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Summary of the Position Paper

Grid Congestion as a Challenge for the Electricity System

Options for a Future Market Design

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The energy transition and the European Energy Union are placing new requirements on electricity grids. Any ongoing grid congestion may well cause high costs and additional risks to grid stability, which can be countered by adjusting the market design. This position paper sets out five policy options. The following points may be noted:

- Suitable **price signals** can ensure that the available transmission capacity is taken into account in dispatch decisions for generation, storage and consumption units. Thereby, grid congestion is **preemptively addressed**. Such signals can apply both to the wholesale electricity price and to grid fees. Such approaches should be more thoroughly investigated.
- **Utilisation-based grid fees** have the advantage that they can be incorporated into the system of a uniform German electricity bidding zone. Such an approach would, however, first have to be developed and trialled.
- **Market-based procurement of flexibility** for eliminating subsisting grid congestion fits well with the guiding principle of a competition regime. It would provide incentives to make better use of flexibility potential, specifically on the load side, and to tap any innovation potential. The functioning of electricity and flexibility markets would, however, have to be monitored. The same applies if increased financial incentives were to be added on to the current cost-based procurement system. Such approaches should be pursued.
- All the policy options have their **advantages and drawbacks**. A **combination** of measures should therefore be considered in order to achieve the best possible outcome.

New market design needed for the energy transition and the European internal electricity market

A power supply failure or blackout could cause major harm in Germany within a very short time, something which has been made obvious to us in recent years in technical papers, science shows and even novels. A stable power supply is fundamental for all electricity consumers and a decisive factor for the country as a location for industry and commerce. The stability of Germany's supply is always among the very best in Europe and worldwide. In specialist circles, however, a wide-ranging debate has been under way for years as to whether, as the energy transition progresses and cross-border electricity trading increases, changes to market design are necessary.

The energy transition and the European Energy Union are exacerbating the challenges facing grid operators who are responsible for ensuring electricity grid stability: rising levels of feed-in from renewable energy units, modified load profiles for new consumers such as electric vehicles, likely growth in electricity consumption and the expansion of cross-border electricity trading are all combining to make **grid congestion** a more frequent occurrence. These are situations in which the capacity of the electricity grid is insufficient to meet transmission demand. **Grid expansion** is not always possible in good time, sometimes difficult to implement due to a lack of acceptance and sometimes not the most favourable solution for ensuring a reliable electricity supply. There is thus a risk of decades of high costs for eliminating grid congestion as well as an increased risk of power outages.

As the market is currently designed, grid operators can intervene in generation unit dispatch in the event of grid congestion. Primarily, conventional large-scale power plants are obligated to adjust electricity feed-in on instruction by the grid operators, but ever fewer such units are available as the energy transition progresses. Subordinately, feed-in by renewable energy units may also be curtailed. There are hardly any incentives for electricity producers and consumers to adjust their electricity feed-in or demand to available grid capacity. Consumption units are called on only very little for congestion management. It should therefore be investigated whether **changes to market design** might in future overcome grid congestion or even nip them in the bud both **more efficiently**, i.e. at lower cost, and **more effectively**. Such a market design would, moreover, have to take account of **European Union requirements** on electricity market design and congestion management. This position paper summarises the current state of knowledge, sets out options as to how grid congestion can be efficiently and effectively avoided and evaluates them against defined criteria in order to provide political decision makers with a basis for further decisions.

How is grid congestion currently eliminated?

Understanding how grid congestion arises at the moment means taking a look at electricity trading: Germany, plus Luxembourg, form a **single bidding zone** for electricity trading. Within this bidding zone, transmission capacity is assumed to be unlimited ("copper plate"). As a result, the wholesale price for electricity is the same throughout Germany. Operators schedule the operation of their power plants and units (dispatch) on the basis of trading operations. **Dispatch decisions** are thus made without taking account of available grid capacity. A complicating factor is the current European drive towards the provision of greater transmission capacity at the bidding zone borders for cross-border electricity trading. This may make grid congestion more acute both at the bidding zone borders and within the bidding zone.

Congestion management measures ensure **security** and **reliability** of the electricity supply. Grid operators in Germany are currently implementing a considerable volume of such measures, the associated costs amounting to around 1.2 billion euro in 2019 or some two per cent of total electricity supply costs. Various options are open to **grid operators** for grid congestion: firstly, they can call on their own resources. If this is not possible, they can instruct third parties to ramp unit output up or down. The most important measures are currently redispatch, which involves operators "upstream" and "downstream" of the grid congestion having to ramp their conventional power plants up or down, and feed-in management, in which grid operators curtail renewable energy units and combined heat and power plants.

Options for an efficient and effective market design

This position paper sets out **five policy options** (see box below), which may be divided into **two categories**: the aim of the first three options is to take greater account of potential grid congestion right from the stage of the electricity transactions and thus during unit dispatchplanning. Grid congestion may consequently be avoided from the outset and grid operators will have to intervene more rarely. The other two options take effect following dispatch decisions and are intended to enable grid operators to procure **flexibility** more efficiently by providing financial incentives for flexibility providers. Both approaches are important for the market design of the future.

