Gradual and Flexible Procurement: A Note on Germany's Power Station Strategy

PETER CRAMTON | AXEL OCKENFELS

Germany and many other countries face the challenge of accelerating the expansion of flexible, climate-friendly generation capacity to ensure security of supply during the energy transition. Current best practice for procurement is inefficient and can be improved. We propose a novel approach that allows for gradual and more flexible government purchases and addresses the shortcomings of existing capacity mechanisms and forward markets.

Introduction

Decarbonization requires an expansion of renewable power generation, the phase-out of coal, and a 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 and constraints on energy supply and pricing, inelastic demand, incomplete markets, and market power. These market failures cause spot market prices to be distorted, resulting in missing money for flexible generation capacity (Cramton and Ockenfels 2012; Cramton et al. 2013). Such problems are seen in every market worldwide.

Many countries are pursuing new capacity due to the challenges of supply security and decarbonization. Germany's power station strategy is an example.[1] It intends to procure 10 GW of hydrogen-ready gas-fired power stations. These gas-fired power stations will be converted to hydrogen between 2035 and 2040, on a fixed date specified in 2032. The plan is to procure these power stations through up to four auctions. Beyond its immediate goals, the strategy also serves as a bridge to a comprehensive capacity mechanism.

In a companion paper (Cramton and Ockenfels 2024), we offer recommendations on a robust auction design for procuring the needed capacity based on best practices in Germany and elsewhere. The approach is to procure a product in four auctions about six months apart. The product bundles physical hydrogen-ready capacity with a financial option to deliver energy when prices are high, and a uniform price is used to encourage participation.

In this paper, we present a novel approach to capacity procurement, one that mirrors the more traditional approach. It is based on the same fundamental principles of market design and on what has been learned about the challenges of supply security and capacity markets.[2] Our approach allows for more grad-

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Schrittweise und flexible Beschaffung: Eine Anmerkung zur deutschen Kraftwerksstrategie

Wir entwickeln einen neuen Ansatz für die Beschaffung von Kraftwerkskapazitäten, der auf bestehenden Best Practices, fundierter ökonomischer Theorie und umfangreicher Erfahrung aufbaut, aber eine schrittweise und flexiblere staatliche Beschaffung ermöglicht. Für die deutsche Kraftwerksstrategie schlagen wir vor, über einen Zeitraum von drei Jahren stündliche Auktionen durchzuführen. Die schrittweise Beschaffung diszipliniert Marktmacht und ermöglicht eine feine zeitliche und räumliche Produktgranularität. Darüber hinaus entspricht sie der Einkaufs- und Risikomanagementstrategie eines rationalen Käufers, indem sie den Kauf einer Mischung aus Terminenergie und Energieoptionen ermöglicht, die je nach Lieferzeitpunkt und -ort variieren kann. Der koordinierte Handel fördert effiziente Preisbildung, Wettbewerb und Innovation und adressiert damit die Unzulänglichkeiten bestehender Kapazitätsmechanismen.

[1] See the German government's "Agreement on Power Station Strategy" press release of 5 February 2024. https://www.bmwk.de/Redaktion/EN/Pressemitteilungen/2024/02/20240205-agreement-on-power-station-strategy.html

ABSTRACT

We propose a novel approach to electricity capacity procurement based on robust economic theory and extensive experience. Our approach builds upon the current best practice but allows for more flexible and gradual government purchases. Using Germany's power station strategy as an example, we suggest gradual procurement in hourly auctions over three years, which effectively mitigates market power and allows fine product granularity in time and space. Moreover, it aligns with a rational buyer's purchase and risk management strategy by enabling the purchase of a blend of forward energy and energy options that vary by time and delivery location, tailored to the buyer's specific needs. By promoting efficient pricing, competition, and innovation through coordinated forward trading, the gradual and flexible approach also addresses the shortcomings of existing capacity mechanisms and forward markets as ACER and the European Commission identified.

ual government purchases. Instead of four auctions spaced over multiple years, we propose hourly auctions over three years. This purchasing method eliminates market failures due to incomplete markets and market power. Our approach also allows for more flexible government purchases. It aligns with a rational buyer's purchase and risk management strategy by enabling the purchase of a blend of forward energy and energy options that vary by time and delivery location. The share of forward energy increases as we approach the day ahead, similar to how service providers buy independently. Finally, by promoting efficient pricing, competition, and innovation through coordinated forward trading, our approach can address the shortcomings of existing capacity mechanisms and forward markets in the EU, as identified by ACER and the European Commission. The following sections explain the basic concepts and ideas in detail.

