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Conall Heussa (conall. heussa @bruegel.org) is a Research Analyst at Bruegel

Georg Zachmann (georg. zachmann@bruegel.org) is a Senior Fellow at Bruegel

MEETING EUROPE'S 2030 climate targets will require massive clean-electricity investment. To facilitate these investments, state-backed de-risking schemes such as contracts for di erence (CfDs) are needed. eir role in supporting renewables has been consolidated by

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(power purchase agreements, PPAs), or merchant investments, referring to generation projects that do not sign long-term contracts at all but instead rely on spot market prices to cover their initial investment costs.

e European PPA market (including the United Kingdom) signed contracts for 16.2 gigawatts of capacity in 2023, a growth of 37 percent from 2018 (Pexapark, 2024). Nevertheless, challenges remain in matching buyers and sellers for PPAs as there are only a certain number of consumers with large enough energy demand and strong enough credit lines to enter into multi-decadal contracts for electricity supply. Merchant renewable plants are also rare as project nanciers perceive the reliance on uncertain, volatile spot market prices as risky. Consequently, CfDs and other similar schemes are the primary nancing option for most new renewable projects.

CfDs are long-term (typically 15 years or more), competitively auctioned nancial contracts between generation assets and publicly-backed entities. e auctions usually take place in a staggered process over a period of several years, with each auction seeking to procure a certain level of generation capacity. Prospective projects bid in the form of strike prices, which are prices for supplied electricity set at a level su cient to cover the lifetime costs of a project and provide a return on investment[7].

e strike price guarantees a xed return for electricity over the period of the contract by varying the payout to the generator in relation to a reference price, typically the spot market electricity price (known as the day-ahead price in Europe) (Figure 4). When the reference price is below the strike price, CfD holders receive a premium on their produced electricity that is equal to the di erence between the reference price and the strike price. Conversely, when the reference price exceeds the strike price, CfD holders must pay back the di erence between the prices. us, the CfD holder receives the strike price for their produced electricity in every hour. ough CfD design is governed by some EU principles, exact implementation is at the discretion of EU countries, meaning that many di erent CfD designs might be tried across Europe[8].

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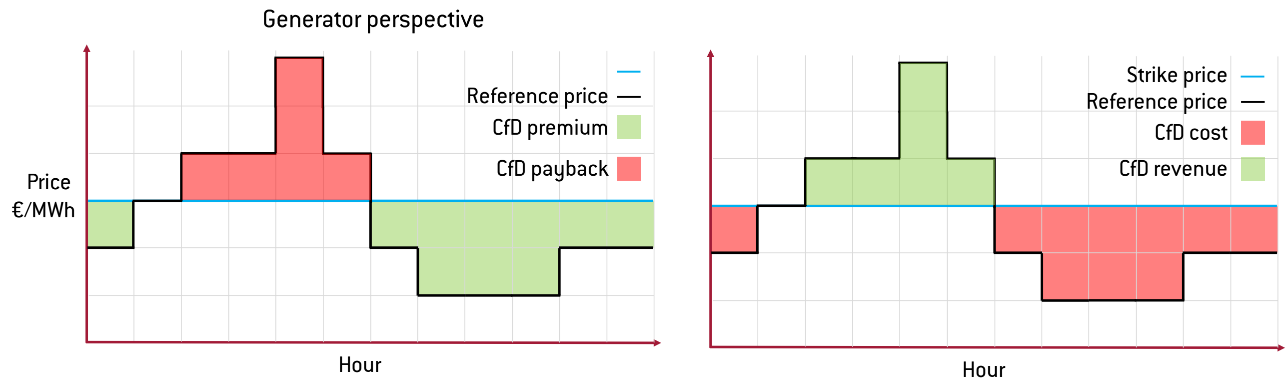

Source: Bruegel.

CfDs were pioneered in the United Kingdom and used initially to provide a premium to wind projects that were uncompetitive relative to incumbent fossil-fuel generation. Now, with solar and wind project costs having fallen in the last decade (Lazard, 2024), CfDs have taken on a new role: simultaneously creating suitable conditions for renewable investment while protecting consumers against high power prices. The effective fixed price of the contract reduces the market risk for the generation project. Wind and solar lifetime costs are dominated by capital expenditure (the operational costs are almost zero), meaning that the cost of capital determines to a great extent the project cost. By minimising market risk through a CfD, projects can reduce their costs of capital significantly (Beiter *et al*, 2023).

