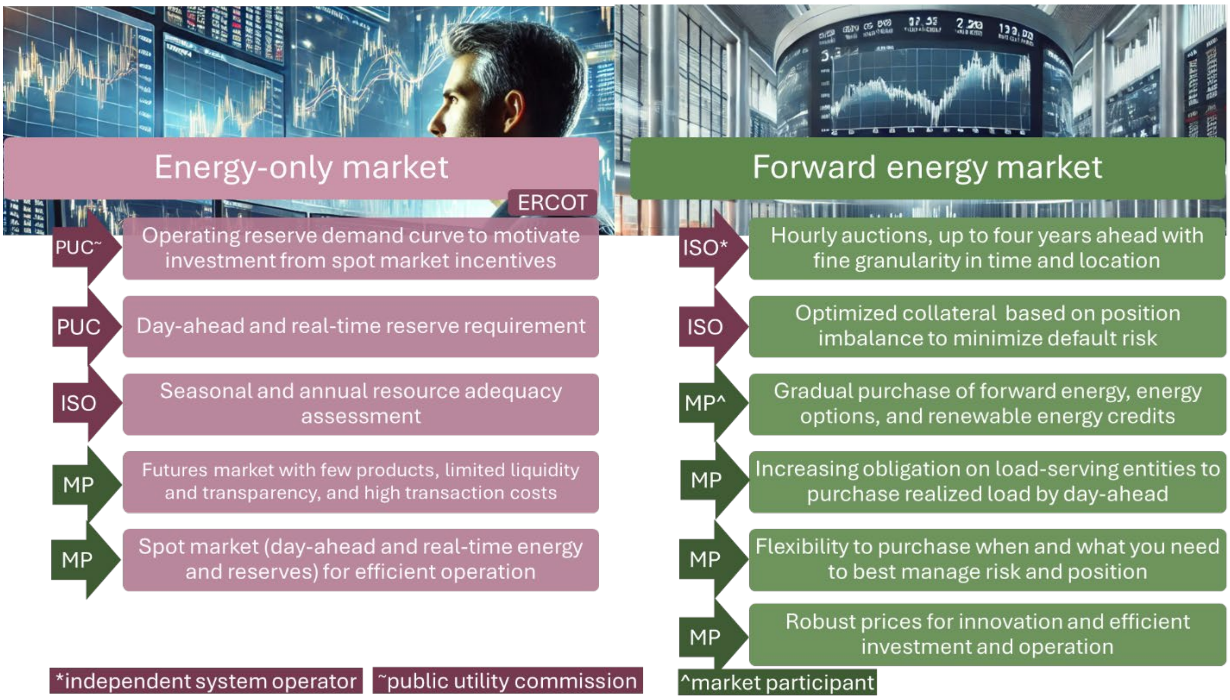

Figure 3: Comparison of the energy-only market and the forward energy market

The centralized and decentralized markets sketched in the options paper would not have prevented the enormous damage from two other costly electricity crises in North America and Europe: California in 2000-2001 and Europe in 2022. This should come as no surprise. Energy supply is always a matter of incentives (prices, including penalties), and procuring capacity does not solve spot incentive problems and sometimes damages them (see above).

Procurement of generation can address immediate problems and support long-term goals

The German power station strategy can resolve urgent supply needs. Still, the procurement must be done to contribute to Germany's long-run goal of an efficient market (Cramton and Ockenfels 2024a, 2024b). This is readily accomplished with a long-term contract that provides the same incentives as merchant investment but with a subsidy sufficient to induce the desired entry. For easy comparison of competitive bids, it is desirable to restrict the initial procurement to natural gas combined cycle units converted to hydrogen at a future date, with the government paying the spread between the hydrogen and natural gas price less the carbon price. The procured generation would participate in the spot market like any other resource with the same marginal incentives. The contract can also specify a forward energy or energy option sale. The exact form of the forward sale should be consistent with what a profit-maximizing owner of the generating resource would want to make. The forward energy market can enable the generation owner to adjust its position in response to new information. Such an approach assures that needed generation is built and yet preserves the marginal incentives of the spot market for efficient operation.

Ultimately, the forward price information will be sufficiently robust that there is no need for central procurement. Investors can look at the forward prices and decide the type, location, and date for the new competitive entry.

Efficient and transparent forward trade provides precise and responsive market incentives

The key to a resilient electricity market is transparent and granular price information driven by supply and demand fundamentals. Forward energy prices are significant and need attention.[5] They provide regulators, policymakers, and market participants with essential information and incentives for risk management and flexibility on all levels (Cramton et al. 2024). For example, as forward prices rise, participants are encouraged to invest additional resources. If high prices raise concerns about reliability, regulators and system operators can look for and address the source of the high prices, such as entry barriers.

A theoretically sound and straightforward way to incentivize a capability of delivering energy is to 'complete' the market in space and time with a forward energy market built on efficient and transparent trade (Cramton et al. 2024; Cramton and Ockenfels 2024b). Like the decentralized approach in the options paper, this capacity mechanism relies on a 'decentralized' obligation for load-serving entities. The obligation is an activity rule that requires load-serving entities to purchase a certain quantity of energy or energy options instead of capacity obligations. The activity rule helps to coordinate trading and ensure energy supply security.

The forward energy market should include a well-designed platform for gradual and flexible trading of different energy products. This promotes efficient pricing, which provides investors the basis for investing in flexible and reliable resources, including energy storage and demand response technologies. It also disciplines policymakers and regulators because it makes the costs of erratic interventions transparent. At the same time, gradual trading allows for optimal risk management, including by regulators and policymakers, and mitigates market power. This model avoids or limits

[5] ACER diagnosed "*that existing electricity forward markets in the EU suffer from problems which prevent achieving the objective of an effective and efficient electricity forward market. The most prominent are insufficient liquidity, accessibility, competition, transparency, and inadequate market structure*" ACER 2023. Accordingly, the current proposal for the new European Union's electricity market design regulation from 7 May 2024 states that: "*The design of the Union's forward markets shall comprise the necessary tools to improve the ability of market participants to hedge price risks in the internal electricity market*". And: "*Where a competent regulatory authority considers that there are insufficient hedging opportunities available for market participants, it may, ... require power exchanges or transmission system operators to implement additional measures, such as market-making activities, to improve the liquidity of the forward markets".* Council of the European Union 2024. See also this study by Connect Energy Economics commissioned by BNE, DIHK, and EEX.

shortages during systemic events, such as extreme weather that continue to occur under traditional capacity market approaches.

Introducing a forward energy market is a robustly beneficial, no-regret option that can be implemented stepwise. The benefits of forward energy trading are strengthened further with pricing that is more consistent with efficient, competitive markets: price equals marginal social cost equals marginal social value. With a well-designed scarcity pricing policy, this market design incentivizes enough investments, competition, innovation, and flexibility. Including carbon externality in the price is also desirable by charging the marginal social cost of emissions. Working against market forces, like the EU emission trading, will make achieving climate and electricity goals more difficult and costly.

Amid the enormous challenges of the energy transition, the German electricity market is at a crossroads between market and central control. Today, government and regulatory interventions control large parts of entry and exit decisions, electricity prices, and dispatch decisions. This creates costs and problems that are met with even more control and intervention. At first glance, it may seem politically or economically easier to build whole new capacity markets that procure enough capacity instead of more directly addressing the energy market flaws. But this won't work. Germany's future electricity market design needs to recognize the severe challenges of existing capacity mechanisms, centralized and decentralized, and focus on capacity mechanisms that improve the spot electricity market supported by efficient and transparent forward trade. The stakes are too high to allow ourselves to repeat the mistakes of other countries.

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