The five options are evaluated on the basis of defined **criteria**: effectiveness, efficiency, contribution to climate protection, contribution to the EU internal market in electricity as well as feasibility and reasonable implementation costs. The analysis has shown that there is no single option that is preferable in every respect. All the options have specific advantages and drawbacks which are of greater or lesser significance depending on the assessment. Some of the options may, however, be combined, so to some extent reducing certain drawbacks.

At a glance: Five options for effective and efficient grid congestion management

Introduction of a nodal pricing system (category: dispatch)

- **Brief description**: In a nodal pricing system, a power price is set for each grid node, i.e. for each feed-in and extraction point, with grid congestion being taken into account. This may result in power prices which vary regionally or even locally.
- **Advantages**: An ideally functioning nodal pricing system models grid congestion perfectly; no congestion management measures are required. Conceptually, it is therefore an excellent model.
- **Drawbacks**: Very high implementation costs, in particular if the distribution grid level is included. Operation of the grid must in part be uniformly managed, which would seem to be problematic for grids operated by different operators, particularly for cross-border transfers. There is also an increased risk of individual flexibility providers in favourable locations gaining market-dominating positions.

Reconfiguration of the uniform German electricity bidding zone (category: dispatch)

- **Brief description**: Structural congestion is addressed by reconfiguring the electricity bidding zone (e.g. splitting into two price zones, one northern and one southern). Insufficient transmission capacity at the bidding zone borders may result in different power prices in the individual bidding zones.
- **Advantages**: Grid operators have to intervene more rarely in the unit operators' dispatch, thus effectiveness is increased and the costs of interventions are lowered.
- **Drawbacks**: Rigid bidding zone borders can never completely model grid congestion. Future changes in grid usage and expansion may make adjustments necessary. Additional costs may arise for power trading. Differing power prices are a delicate political issue in Germany. Grid congestion within bidding zones still remains, in particular at the distribution grid level.

Introduction of utilisation-based grid fees (category: dispatch)

- **Brief description**: In a utilisation-based tariff system, the grid fees payable by electricity consumers and possibly by generators on feed-in are higher when grid utilisation is critical than when it is low, with both location and timing playing a determining role.
- **Advantages:** Power market liquidity is maintained. Grid operators need to intervene in dispatch more rarely, so reducing costs. Potentially highly effective, but dependent on appropriate configuration.
- **Drawbacks:** Setting adequate grid fees is complex and their steering effect is currently almost impossible to estimate. There is a lack of practical experience and a major need for research.

Expansion of market-based procurement of flexibility (category: flexibility)

- **Brief description**: Flexibility for congestion management is procured by methods in which remuneration is (largely) freely negotiated between flexibility provider and grid operator, with the lowest cost offers, for example via regional flexibility markets, being selected.
- **Advantages**: Potentially lower costs thanks to additional flexibility offers and innovation. In particular, incentives are created for flexible load providers, such as commercial or industrial consumers.
- **Drawbacks**: The market power of individual providers can compromise the funtioning of the market. Strategic bidding behaviour can raise flexibility demand and costs. Regulatory control of power and flexibility markets is required.

Increased incentives for non-market-based procurement of flexibility (category: flexibility)

- **Brief description**: Flexibility for congestion management is procured via expressions of interest. Remuneration is as far as possible on a costs basis supplemented by additional financial incentives for the flexibility provider.
- **Advantages and drawbacks**: Similar to those for market-based procurement. Lower incentives for flexibility providers but also lower cost risks for grid operation.

Addressing congestion preemptively to save costs and reduce risks

Under the current framework, considerable grid congestion will probably still continue to occur for decades. This would suggest the need to adapt the market design in order to **preemptively prevent congestion** and thereby improve effectiveness and cost-efficiency. Three options would appear to be very promising here: changeover to a nodal pricing system, reconfiguration of the German electricity bidding zone and further development of the grid tariff system towards utilisation-based grid fees (options 1 to 3, category "dispatch"). The following points may be made:

Nodal prices: Theoretically ideal but very demanding to implement

- An ideally functioning nodal pricing system is capable of **completely factoring in grid congestion in electricity price setting**. As a result, grid operators need to intervene at most only to a very limited extent in unit dispatch. At the same time, providing generation costs and transmission capacity are correctly modelled, the generation units used are those which are capable of meeting electricity demand at the overall lowest costs. Nodal prices are used in some regions of the world.
- However, considerable objections may be raised against a nodal pricing system: its introduction entails root and branch reform of the current market design. **Practical implementation would be very complex,** in particular if distribution grids were to be included. Distribution grids are, however, becoming increasingly significant due to the energy transition, and grid congestion in the transmission and distribution grids may be interlinked.
- In addition, the grid operators involved in a nodal pricing system would have to **hand over some areas of authority** to a central body. This intervention in their present responsibilities is a considerable impediment to implementation, most particularly for the creation of cross-border nodal pricing systems. Furthermore, the earnings potential for market participants in a nodal pricing system is heavily dependent on the organisation of the pricing rules and the decisions taken about the operation, maintenance and expansion of the grid. **Regulatory controls for ensuring that grid transactions are conducted in a non-discriminatory and transparent manner will therefore have to be stricter** than at present. Finally, nodal electricity prices might raise electricity trading costs as a result of lower liquidity and increase the **risk** of individual market participants assuming **market-dominating positions**.
- A nodal pricing system is therefore not currently considered to be the **priority policy option**. A hypothetical, ideally functioning nodal pricing system may, however, serve as a **benchmark** for other market design options.