From the state perspective, when the market price exceeds the strike price (for example, during a price shock driven by fossil-fuel costs, as during the energy crisis), CfD holders pay back the extra revenues earned above the strike price (Figure 4). This provides a hedge against high prices for the state, and, by proxy, the consumer. EU electricity market design rules require states to distribute the revenues of CfDs to consumers in a fair way. However, it is less clear how the costs of CfDs, if they materialise, should be recovered from consumers.

The dual benefits of CfDs in both protecting consumers and reducing investment risk are delivered through a reallocation of the market risk associated with renewable investments. Consumers are protected from the risk of high prices and renewable projects are protected against the risk of low prices – but this risk of low returns from low prices does not disappear. The downside risk of the contract is assumed by the CfD counterparty and ultimately rests with whoever the cost of the contracts are recovered from – consumers, present taxpayers or future generations. The state is well-suited to bear this risk, but it is important to consider how it will allocate that risk to consumers[9].

From the state perspective, several potential liabilities could arise from CfD contracts, related to electricity demand, renewable electricity supply and the CfD strike price. Lower electricity demand will cause lower spot market electricity prices, all else being equal. As demand falls, more expensive fossil fuel units will be used less and wind and solar, with their very low marginal costs, will set the price in more hours[10]. Lower spot market prices will lead to higher CfD costs, as states pay out the difference between the reference price and the CfD strike price (although costs from the wholesale market will decrease). More renewable output will similarly drive down the price of electricity, as cheap marginal-cost wind and solar push out fossil fuels from the merit order. Finally, higher CfD strike prices, because of, for example, inflationary or supply-chain pressures in the wind industry, would also lead to more costs for governments, as the difference between the reference price and the strike price becomes larger.

Such electricity market dynamics are already emerging in the real world. For example, the early months of 2024 saw extremely low spot market prices in Spain and Greece because of high renewable output[11].

[illegible] (… *et al*, 2023).

10 [illegible]

11 [illegible] *GEM Energy Analytics*, 13 … 2024, https://gemenergyanalytics.substack.com/p/solar-and-the-need-for-more-flexibility.

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We assess how the risk factors set out above might impact the extent to which electricity costs are channelled through CfDs, and how the state could recover such costs, using the DISC model (Box 1).

Box 1:

e Dispatch and Contracts (DISC) model is applied to illustrate potential cash ows between electricity market players in di erent scenarios.

DISC is a highly stylised representation of the electricity system and the associated nancial exchanges, developed by Zachmann *et al* (2023). Based on electricity demand, generation availability and generation cost data, DISC outputs the optimal hourly production of di erent generation types and the hourly spot market price. Storage behaviour is modelled heuristically in a similar approach to Zerrahn *et al* (2018). Interconnection and cross-border electricity ows between countries is not represented. e hourly spot market price and generation outputs are combined with assumptions about contract design, volume and price for di erent generation types to model electricity market cash ows. A core assumption of the DISC framework is that the operation of the electricity system and contractual arrangements are ly in [illegible]

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Scenario	2030 input variables
Baseline	-Demand, generation capacities and renewable output projected by ENTSO-E -Wind and solar contract volumes according to IEA (2023) -CfD strike prices based on recent auction results (€35-€85/MWh) -€30/MWh gas price -€150/tonne carbon price
20% less demand	-20 percent demand reduction in every hour -All other variables are constant
Fossil fuel shock	-Gas, coal and oil prices increase x3 -All other variables remain constant

Source: Bruegel.

e stylised scenario analysis is not intended to provide a complete picture of future elecacross the year. is is because of the dominant role of gas- red generation in Italy's power mix, even in 2030[14]. e average wholesale price only falls from €78/MWh in the baseline scenario to €58/MWh in the '20% less demand' scenario, as gas continues to set the marginal price in many hours of the year. e contrast between Germany and Italy highlights the major role of the underlying generation mix on electricity prices and the associated nancial ows in electricity markets (Figure 6). Despite the urgent importance of ramping up renewable deployment, there is a risk that certain countries could build out too many renewables that don't add value to the system, leaving consumers or taxpayers to foot the sizeable bill for these ine cient investments if state-backed contracts continue to be the primary nancing option. Weak demand growth could further increase these costs.