Basic idea

Our companion paper recommends a sequence of four open or sealed-bid auctions and uniform pricing to procure the energy option tied to hydrogen-ready capacity. The gradual and flexible procurement approach we outline in this section extends the rationale of having several auctions. Instead of one or a few big auctions, we purchase gradually.

To see why this is a good idea, consider the rationale of favoring four 2.5 GW auctions spread over multiple years instead of one auction in Germany's power station strategy:

- Reducing risk. Following the adage of not "putting all eggs in one basket," a multi-billion procurement conducted over time reduces the associated risks, as opposed to a single procurement auction.
- Reducing market power. Buyers naturally buy over time to avoid adverse price impacts from their purchase. This is a crucial and pervasive insight into financial markets. The best response is to purchase over time to mitigate market power (Black 1971; Coase 1972; Kyle 1985; Vayanos 1999).
- Reducing uncertainty. The early auctions reveal information relevant to the later auctions; market participants can adjust their bidding strategies based on the latest information. The buyer can also adjust the reserve price and downward-sloping demands based on the outcomes of the earlier auctions, ensuring that the quantity goal of Germany's power station strategy of 10 GW is reached by the final auction.
- Accommodating lumpiness. The market participants may have vendor or other constraints requiring buying lumps. For instance, the participant may want to do .5, 1, 1.5, or 2 GW, depending on the price. Multiple auctions let bidders gradually commit to larger quantities over the sequence of auctions. If the price is low, a participant may sell .125 GW in the first auction, and if the price is attractive, sell .5 GW. Then, adjust to achieve the correct number of .5 GW lumps in the later auctions based on price.

Thus, splitting the 10 GW into four 2.5 GW slices is useful to mitigate several kinds of market failure. But the key to our flexible approach is recognizing that the number four is arbitrary. Eight 1.125 GW auctions instead of four would not invalidate the above arguments. The only problem would be if the cost of running an auction were constant regardless of its size, which is not the case. For market participants and buyers, auction costs are related to the volume of trade, not the number of auctions. This is also the case for frequent batch auctions such as those conducted in day-ahead, intraday, and real-time markets. Higher frequency is helpful because it mitigates the four market failures mentioned above. Also, while a single multi-billion procurement may seem simpler than a series of four or more auctions, it is not. The buyer and market participants must try

[2]Since 2000, electricity market experts have learned much about those challenges in restructured markets: Aagaard and Kleit 2022a, 2022b; Ambes et al. 2023; Borenstein and Bushnell 2015; Cramton 2017, 2022; Cramton et al. 2024; Cramton and Ockenfels 2012; Cramton et al. 2013; Cramton and Stoft 2006, 2007; Gimon 2020; Gramlich and Hogan 2019; Jha and Wolak 2023; Kahn et al. 2001; Macey and Ward 2021; Macey et al. 2024; Mauch et al. 2022; Patterson and Reiter 2016; Shu and Mays 2023; Watkiss et al. 2023; Wilson 2002; Wolak 2021, 2022.

to find other ways to deal with risk, market power, uncertainty, and lumpiness. The techniques are complex, administrative, and imperfect. On the other hand, a sequence of auctions directly mitigates critical market failures simply by repeating the well-designed auction many times.

We now consider an auction frequency consistent with the day-ahead energy product of one hour, a global standard. Although arbitrary, the one-hour frequency has proven robust across electricity markets. As we near real-time (the intraday market), finer time granularity is required, such as 5 minutes, but here, we focus on products that are derivative of day-ahead energy, so the one-hour frequency is fine.

There are $24 \times 365.25 \times 3 = 26{,}298$ hours over three years. Purchasing 10 GW would involve purchasing at an average rate of 0.38 MW each hour. Assuming that the present value totals €10 billion, each auction involves a present value of about €380,257, a relatively modest sum.

