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Reacting to changing paradigms: How and why to reform electricity markets

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ABSTRACT

The energy crisis and the accelerated transition to climate neutrality result in a shift from the traditional energy trilemma to an "energy quartet" across Europe. Firstly, the criteria of affordability, previously focused on short-term price developments, broadens to reliable affordability including in crises. Secondly, clean energy traditionally focused on clean production now extends to clean energy systems with climate neutral provision of flexibility and enhanced energy efficiency. Thirdly, generation adequacy extends to energy system resilience, for example to interruptions of fuel supply. Fourthly, a new objective of reliable speed is emerging, responding to the constrained carbon budget and the need for predictable demand for energy technologies to unlock investments in manufacturing capacity. Synergies can be realized by jointly addressing the energy quartet. First, hedging of both consumers and producers against power costs (but not price) fluctuations by passing on the conditions of contracts for differences to consumers can enhance speed and predictability of renewable investments. Second, nodal pricing allows the demand side to resolve rather than contribute to transmission constraints, enhancing system security and reducing emissions from fossil assets, which are currently dispatched to resolve transmission constraints. Third, a reformed strategic reserve can contribute to reliable affordability and system security.

1. Introduction

Historically, energy economists have identified a trilemma of objectives in trying to achieve an affordable, clean, and secure power supply (Egenhofer, 2007). However, recent developments indicate that the European policy landscape has changed drastically and that there is a need to reform European electricity markets (Schittekatte and Batlle, 2023). On the one hand, European countries have achieved an unprecedented increase in their (variable) renewable generation capacity, showing the progress toward achieving a clean power supply. Across the European Union, electricity production through wind and solar increased from 56 TWh in 2004 to 516 TWh in 2021 and now amounts to more than 20% of electricity produced in the continent (Eurostat, 2023). On the other hand, the war in Ukraine and the ensuing energy crisis have underscored the perils of fossil fuel dependency, shown a lack of risk hedging for consumers, and led to the re-emphasis of a broader definition of energy security (Cherp and Jewell, 2014), which is perhaps best reflected in a statement of German finance minister Christian Lindner, referring to renewable energy as the "energy of freedom" (Reuters, 2022). Therefore, it is time to rethink the energy trilemma, learning from the energy crisis and the needs of the energy transition. The notion of an energy quartet could reflect the new objectives:

First, energy policy must ensure predictable and stable energy expenditures for households and industry in order to ensure social cohesion, long-term competitiveness of the economies, and to avoid future policy interventions in market design, thus enhancing investment security. The criteria of affordability is therefore broadened to reliable affordability.

Second, the notion of green energy must shift from a narrow focus on investment in renewable power generation. Flexibility options other than dispatchable conventional power generation (e.g., storage, demand side response) and energy efficiency measures need are equally important. The objective of clean energy supply is hence broadening to clean energy systems.

Third, the energy crisis shows that a focus on generation adequacy is insufficient and a systemic view of energy security requires more attention and has to extend to system operation and fuel delivery. The focus on system adequacy is hence broadened to resilient energy systems that through electrification increasingly include adjacent sectors such as the transportation, industry and heating sectors.

Finally, production of renewable energy technologies needs to be scaled up in order to achieve carbon neutrality and this requires reliable demand from project pipelines to trigger investments in additional industrial production capacities for new wind and solar plants. This is

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reflected in a new objective of reliable speed.

Fig. 1 illustrates how these new paradigms transform the energy trilemma into the energy quartet. While the old energy trilemma often focused on different technological solutions being unable to address all goals simultaneously, it is now widely accepted that there are also large synergies that can be unlocked in pursuing these objectives jointly (e.g. the cost decreases for renewable electricity generation allow for simultaneously addressing affordability, energy security, and environmental goals). However, just as in a musical quartet, it is important to coordinate between these components to achieve overall success, as policy determines if the objectives can be achieved for all actor groups and some trade-offs remain.