Overall, from the ve country results in Figure 5, the model results illustrate that 20 percent lower electricity demand than expected in 2030 could lead to annual increases in CfD costs for European countries of tens of billions of euros.

As the DISC modelling framework does not account for cross-border ows between countries, an 'EU5' system, combining the demand, generation capacities and renewable output of the ve selected countries, was also modelled. is represents an idealised scenario in which there are no interconnection capacity constraints between European countries. e results show similar dynamics to the individual country modelling. Annual CfD costs for the EU5 increase from €4.4 billion in the baseline scenario to €26.2 billion in the '20% less demand' scenario, showing that there is a substantial increase in CfD costs with less demand. However, there is a saving of €3.6 billion compared to the sum of CfD costs for the ve independent systems (12 percent of the total CfD costs of the ve independent countries), highlighting the bene t of electricity-system integration through cross-border interconnection. Even with a fully interconnected system, the share of CfD costs in the total costs of the EU5 system increases from 4 percent in the baseline scenario to 31 percent in the '20% less demand' scenario, emphasisiof the 397(e)1 (ant)1 (en)7 (ti)1 (al for r)85 (,)]TJ0 -1.444 Tdj1(y)1 (en) co)4 (un)7ii(gr)11 i7(6 the cost of electricity bought by consumers from the wholesale market itself decreases. e opposite is also true. When wholesale market costs increase due to increased spot prices, the costs of CfDs decrease and can even become revenues if the average spot price rises above the CfD strike price. Figure 7 illustrates this relationship for the EU5 system, showing the price per cost category for all three scenarios.

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Source: Bruegel.

In the baseline scenario, CfD strike prices are close to wholesale prices, meaning that there (i)9sot tensive industry, although the exact approach to industrial consumers varies by country[15]. Such an approach, which allocates the risk of the renewable part of the electricity system to a subset of consumers, has been sustainable to date as CfD costs have typically been a small share of the total nal bill paid by retail consumers (shown in the baseline scenario in Figure 7). But as more and more renewables are nanced through state-backed schemes, and if wholesale electricity prices fall because of increasing renewables, CfD and similar costs will take up a larger share of the total system costs. e current approach will lead to unfair outcomes as this likely shift in cost components unfolds.

CfD costs as a share of total costs increase disproportionately for households when demand falls, becoming a large share of the total cost paid by households. As no industrial consumers pay for CfDs in this stylised scenario, their costs decrease with falling demand, and the xed costs associated with their PPA contracts take an increasing share of costs, while the share of wholesale costs falls. Because CfDs become a larger part of the total system costs and industrial consumers do not pay, households actually pay more overall than industrial consumers in the '20% less demand' scenario. If a fairer approach to cost recovery is taken, with a so-called 'CfD levy' placed on the electricity used by all consumers, thereby allocating the costs of renewables evenly, the picture changes signi cantly. e share of costs becomes balanced and proportionate to electricity consumption (Figure 9). In both demand scenarios, the shares of CfD costs and wholesale costs take up roughly the same share of total costs for both household and industrial consumers.

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Source: Bruegel.

Beyond fairness considerations, recovery methodologies that put the costs of CfDs onto a subset consumers may result in weak incentives for consumers to invest in clean-energy technologies, such as heat pumps and EVs. If demand goes down, prices should decrease accordingly, increasing the incentive to invest in electri cation, eventually increasing demand and