In addition to the benefits of frequent trading discussed above, this approach could accelerate the start of the market. A multibillion-dollar auction scheduled for 2024 would create challenges for bidders to complete due diligence, and allowing inadequate due diligence hurts competition and forces bidders to include large risk premiums in their bids. However, a slow rate of purchase based on a sequence of frequent batch auctions can be initiated in 2024. Doing so would require a large effort by the government to finalize essential details, but the implementation step is modest.[3] The government and the participants would be making financial commitments of, say, $24 \times 5 \times$ €380,257 = €45.6 million if five days of auctions are conducted in 2024. The due diligence required of bidders to commit resources of this magnitude is negligible. Other elements of preparation are also reduced in time and expense because of the lower amount at risk and the mitigation of market power and other market failures. The bidding strategy is simplified, and mistakes are readily addressed in future auctions.

[3] It is planned that open source code will be available later this year, providing a commercial implementation of the approach we are analyzing here. The platform and tools will be tested using ERCOT market data (Cramton et al., 2024). The platform and tools will be available at no cost, requiring only customization for the German application. An expedited process will allow a thoroughly tested commercial implementation to be completed so that the procurement auctions can be conducted by the end of this year or early next year.

A further virtue of this gradual approach is that it is consistent with essential innovations in capacity mechanisms and, indeed, is similar to the approach developed for system operators in North America and Europe, described in the next section. The gradual approach not only addresses the immediate procurement challenge but could also be embedded into a consistent capacity mechanism based on foundational economics and optimization to provide reliable electricity at the least cost.

We now provide more details about the gradual and flexible trading approach.

Gradual trading

Auctions for capacity are conducted every hour, 24/7, except during recess periods. The demand curve is specified in advance (see **Fig. 1**). It can be adjusted periodically. The target quantity of 10 GW is fixed. At the end of three years, approximately 10 GW capacity is purchased. Although the government is organizing the procurement, presumably, it makes sense to assign the purchase requirement to load-serving entities in proportion to market share. The sellers would be any qualified party, including the existing producers.

The suppliers submit persistent, piecewise-linear hourly offers, which form the aggregate supply. Orders may be changed at any time. The current orders on the hour are used for market clearing. The unique clearing price and quantity that balance supply and demand are reported on the hour, as in **Fig. 2**.

Participation in the market is not difficult. A simple, effective, and easy-to-implement supplier trading strategy would be trade-to-target. Participants state their target and the rate at which they want to move toward the target. In the simplest case, a supplier may set its target at 1 GW and gradually purchase about 0.038 in each hourly auction to reach about 1 GW after three years. Producers typically have some scope to adjust a unit's construction to achieve different levels of capacity. Still, the gradual purchase gives the participant the flexibility to adjust the rate of purchase (or sale) based on price to attain the desired quantity when the auctions end. The strategy also specifies the participants' willingness to buy faster when the price is attractive and slower when the price is unattractive. A participant's urgency to trade may also depend on the proximity to the day-ahead for the forward products and the adjustment size. Faster trading is preferred when larger adjustments are needed closer to day-ahead. Because one's portfolio can be adjusted frequently by buying and selling capacity, lumpiness can be ad-

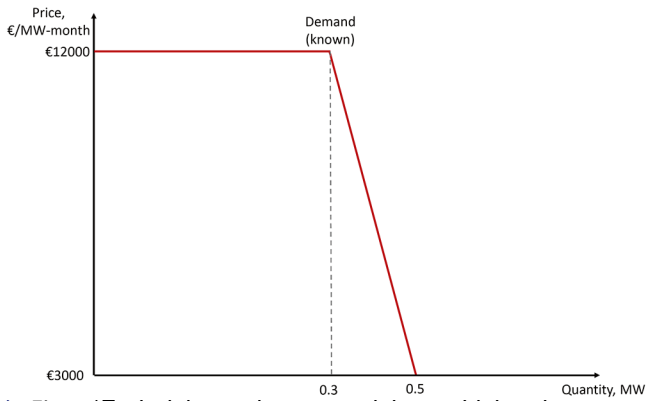

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Fig. 1 / Typical demand curves each hour with hourly auctions