In the following, we present key policy developments addressing the objectives of the energy quartet. The package combines previous suggestions for a Renewable-CfD-Pool (Kröger et al., 2022), nodal pricing (Bichler et al., 2021), and a strategic reserve with a price defined trigger point (Neuhoff et al. 2016). The remainder of the article is structured around the four elements of the energy quartet. We present how the notion of these policy goals need to change according to the new challenges facing energy markets.

To achieve the policy objectives, the market design framework needs to be fit for purpose. Several challenges exist on the way to a climate neutral electricity system. However, existing market failures prevent the current power market design from overcoming these challenges. For each of the objectives, we discuss the current situation, what changes need to take place in the course of the transition, and what market failures of the current market design need to be resolved.

2. Making affordability reliable

Renewable technology costs fell sharply in the last decade with the world-wide average of levelized costs of electricity for new power plants decreasing from 420 to 50 US dollars per MWh for solar and from 100 to 30 US dollars per MWh for onshore wind between 2010 and 2020 (International Renewable Energy Agency, 2022).[1] However, consumers in many countries have not, during the energy price crisis of 2022, benefited from the low renewable electricity costs because one-sided renewable remuneration mechanisms and fixed premia protect renewable projects against downside risks, leaving upside benefits with the projects. Indeed, during the 2022 energy price crisis the average pre-tax household electricity price in Europe nearly doubled compared to its pre-crisis levels (Eurostat, 2023).

Whereas short-term markets were often blamed for the high energy costs in 2022, the challenge lies in long-term markets and the way renewable policy has been designed (Schittekatte and Batlle, 2023). Furthermore, market design changes that increase the risk exposure of renewable investors translate to higher financing costs that are passed through to consumers (Neuhoff et al., 2022; Đukan and Kitzing, 2023).

Power Purchasing Agreements (PPA) and Contracts for Differences are being discussed as key policy instruments to reduce financing risks and costs and exposure of consumers to price volatility (Meeus et al., 2022). However, PPAs between renewable projects and electricity consumers only partially address this challenge. Electricity consumers cannot underwrite PPAs at the scale of the renewable investment needed in the coming years. The implied liabilities from undersigning PPAs may be acceptable for a set of initial projects, however, at the scale needed for achieving the renewable energy targets, they would accumulate a financial burden that exceeds the financial capacity of most large energy companies and industrial consumers (May and Neuhoff, 2019). In addition, utilities facing retail competition need to consider being undercut by competition in case electricity prices fall below the contract price (Green, 2004), especially when maximum contract lengths with final consumers are limited. Meanwhile, transaction costs and required guarantees limit the ability of small businesses to underwrite PPAs. Furthermore, counter-party risks for project developers, as well as the increase of liability, increases financing costs for off-takers (May and Neuhoff, 2021). Indeed, six of the seven largest off-takers of PPAs in the past decade were large technology and telecommunications companies (International Energy Agency, 2022). Overall, these effects, and overall policy uncertainty due to the strong influence of regulation on electricity markets, lead to the market failure of incomplete markets, i.e. a lack of long-term contracting below an efficient level. This is not only observed in Europe, but also in electricity markets outside the EU (Mays et al., 2022). In 2022, European companies signed a total of 8.4 GW (10.7 GW in 2021) in PPAs which is equal to 9% (2021: 12%) of the additional capacity needed per year to reach the EU's renewable energy targets (Pexapark, 2023, European Commission, 2022). However, since these numbers include short-term and post-subsidy PPA's, the number of new installations built under private PPAs is even lower. Thus, even if the market for PPAs will grow in the coming years, the overall added capacity through PPAs will be limited as compared to the overall neeeded capacity of renewable energies (European Investment Bank, 2022).

Meanwhile, Countries like France, Poland, and the UK have successfully tendered Contracts for Difference (CfD) for renewables. CfDs are long-term contracts under which renewable projects obtain the price difference between the strike price they offered in the renewable tender and the spot price in every hour they produce. Thus, projects are secured against low prices in exchange for returning revenues from high prices in periods when the strike price is exceeded. At the same time, the energy is completely sold in short-term markets, thus strengthening the functioning of the European power market. The stable revenue streams and a government agency as a credible counter-party simplify financial arrangements for project developers, enhance competition in the tenders, and reduce the risks of non-delivery of projects. This also reduces financing costs for all parties, such that the costs of renewable electricity are about 30% lower compared to a PPA financing structure (May and Neuhoff, 2021).