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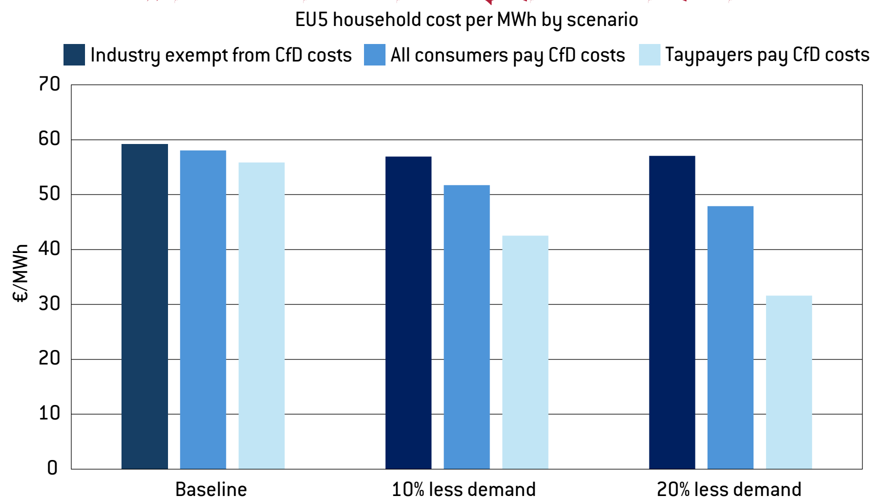

Source: Bruegel.

Ensuring that households feel that the energy transition is fair is critical to maintain support for climate policies. Burdening a subset of consumers with all CfD costs would be an unfair distributive policy. In an extreme case in which electricity demand does not keep up with supply and households still face significant electricity costs arising from the CfD cost-recovery design, public opposition could build against climate and energy policies. The 2022 energy crisis showed that even technical energy-policy areas such as wholesale electricity markets can come under scrutiny if citizens feel that policy choices are unfairly imposing costs. Furthermore, if CfD costs become a substantial portion of the total costs of electricity generation, different approaches to CfD cost recovery in different countries could lead to competitiveness issues in Europe, as some countries might continue to exempt energy-intensive industries while others take a more even approach (McWilliams *et al*, 2024). Germany has already moved to financing renewable energy expansion through the federal budget[16]. Other European countries could consider following suit to recover CfD costs in a way that delivers appropriate price signals to all consumers.

The European Commission as the EU's competition authority will have a significant role to play in monitoring the national implementation of CfD schemes. European countries may seek to provide preferential electricity prices or lump-sum transfers to certain consumers, while burdening others with a disproportionately large share of the costs. To ensure that electricity policy does not incentivise inefficient dispatch and investment decisions, and that is it not used for stealth industrial policy and/or social policy, the Commission should scrutinise the proposed CfD scheme designs for both the distribution of revenues and the recovery of costs.

What matters, in terms of incentives to invest in electrification, is whether this increase in final bills changes the cost differential between the clean-energy technology and its fossil-fuel alternative. For heating, the difference in cost between a gas boiler and a heat pump depends on the cost of gas, the upfront investment in the gas boiler and the heat pump, efficiency parameters and the electricity price. Similarly for transport, the cost difference between an internal combustion engine vehicle and an EV depends on the upfront cost for each vehicle, fuel costs and electricity costs. In the context of state-backed contracts for clean energy and recovery of their costs, policymakers must avoid a vicious cycle in which overinvestment in surplus electricity leads to higher costs for consumers, diminishes the incentive for electrification just when it is most needed and exacerbates the initial problem of supply-demand imbalance.

1 2. A 2022, ; https://www.bundesregierung.de/breg-en/news/renewable-energy-sources-act-levy-abolished-2011854.

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e state's growing role in supporting electricity supply, from subsidising small amounts of renewable generation to becoming the central guarantor for the majority of the electricity system, raises questions about whether European countries' supply-side power system investments entail substantial scal risk. If demand does not grow as anticipated, oversupply of electricity (or underdevelopment of demand) can be costly and ine cient, potentially leading to complex distributional questions about who should pay for the system. Better coordination between supply and demand is needed to mitigate these risks, potentially through targeted electricity demand stimulus.

In Europe's integrated wholesale electricity markets, investments in neighbouring countries can have signi cant cross-border e ects that in uence prices and a ect the market value of renewables and other essential clean-energy technologies, such as batteries. erefore coordination is important to all parties. States could address these spillovers through jointly funded regional auctions and EU-backed contracts, with volumes and award criteria based on a regional assessment of clean-electricity supply needs. Within countries, coordination of supply and demand investments could be tightened by introducing sectoral electri cation targets in National Energy and Climate Plans (NECPs). Such targets would need to be aligned with the renewable energy targets already reported in the NECPs.