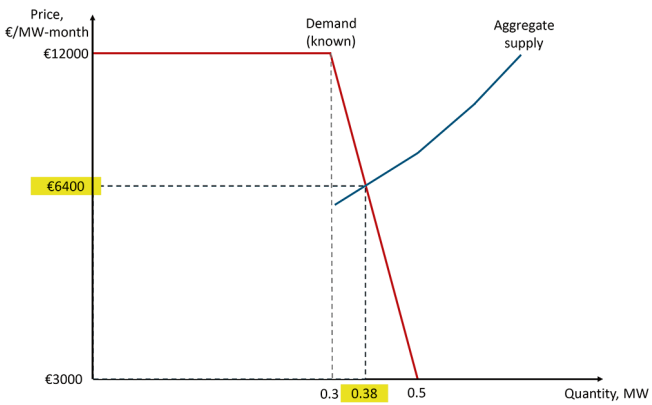

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Fig. 2 / Outcome in hourly auctions

dressed easily and with less complication than with the traditional market approach.

Trading over three years, until shortly before the earliest generation capacity comes online, allows the market price to be determined with fewer uncertainties and smaller risk premiums and, indeed, creates an incentive for regulators and policymakers to resolve uncertainty as quickly as possible. Moreover, intertemporal arbitrage will lead to a smooth price path unless it is affected by unanticipated external shocks. Unlike the market's price under the current best practice methods with few big auctions, the price in the more gradual market can efficiently adjust to such shocks, maximizing trade efficiency and minimizing procurement costs.

Flexible trading

The gradual approach, by completing the market in the time dimension, allows for more flexibility with respect to energy products. Indeed, the products purchased should be purchased consistent with what a rational buyer would want to buy and purchased when a rational buyer would want to buy them. This requires a buyer's consideration of the shape of the load when purchasing energy.

Fig. 3 summarizes the main determinants of the day-ahead energy price. Load is shown in black, renewable energy share is in pink, and price is in red. Hours with a low renewable energy share indicate that reliability in a system with high renewable penetration has little to do with serving peak load. Instead, net peak load, peak load minus renewable production, is what is needed for reliability.

A good buyer strategy for managing real-time price risk is to buy the expected load in energy and then purchase its right tail – the possibility that the load is surprisingly high because of extreme weather or other shock that was not anticipated day-ahead – as an energy option with a high strike price of, say, €900/MWh plus the natural gas price index times a typical heat rate. It is better to buy the right tail as an option since only occasionally will the buyer need this right-tail energy, and in those rare circumstances, the energy price is above the strike price.

With a long delivery time, the buyer demands more energy options. The reason is the lack of gas liquidity many years ahead. Thus, a generator with a combined cycle unit is happy to sell an energy option far ahead. The unit provides a physical hedge covering the capacity obligation, but the generator needs fuel to produce energy. The generator would require a hefty risk premium to accept unhedged fuel price risk. The buyer prefers to accept the fuel-price risk and gradually convert the energy options into forward energy as we get closer to day-ahead.

Fig. 4 illustrates a rational purchase of energy (green) and energy options (blue) in the three years from 1 January 2025 to 31 December 2027 for delivery in January 2028. The buyer demands more energy, given the short delivery time. Suppliers are happy to sell energy with a slight risk premium because the supplier can purchase forward gas in liquid markets.

Fig. 5 illustrates a rational purchase of energy (green) and energy options (blue) for delivery in December 2031 in the three years from 1 January 2025 to 31 December 2027. Given the long delivery time, the buyer demands energy options. The reason is the lack of gas liquidity many years forward. Suppliers would require a risk premium that is too large to sell energy and accept the fuel price risk.

In a two-sided market, the participants should be able to understand their needs and capabilities. Let them determine the blend of forward energy and energy options throughout time. However, in the government's procurement of 10 GW, the purchase is on behalf of service providers. Government purchase