To ensure that both producers and consumers benefit from the price stability – and thus to leverage the full benefit of CfDs for reliable affordability – each final consumer should be granted access to a share of this pool of CfD contracts through a pass-through of the conditions and payments (Kröger et al., 2022). In the initial years, demand for access to a CfD pool will likely exceed available capacity. If access to this scarce resource were auctioned to consumers, then current scarcity would imply that their power prices increase. Hence, we suggest to define a clear strategy on how to allocate access to the CfD pool. Priority access could for example be given to companies with investments in electrified climate neutral production processes or to consumers in the vicinity of renewable projects as this is an effective channel to enhance acceptance (Knauf, 2022).

The major effect of such a Renewable CfD-pool is fivefold. First, it ensures reliable affordability by stabilizing electricity expenditure for consumers. Meanwhile, payments can be structured to correspond to a quasi-fixed delivery volume (linked to production in the pool, with the contract volume corresponding to a standard weather year) to maintain incentives from price signals, as contract volumes are decoupled from the actual consumption, thus exposing consumers to electricity prices at the margin. Second, it reduces complexity of financial arrangements for renewable projects and contributes to stable financing conditions, thus supporting the deployment of renewable energy and avoids the risk that projects are abandoned if power price expectations decline. Third, it allows for a robust "competition for the market" (Demsetz, 1968) by attracting additional wind and solar developers to strengthen the project pipeline and to reduce costs. The effective long-term contracting arrangement also reduces the incentives to exercise market power,

[1] The levelized costs of electricity are heterogeneous between different regions depending on the quality of the resource and the project costs. For instance, the average LCOE for onshore wind in 2021 were between 42 US dollars per MWh (2010: 130 US dollar per MWh) in Europe and 31 US dollars per Mwh (2010: 103 US dollar per MWh) in North America.

contributing to further cost reductions for consumers (Allaz and Vila, 1993). Fourth, the stability and speed of deployment of renewable energy projects is enhanced, thereby also contributing to a stable investment framework; for instance, for manufacturing capacity in the supply chain. Finally, having many consumers hedged by a standard renewable production profile catalyses the demand for forward contracts, that hedge the gap to typical demand profiles, and it focuses attention on realising demand response. Such a forward market for flexibility products will facilitate stable revenue streams for flexibility options to support the necessary investments in these technologies. Thus, it contributes to an overall clean system.

Furthermore, a CfD-pool offers the opportunity for the effective integration of European renewable policy. Countries may opt to pursue joint CfD tenders for renewable projects that can be located in either of the countries. By allocating (financial) transmission capacity between the countries at the time of the tender, this ensures that the price hedge renewable projects in neighbouring countries provide can also be passed to domestic consumers. As long-term access to (financial) transmission is granted to final consumers, the difficulties involved in pricing such rights in allocation to commercial actors can be avoided. Thus, European pooling benefits across wind and solar generation profiles and different resources basis can be realized through joint CfD auctions.

3. Ensuring not only clean energy sources, but a clean energy system

With increasing shares of wind and solar power generation replacing fossil production, there is a growing demand for flexibility to bridge the gap between the profile of renewable power generation from wind and solar production and the demand profile. Providing clean flexibility resources that are complementary to renewable electricity production should be considered an equal complement to the extension of the green generation capacity. For the transition period, it was often assumed that gas power generation would play a major role in providing this required flexibility, by operating at times and locations when wind- and solar output was insufficient. However, both the carbon intensity of gas power and the challenges of accessing sufficient amounts of natural gas require an accelerated shift to clean sources of flexibility. These include different types of electricity storage as well as demand side flexibility, by shifting production or storing intermediary products such as heat (Brown et al., 2018).