Reconfiguration of bidding zones: can reduce costs but effects are limited

- **Reconfiguration, for example splitting, of the German electricity bidding zone,** would address **structural congestion** from the electricity trading stage onwards and thus during dispatch. The better the new bidding zone borders map structural congestion in the transmission grid, the **fewer interventions will be required in unit dispatch**.

- However questions remain in terms of effectiveness and efficiency: since electricity flows vary by time of day and seasonally, **grid congestion can never be completely modelled by rigid bidding zone borders**. Changes in grid usage and grid expansion may in future also displace structural congestion, so possibly entailing regular adjustment of zone borders, something which is always a **very costly** process. Moreover, **liquidity on electricity markets might decline,** possibly resulting in increased wholesale electricity prices. This is also the lesson learned from splitting bidding zones in Sweden and splitting the German-Austrian bidding zone. The effects on wholesale electricity prices would have to be investigated in greater detail so they can be weighed up against the cost benefits of reconfiguring the bidding zone.
- If bidding zones were made relatively large, for example a northern and a southern German bidding zone, **grid congestion within bidding zones** would to a considerable extent **remain in place**. In particular, grid congestion in distribution grids is not generally taken into account when bidding zones are configured.

Utilisation-based grid fees: potentially efficient, but untested

- Utilisation-based grid fees provide **incentives to make preferential use of the electricity grid in times when transmission capacity is available**. They can identify grid congestion within bidding zones and would therefore be possible even if electricity bidding zones remain in place. **Electricity market liquidity would in principle be retained**.
- Utilisation-based grid fees would nevertheless also be **complex** to introduce. Such a tariff system would firstly have to be devised and its steering effect tested. Very little experience is available as yet. A decision would have to be made about how far grid fees should be **differentiated by congestion regions and times**. In addition, apportioning the costs of congestion management to specific grid users is a **very inexact science**. Finally, **effects on electricity prices** would have to be investigated.
- Achieving an efficient system might also entail extending grid fees to **electricity feed-in suppliers**. At present, only electricity consumers pay grid fees. Furthermore, grid users must be able to influence the level of grid fees by their behaviour. This is not the case for small customers (generally private households) under the currently used **standard load profiles**. In addition, various **fixed electricity price components** such as the EEG surcharge and electricity tax may reduce the incentive effect.

Providing financial incentives to boost the efficiency of flexibility procurement

Even if some grid congestion can be preemptively prevented, **dispatching flexibility** will probably remain necessary to eliminate congestion. This should be done as efficiently as possible. Since conventional large-scale power plants are increasingly going off-line, the significance of flexibility from smaller generation and storage units and from consumption units is simultaneously rising. It is important to improve the availability of flexibility from such units. Financial incentives, which purely cost-based remuneration cannot offer, would seem to be a sensible way of achieving this. An expansion of market-based procurement and increased incentives for non-market-based procurement of flexibility (options 4 and 5, category "flexibility") may be considered. An analysis yields the following results:

- Both options would provide financial incentives to increase the **supply of flexibility** and release innovation potential. In particular, incentives would be created for flexible **load** providers, such as commercial or industrial consumers, a potential which is at present largely untapped.
- Market-based procurement fits well with the guiding principle of a competition regime. The **new EU legislative provisions** set out in the Clean Energy Package also make market-based measures the basic principle for procuring flexibility. Barring any sound reasons to the contrary, **market-based approaches** such as regional flexibility markets should thus be further investigated. Market function may in particular be disrupted by individual providers' market-dominating positions.
- If **non-market-based procurement** of flexibility continues to be applied, it should be investigated to which extent additional financial incentives may be capable of expanding the supply of flexibility and innovation, and whether the value of this flexibility exceeds the costs of the additional financial incentives. In the case of flexible loads for which cost-based remuneration cannot be determined, the remuneration could be limited by the most inexpensive alternative flexibility option for which a cost-based calculation is possible.
- Both options involve a risk of **strategic bidding behaviour**: market participants could withhold bids from the electricity market and subsequently market their supply or demand as flexibility at a better price. This may firstly increase flexibility demand from grid operators and secondly raise procurement costs. In an extreme case, market participants could make bids on the electricity market in order to have them "bought" back again as flexibility. Electricity markets and flexibility procurement would have to be **monitored** in order to counter such risks.

The Academies' Project "Energy Systems of the Future"

The Position Paper *Grid Congestion as a Challenge for the Electricity System. Options for a Future Market Design* evolved within the framework of the Academies' Project "Energy Systems of the Future". In interdisciplinary working groups, about 100 experts are working on different courses of action for the pathway to an environmentally sustainable, safe and affordable energy supply.

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