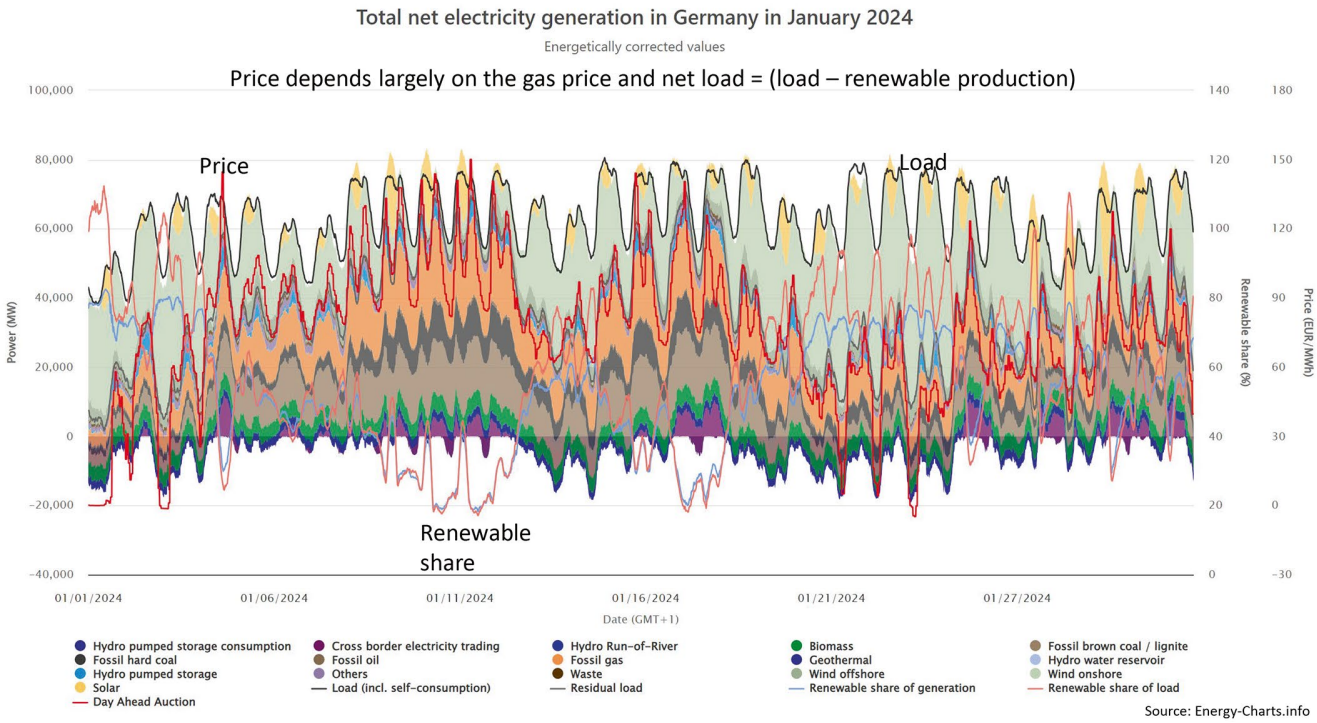

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Fig. 3 / Total net energy generation in Germany, January 2024

means the split between energy and options must be specified.[4] Still, there is no reason that the split cannot be consistent with what a rational buyer would want to buy: buy gradually over time, buy faster when the price is low and slower when the price is high, buy primarily energy options for quantity more than two years ahead, buy mainly energy for quantity less than two years ahead, and purchase consistent with anticipated load shape.

The role of market design is to allow transparent and efficient pricing. That enables the participants to trade without friction and with robust price information reflecting the market's consensus. The traditional approach cannot achieve this because it only considers energy options procured regardless of load shape. It does not reflect what consumers would want to buy. However, our flexible approach allows the buyer to incorporate forward energy into the product design mix to reduce risks and costs as the procurement progresses. In real-time, the consumer needs energy, not capacity.

Gradual and flexible long-term capacity mechanisms

An energy transition and increasing reliance on intermittent renewable sources demand more than the procurement of many power stations. Indeed, Germany's power station strategy is intended to bridge a comprehensive capacity mechanism that should be in place by 2028. Several approaches to resource adequacy exist, and their theoretical properties and empirical performance are well-documented (Cramton and Ockenfels 2012; Cramton et al. 2013). However, while the scope of a comprehensive mechanism is broader than the scope of a narrow power station strategy, they both must address similar fundamental market challenges when incentivizing market entry. In fact, they can both be based on similar principles of gradual and flexible procurement as outlined above, addressing remaining market imperfections by completing the market in the product and time dimensions.