On average, wind and solar projects only produce electricity at 10–35% of their maximum capacity. The values vary heavily between but also within countries and depend both on the technology deployed and the climatic conditions. For instance, new onshore wind installations had a capacity factor of 28% in Germany and 43% in Spain (International Renewable Energy Agency, 2022). Therefore, to deliver the same, or even increasing, volumes of electric energy, the generation capacity of a clean electricity must be a multiple of today's conventional capacity. Likewise, demand from e-mobility or heating has high peaks in consumption, as compared to their yearly average. Therefore, the available transmission capacity relative to generation or load connected to the system will decline drastically. This implies that, in hours of very high renewable production or high local electricity demand, the primary response needs to come from local flexibility options.

The lack of local electricity prices at a sufficiently granular level creates a strong unpriced externality in the current design of electricity markets. The current market design with large pricing zones, provides the same price and the same incentives for all flexibility options. Thus, it does not allow for the use of flexibility options to address constraints in the transmission network. As flexibility is neither used nor rewarded for managing such transmission needs, investments in flexibility are not sufficiently incentivized in the current system. This market design must thus be reformed. Otherwise, an increasing scale of fossil generation assets (with regulatory determinable redispatch costs), like gas turbines, will be required and re-dispatched to address these transmission needs and an uneconomical amount of renewable energy will be curtailed.

Two options are currently discussed to solve this problem and prevent the continued deployment of fossil assets. First, as part of the bidding zone review, European transmission system operators have explored options to split existing pricing zones, which largely correspond to countries, into smaller and, therefore, sub-national pricing zones. In principle this could allow for prices to better reflect the value of electricity in specific parts of the network, thus allowing for flexibility options that better contribute to system needs. In practice, it is proven to be challenging to define pricing zones small enough to address these needs, particularly in light of the evolving, uncertain and volatile congestion patterns. These are difficult to predict given uncertainties surrounding grid expansion and the location of future generation plants and load (Neuhoff, Wolter, and Schwenen 2016). The main challenge is that the resulting necessary frequent rezoning creates regulatory uncertainty, doesn't allow market participants to effectively hedge resulting price risks and thereby undercuts future markets liquidity.

Given the accelerated deployment of renewables and the shift away from gas power generation, the need for local pricing systems to allow storage and demand side to operate in support rather than against system needs is now far more pressing. Hence, there is now urgency and a strong case for the implementation of local pricing – and there are compelling arguments for doing so by building on successful nodal pricing approaches implemented outside of the EU (Neuhoff et al., 2013; Bichler et al., 2021). Far from being a niche approach, nodal pricing is a commonly employed market design in most liberalized power markets outside Europe. For example, all liberalized US-American electricity markets use a nodal pricing approach after the last liberalized market, Texas-based ERCOT, switched from zonal to nodal pricing in 2010 (Ryan and Frank, 2022) and New Zealand already introduced a first version of Nodal pricing in 1997 (Antonopolus et al., 2020). In such systems, market clearing for spot markets is not, like currently in the EU, based on a regulatory defined pricing zone, but instead by integrating the allocation of transmission capacity in the energy market clearing. The resulting clearing prices provide the efficient incentives for all flexibility elements.[2] Thereby, a nodal pricing approach allows to locally match demand and supply, e.g. charging electric vehicles in the windy regions, while lowering demand of industrial processes after a transmission bottle neck (Bichler et al., 2021).

From a technical perspective, Hitachi (formerly ABB), Siemens, and GE, i.e. three globally established firms, offer the necessary IT solutions. Hence, subject to political agreement, the technical implementation of such nodal pricing mechanisms at the transmission level is viable. It is important to also coordinate with congestion management at the distribution level (Lind et al., 2019). An agreed and long-term robust framework at the transmission level will offer a valuable interface for further improvements of congestion management at the distribution level (Neuhoff and Richstein, 2017, 2018).