Targeted electricity demand stimulus could help reduce the costs associated with oversupply. For example, if electri cation of heating and transport happens more slowly than expected, nance ministries could expect signi cant liabilities from CfDs (section 3). In such a scenario, policies to drive rapid electri cation of transport and heating would not only help with emissions mitigation, but would also be scally prudent, provided that the public money spent on demand-side policies does not exceed the expected liability from CfDs.

Such an intervention could simply be to remove CfD costs from all electricity bills, instead

State-backed contracts such as CfDs should incentivise renewables that provide value to the system and can generate electricity during periods of high demand. Several proposals have been made for CfD designs that can nudge wind and solar projects to places with sufficient grid capacity to transmit the clean power to demand areas, or that will produce power that is complementary to other assets (Morawiecka and Scott, 2024).

Flexibility will also be increasingly important as more variable solar and wind is deployed. Flexibility can facilitate efficient matching of supply and demand in a decarbonised system and is a characteristic of technologies: interconnection, to take advantage of geographical averaging in renewable outputs; demand response, enabling consumers to respond to system conditions; and storage, to shift clean electricity from times of abundant supply to high demand. Each of these technologies can increase offtake in periods of high renewable output, simultaneously reducing the carbon intensity of electricity and reducing the need for states to pay for surplus supply. Coordinated investments involving neighbouring states – for example, through joint auctions – could also help maximise the value of clean-electricity supply.

Second, huge investment in clean electricity is a necessity, but excess electricity supply is costly too. Therefore, demand incentives need to be retained and strengthened while ensuring that energy efficiency is prioritised. With the build out of massive renewable electricity generation capacity, governments will have a growing fiscal incentive to drive heating and transport electrification to ensure that there is sufficient electricity demand for the state-backed supply. Inefficient incentives such as inflated electricity prices or wasteful consumption should be guarded against. Instead, governments should encourage the electrification of energy services that must anyway be decarbonised to meet Europe's climate targets.

Electrification could be incentivised, for example, through temporary electricity price reductions (for example by shifting support scheme costs to the budget) or through tax incentives for specific clean-energy technologies such as heat pumps and EVs. The European Commission could set out a list of policy options for encouragement of electrification, similar to the policy toolbox that was provided during the energy crisis (European Commission, 2021). The introduction of electrification targets in NECP reporting could also lead to better coordination of electricity supply and demand throughout the energy transition. At present, there are clear targets for clean-electricity supply, while electricity demand targets are ambiguous.

Third, CfD costs should be recovered fairly. Electricity will become the primary energy carrier in a decarbonised system. How to recover the costs is becoming both a social policy choice and an industrial policy choice. As state-backed schemes becomes more central, all electricity consumers must pay their shares of these schemes fairly and the costs should not burden a subset of consumers, specifically small businesses and households. Disproportionate costs for households could hamper public support for the energy transition while reducing the incentives for electrification.

EU rules are clear that the revenues from such schemes should be distributed evenly to consumers in a non-distortive fashion; the same should be applied to the costs, through an even levy on all electricity consumption or potentially through the national budget. If a levy is chosen, it should be charged on a monthly or annual basis to preserve the short-term signals for demand response, especially as consumers are further empowered to engage actively in electricity markets. If the budgetary route is chosen, incentives for energy efficiency and demand response in the remaining price signals should nevertheless be retained.

The EU is embarking on a clean-energy investment wave, in which most renewable electricity generation will be secured through state contracts. Thanks to their near-zero marginal costs and the merit-order mechanism in Europe's internal electricity market, renewable expansion will likely exert downward pressure on electricity prices, possibly leading to a new norm of low wholesale power prices in many hours. To head off fiscal risks, Europe needs a

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Zerrahn, A., W.P. Schill and C. Kemfert (2018) 'On the economics of electrical storage for variable renewable energy sources', *European Economic Review* 108, available at https://doi.org/10.1016/j.euroecorev.2018.07.004