However, developing a robust capacity mechanism based on the classical approach has proven difficult in practice. All traditional markets struggle with finding both prices and quantities, which are almost always subject to protracted disputes, fre-

[4] Alternatively, the purchase can be by load-serving entities that face a purchase requirement consistent with their current market share. The advantage of this approach is it lets the service providers decide when to purchase and in what form. However, there must be well-defined rules on how the service providers will be compensated for making the purchase. One approach is for a two-sided auction that allocates subsidy euros to service providers and simultaneously allocates those subsidy euros to producers.

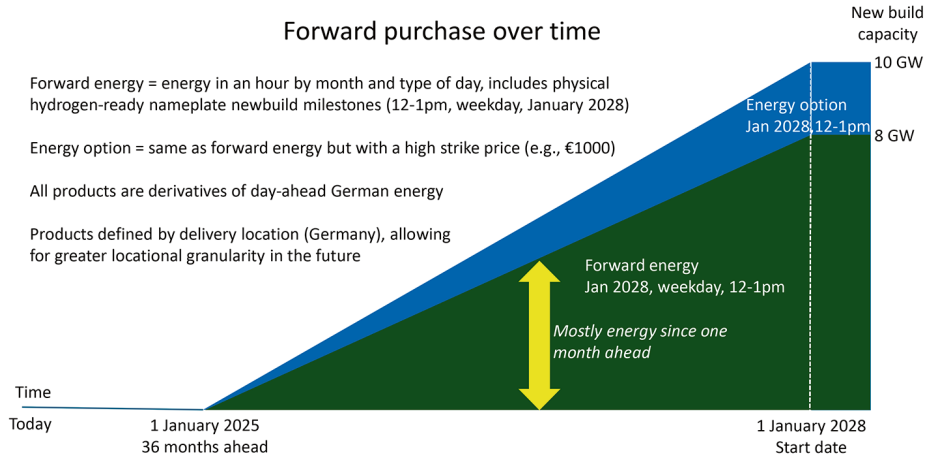

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Fig. 4 / Forward energy purchase over time for energy one month ahead

quently leading to frustration among market participants, system operators, regulators, and policymakers (Cramton et al. 2024; Macey and Ward 2021; Patterson and Reiter 2016; Aagaard and Kleit 2022a, 2022b). Many countries have also unsuccessfully used capacity market reforms to mask the sources of the capacity and resilience problem, such as regulatory imperfections, lack of demand-side flexibility, inefficient pricing, market power, and insufficient transmission.

This is why the traditional approach to capacity market mechanisms has recently been further developed. The idea is also to 'complete the market in the location and time dimensions' into a forward energy market that addresses these challenges (Cramton et al. 2024). The forward energy market approach is based on 1) more gradual and flexible trading of different energy products, as exemplified above for the power station strategy, and 2) purchase requirements for load-serving entities to help coordinate trade and ensure the security of supply. The key idea is to promote efficient pricing through forward trading, and efficient prices give investors a basis for investing in flexible and reliable resources, including energy storage systems and demand response technologies. These innovations and the purchase requirement for load-serving entities avoid or limit shortages during systemic events, such as extreme weather, which continue to occur under traditional capacity market approaches. Indeed, the costliest twenty-first-century failures in North America and Europe were resiliency events, not resource (in)adequacy events: California in 2000-2001, the Northeast in 2003, Texas in 2021, and Europe in 2022.

This approach also addresses the ACER's diagnosed basic electricity market flaw "that existing electricity forward markets in the EU suffer from problems which prevent achieving the objective of an effective and efficient electricity forward mar-