The US experience illustrates that nodal pricing can be implemented at the regional level using clearly defined and established interfaces for energy trade between regions. This represents a potential first step to a European-wide nodal pricing system, one where many perceived challenges have already successfully been addressed (Eicke and Schittekatte, 2022). Such sequential implementation across European regions (i.e., groups of countries) may also be desirable and would require some adjustments to EU energy market regulation in order to support rather than hinder such developments (Richstein et al. 2018). A coherent future trading framework based on trading hubs, including financial transmission rights, allows for effective management of locational price

[2] To fully realize these benefits, it will be important to ensure bidding formats evolve to different technologies to reflect their capabilities in short-term markets (MCCC, 2022; Neuhoff et al., 2016b; Richstein et al., 2020) and design choices on the role of intraday auctions will need to be clarified (Herrero et al., 2018).

risks (Neuhoff and Boyd, 2011).

Nodal pricing contributes threefold to the objectives: by enabling broad market participation for all distributed actors, it is a pre-condition to achieve an overall clean energy system with flexibilities (Pérez-Arriaga and Knittle, 2016). At the beginning, small nodal pricing regions could be a local niche market for local flexibility. It also contributes to affordability since both *ex-post* empirical evidence (Wolak, 2011; Zarnikau et al., 2014) and projected modelling for Europe show that the introduction of nodal pricing lead to efficiency gains (Neuhoff et al., 2013). Nodal pricing is now increasingly analyzed by European stakeholders (ENTSO-E., 2022). Finally, it will lead to higher system security by setting incentives for locationally optimal placed resources so as to allow for a coordinated response of generators and flexibility providers using the pricing mechanism (Babrowski et al., 2016; vom Scheidt et al., 2022).

4. Ensuring not only generation adequacy but a resilient energy system

In Europe, power market design with regard to energy security has, in the last decades, been focused primarily on generation adequacy (i.e., the provision of sufficient capacity to cover peak demand, (Fabra, 2018)). The gas crisis has pointed to the re-emerging importance of a broader perspective to also ensure resilience to interruptions of energy supply chains, including fuel supplies. Market participants are unlikely to invest in sufficient resilience, either for generation adequacy (Rodilla and Batlle, 2012; de Maere d'Aertrycke et al., 2017; Fabra, 2018) or, in particular, against broader fuel security because returns are highly uncertain. Additionally, such returns are often reduced by regulatory interventions that limit windfall profits in the energy sector and reduce the exposure of actors that failed to provide for resilience, as happened during the gas crisis of 2022. These dynamics lead to insufficient returns for such investments in the short-run (Fabra, 2018) and to missing markets for securing long-term contracts (Newbery, 2016).

While designed to provide generation adequacy, i.e., to prevent a shortage of electricity production, the strategic reserves of generation capacity built up in some member states turned out to be highly valuable during the gas crisis. These reserves provided fuel security by allowing non-gas power stations, that would have otherwise been closed down, to remain available and meet electricity demand when it was not met by scarce gas supply and unavailable nuclear power stations. Likewise, a strategic reserve – similar to the strategic reserves in oil markets - could offer an effective tool for system security in times of extreme weather patterns in systems with high renewable penetration. A strategic reserve composed of assets that are kept in the reserve and supported for this purpose with payments to ensure their availability can avoid many of the market distortions that are associated with broadly applied capacity markets. These include a bias towards capital-light and operational-heavy resources (Mays, Morton, and O'Neill, 2019; de Maere d'Aertrycke et al., 2017), the difficulty of setting parameters to include novel technologies (for example for demand side flexibility, or the number of hours for which storage capacity can be operated), and the general price dampening effect of generally available overcapacity that limits incentives for investments in flexibility.

However, the design of the strategic reserve must be adjusted to reflect the new reality of energy markets. European and national regulation had prescribed that generation assets in the strategic reserve can only be used if power supply fails to meet demand. This was to reassure investors that the strategic reserve would not undermine their returns during times of high prices, otherwise investment incentives would be limited. However, to avoid a further escalation of already extreme energy prices, generation from the strategic reserve was allowed to return to the market and sell at marginal generation costs. With the promise broken, a new approach needs to be defined that is consistent with the repeated experience that policy makers intervene if prices are too high.

For energy prices to reflect scarcity and, hence, differentiated incentives to support investments in the various flexibility elements, a credible and European-wide harmonized rule is necessary for the use of generation assets in the strategic reserve (Neuhoff et al. 2016). With the current rule no longer credible, we propose to set a price trigger in the range of, for example, 500–1000 Eur/MWh for the deployment of strategic reserves. The level of the trigger price should be set to balance the risks for consumers and counterparties in hedging contracts with the incentives to install flexibility options. The size and design of the reserve should be reviewed with growing renewable shares and the diffusion of other flexibility options (Bhagwat et al., 2016).

Thus, the strategic reserve can be an adequate tool to allow for system security while simultaneously providing for a framework in which a clean energy system can be created. Additionally, its deployment in times of high prices can contribute to the goal of reliable affordability by limiting excessive price spikes that threaten electricity consumers and integrity of forward contracts.

5. Ensuring a reliable speed of the transition for investors

Affordable and secure electricity supply requires a significant increase in the annual deployment of wind and solar generation capacity as well as in flexibility technologies (Victoria et al., 2022). Fig. 2 shows the annual development of renewable energy capacity between 2000 and 2021, as well as the projected growth rates necessary to achieve the EU's 2030 targets of 510 GW installed capacity of wind and 592 GW installed capacity of solar power generation (European Commission, 2022).

To achieve these infrastructure investments, thus ensuring resilient and scalable supply-chains, the continent will require a large-scale expansion of manufacturing capacity for these technologies. The US is currently deploying the Inflation Reduction Act (IRA) to subsidize such manufacturing investments, while China has a long tradition of providing soft loans for such investments. The EU does not have the fiscal capacity available for either measure. Hence, EU policy needs to ensure private investors that there will be demand for their technologies in the coming years in order to unlock manufacturing investments from their side. The recent EU Net Zero Industry Act is a first step in the direction of supporting the production of strategic net-zero technologies in Europe, e.g. by removing administrative burdens on permitting, but will in itself not be enough create sufficient investment incentives.

The previously discussed policies – a Renewable CfD-Pool, nodal pricing and a reformed strategic reserve are necessary elements for such an investment framework, to provide firms across the continent sufficient certainty that renewable projects and complementary flexibility investments can and will be realized. In other words, the policies able to contribute to the *reliable speed* of the energy transition. They translate a politically determined deployment path into an investment framework in which firms across the entire value chain of renewable generation and accompanying flexibility options can expand their production facilities to meet the agreed renewable energy and climate targets.

In particular, the Renewable CfD-Pool reduces these risks by avoiding project cancelations if expected power prices decline and by avoiding that the limited capability of private parties to sign PPA contracts will constrain renewable deployment. The CfD investment framework thus complements the successful political initiatives to address planning and permitting obstacles and delays.[3]

For the deployment of flexibility technologies, the lack of sufficient remuneration in short-term markets in combination with a lack of forward contracting opportunities to stabilize revenue streams has so far reduced attractiveness of investments. Nodal pricing will allow flexibility to realize the full value it provides to the system, thus helping markets (at locations with higher than average price volatility) to scale

[3] See for instance: https://www.evwind.es/2022/11/08/europe-takes-emergency-action-to-remove-permitting-bottlenecks-for-wind-power/88716.

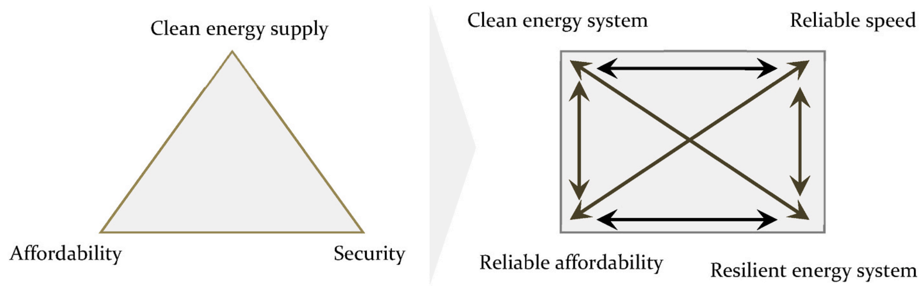

Fig. 1. From the energy trilemma to the energy quartet.