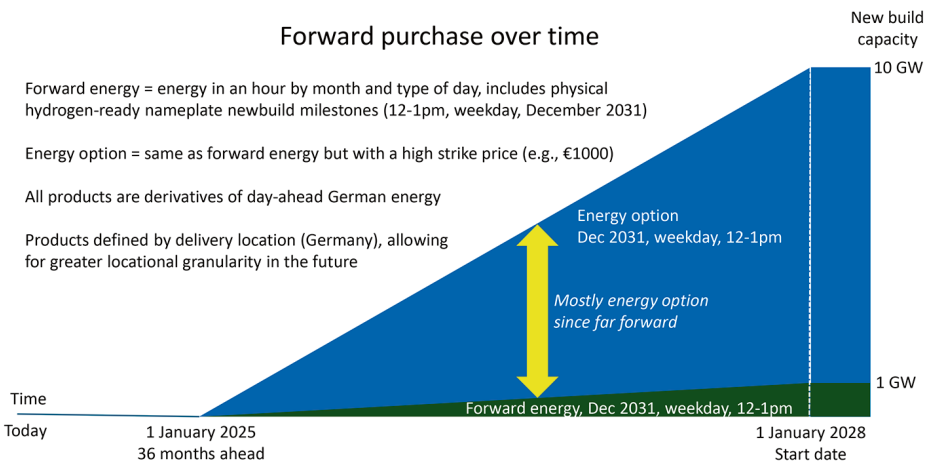

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Fig.5 / Forward energy purchases over time for energy four years ahead

ket. The most prominent are insufficient liquidity, accessibility, competition and transparency as well as inadequate market structure" (ACER 2023), as well as the European Commission's recent market diagnosis and reform that is based on the observation that "The future forward electricity market design needs to provide sufficient hedging opportunities" (Council of the European Union 2024).

The forward energy market could and should incorporate several other features that contribute to system resiliency, such as – as with the power station strategy – forward energy options that provide financial protection against extreme events, requiring market participants to manage risks and enhance system reliability. The market could and should also include products for forward procurement of reserves, which are additional capacity resources held in reserve, ensuring sufficient backup capacity is available during periods of peak demand or unplanned outages.

We describe the forward energy market, how it simplifies market participation and regulation and how it relates to the power station strategy in more detail elsewhere (Cramton et al. 2024). We believe that the market presents a sound approach to constructing a resilient and resource-adequate power market in Germany as a flexible alternative to traditional approaches to resource adequacy.

Conclusion

Germany and other countries are facing the challenge of accelerating the expansion of flexible, climate-friendly generation capacity to ensure supply security during the energy transition. Traditional approaches to procuring new capacity, such as infrequent big auctions, have limitations in addressing market failures, managing risks, and fostering competition and innovation.

In this paper, we present a gradual and flexible approach to procuring capacity that offers several advantages over current best practices. By conducting many smaller auctions over an extended period, the approach mitigates risks, reduces market power, accommodates uncertainty, and allows for more efficient resource allocation. The flexible and gradual procurement enables market participants to adjust their strategies based on the latest information and provides the government with the flexibility to adapt to changing market conditions.

Moreover, our approach allows for more flexible trading of energy products, bundled with capacity. By purchasing a blend of forward energy and energy options that vary by time and delivery location, the government can better align its procurement with the actual needs of the power system. This approach reduces risks and costs, as the share of forward energy increases closer to the day-ahead market, similar to how service providers independently purchase energy.

The gradual and flexible approach to procuring capacity is applicable to Germany's power station strategy and to many more procurement contexts. In the electricity context, it can serve as a foundation for comprehensive capacity mechanisms with a broader scope. As countries work towards decarbonizing their power systems, adopting such innovative market design principles will be crucial in achieving a reliable, resilient, and low-cost energy future.

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PETER CRAMTON
is an emeritus professor of economics at the University of Maryland, USA, and an international research fellow at the Max Planck Institute for Research on Collective Goods in Bonn, Germany.
pcramton@gmail.com

AXEL OCKENFELS
is a professor of economics at the University of Cologne and director at the Max Planck Institute for Research on Collective Goods in Bonn, Germany.

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Der Finanzbereich ist im Wandel. Unternehmen nutzen digitale Entwicklungen, um in Zeiten der permanenten Veränderung reaktionsschneller zu werden und ihr Datenpotenzial gewinnbringend einzusetzen. **Controlling & Management Review** zeigt innovative Ansätze und zukunftsweisende Technologien, die Unternehmen dabei helfen, sich optimal für die Zukunft aufzustellen. Das Informationsmedium der Controller-Community unterstützt den Dialog zwischen Praxis und Forschung und dient dem Management als Kompass, um zielgerichtet durch anspruchsvolle Zeiten zu navigieren. **Nutzen Sie dieses Wissen für eine erfolgreiche Unternehmensführung!**

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