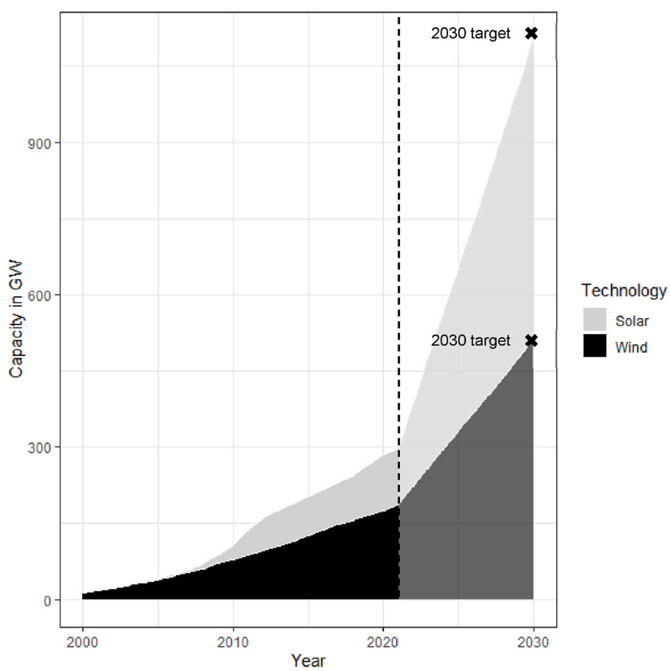

Fig. 2. Historic capacity development and required growth rates for the European Union's renewable energy targets.

new technologies and creating a framework for technology companies to invest in the technical solutions.

Finally, on the consumer side, electricity consumers need a clear framework to invest in flexibility options. Passing CfD contracts on to consumers using a standardized Rebewable CfD-Pool contract puts consumers and their energy suppliers in charge of matching their physical demand profile with the production profile of the renewable pool. This will encourage consumers and retail companies serving these consumers to invest in making their own demand more flexible (where economic) or to purchase forward contracts that hedge the remaining flexibility needs – thus enhancing the economics of flexibility technologies and business models to realize these. In addition, further policy action is needed (and partly already in the process of implementation) to speed up permitting processes.

All in all, by providing a secure framework for investment through CfDs and putting a price on the locational externalities through nodal pricing, the EU can provide an energy system that allows for the required investments at the speed necessary to achieve climate neutrality.

6. Conclusion and policy implications

We propose a Renewable CfD-Pool, nodal pricing, and an advanced strategic reserve to address the policy objectives of reliable affordability, a resilient energy system, a clean energy system, and reliable speed. These policy instruments are complementary to existing European and national market design and policy elements, and aim to build on and strengthen existing spot and futures markets, especially for the integration of new clean flexibility sources.

First, the EU 2030 Governance comprises commitments to renewable targets. These define the scale of CfD tenders; reliable speed will help the realization and credibility of the targets.

Second, the European Emission Trading System improves the economics of clean options – both of renewable energy generation supported by CfDs and of flexibility options with local pricing. Thus, it enhances the political viability and credibility of these instruments for investors.

Third, Carbon Contracts for Difference cover incremental costs and hedge investors in clean production processes that are disadvantaged by continued free allowance allocation under EU ETS (Richstein et al., 2022). The review clauses under the CBAM files offer a perspective that carbon leakage risks will eventually be addressed in a manner that does not undermine effective carbon prices.

This list is, of course, not exhaustive. Further policies, such as hedging mandates or an operational demand response curve, to give early scarcity signals (Hogan, 2013; Papavasiliou and Smeers, 2017), may be beneficial for hedging consumers and creating demand for complementary flexibility investments.

In combination, these discussed reforms are able to address the requirements of the energy quartet, providing reliable affordability and speed as well as a secure and clean energy system. Thus, the reforms can be a valuable policy package that advance the energy transition as we move to the next stage of European energy policy.

CRediT authorship contribution statement

Karsten Neuhoff: Conceptualization, Writing – original draft, Writing – review & editing. **Jörn C. Richstein:** Conceptualization, Writing – original draft, Writing – review & editing. **Mats Kröger:** Conceptualization, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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