Framework for cross-border participation in capacity mechanisms
FINAL REPORT

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December 2016

EUROPEAN COMMISSION
Directorate-General for Energy
Directorate B — Internal Energy Market
Unit B2 — Wholesale Markets; Electricity & Gas
European
B-1049 Brussels

EUROPEAN COMMISSION

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Directorate-General for Energy
Internal Energy Market
2016
EUR 2016.4053
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Luxembourg: Publications Office of the European Union, 2014
ISBN 978-92-79-58394-0
doi:10.2833/20431
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EXECUTIVE SUMMARY

Capacity mechanisms are measures aimed at correcting market failures that distort investment incentives and creates a concern for future capacity adequacy in electricity markets. In the EU internal electricity market (IEM), capacity adequacy in one Member State depends on the capacity situation in the whole interconnected market area. This also implies that the implementation of national capacity mechanisms has to take cross-border contributions into account in order not to distort market signals in surrounding markets.

The issue discussed in this report is how a common framework for capacity mechanisms in Europe can be designed in order to mitigate adverse cross-border effects from capacity mechanisms and facilitate cross-border participation.

A distinction has to be made between capacity markets and strategic reserves

Two distinctly different approaches to capacity mechanisms are assessed:

- *Capacity markets*, which are market-wide instruments aimed at strengthening investment incentives due to market failures, in order to achieve acceptable capacity adequacy in the market.
- *Strategic reserves*, which are targeted measures to keep capacity that is activated should the energy-only market fail to equate supply and demand.

As capacity markets and strategic reserves differ on a number of characteristics, a common framework for cross-border participation will not be suitable. We therefore propose different frameworks for capacity markets and strategic reserves.

A regional approach to capacity adequacy and sound de-rating is crucial for the efficiency of capacity mechanisms

In all cases, it is absolutely crucial to make a sound capacity adequacy assessment that views capacity adequacy from a regional perspective and applies a probabilistic modelling approach. Such assessment requires development of common principles and comprehensive cooperation between TSOs.

The modelling should also be used as the basis for de-rating of capacity, including import capacity. If there is a high likelihood of simultaneous stress events, the de-rated import capacity will be low. Hence, the de-rating is a safeguard against the risk related to uncertain cross-border contribution during stress events.

In case national rules apply a too strict de-rating approach, capacity mechanism design and provisions for cross-border participation will not be able to mitigate the efficiency loss due to too conservative de-rating. A EU framework with a common methodology for de-rating could mitigate this risk.

Capacity adequacy assessments should be updated quite frequently (e.g. annually) to take into account changes in market dynamics such as e.g., fuel prices, economic growth and demand levels, and renewable capacity developments.

Criteria for the design of a common framework

The analysis of the different options for a common framework is based on an assessment of the efficiency and effectivity of the design elements:

- Capacity markets are aimed at correcting identified market failures in terms of distortion of *long-term* investment incentives. Capacity markets do not guarantee availability of capacity, but provide an additional revenue stream to support investments. Cross-border participation should ensure that overall costs are reduced and that cross-border investment incentives are not distorted.

- Implementation of capacity markets should not distort the short-term merit order operation of the integrated electricity system. Efficient energy market design is crucial for capacity adequacy and the efficiency of capacity markets.
- The framework should remove or reduce barriers to cross-border participation, i.e. economic barriers such as administrative and transaction costs, legal barriers, and political barriers should be taken into account.

The basis for efficient capacity market design, including cross-border participation, is the optimal energy-only market solution.

Proposed frameworks for capacity markets with direct participation

The analysis focus on the model proposed in the Annex to the Sector Inquiry on Capacity Mechanisms. This is *a direct participation model* with explicit participation by cross-border capacity providers (generators, load, and storage).

The two main options for a common framework for direct participation are discussed.

- Option 1: One common framework for cross-border participation, which does not interfere with the design of the national capacity market itself. Alternatively, some cross-border provisions may differ between centralized auctions and decentralized obligation schemes.
- Option 2: A framework that harmonizes some of the general design features of national capacity markets in addition to the framework for cross-border participation.

Option 1: A common framework for cross-border participation

The main features of the proposed common framework for direct cross-border participation in capacity markets (centralized auction or decentralized obligation schemes) are presented in the table.

The recommendation is *inter alia* based on the following considerations:

- *Participation in several capacity markets:* In an optimal, integrated energy-only market, resources are rewarded for their contribution to several markets. If the capacity remuneration is limited to one capacity mechanism, foreign providers would be put at a competitive disadvantage, and the overall investment efficiency would be reduced. Efficient de-rating and penalties will contribute to an overall efficient level of capacity if participation in several capacity markets is possible.
- *Availability obligation:* Imposing a delivery obligation on foreign providers may compromise short-term efficiency in the foreign market. The risk that power may not flow towards the market with the capacity mechanism should be mitigated by making sure that the short-term energy market is efficient.
- *Explicit "admission" auction*: An implicit auction is likely to be more efficient, but it is difficult to see how an implicit auction can be implemented in a decentralized obligation scheme. If the framework were

to distinguish between centralized auctions and decentralized obligation scheme, implicit auctions should be required for the former.

- *Incentives for TSOs:* Interconnector operators should be incentivized to make capacity available during stress events within the general regulatory framework. They should not be obliged to deliver or to influence flows. When it comes to simultaneous stress events, these must be handled according to separate rules and regulations in any case.

Option 1: Proposed common framework for capacity markets with direct participation

Element	Provision per element
Capacity adequacy, capacity requirement and de-rating	Based on common principles Regional, probabilistic approach
Eligible providers	All relevant resources, according to de-rated capacity Geographical limitation based on the regional assessment and grid constraints Providers should be allowed to participate in several capacity markets according to their de-rated capacity
Obligation and penalties	Availability obligation Same penalty as domestic providers
Competitive IC allocation process	Explicit "admission" auction (if general framework) Implicit auction for centralized auctions if different frameworks for centralized auctions and decentralized obligation schemes
Remuneration to IC operators	Auction revenues
Secondary trading	Should be allowed
Obligations and penalties for IC operators	Specific obligations should not be imposed in capacity markets with direct participation
Rules for influencing x-border flows	Specific rules related to capacity markets with direct participation not needed
Allocation of costs	Domestic consumers in the capacity mechanism market should pay the cost of the capacity mechanism
Rules for TSO compliance	Rules regarding the TSOs role in different phases of implementation and operation of capacity mechanisms should be developed

Option 2: Harmonization of basic elements

Capacity products should be tailored to the specific, individual adequacy challenge, and not be harmonized across schemes. Benefits could however be realized by imposing the following common requirements for all capacity mechanisms and providers:

- Definition of capacity products according to a common structure could reduce the costs of providers potentially participating in several, and for TSOs in the implementation and operation of schemes.

- Documentation and technical data, testing procedures and coordination of testing, would reduce the administrative costs of TSOs and reduce the risk of cross-border participation.
- Common rules for the application of penalties with specified procedures for the imposition of penalties cross-border, and a common EU penalty appeals system, in order to reduce the risks and costs related to processes regarding penalties due to differences between jurisdictions.

Risks related to direct cross-border participation

The analysis raises the concern that the competition for cross-border participation may not be efficient, even with implicit admission auctioning. The capacity of eligible foreign capacity providers is likely to be much larger than the de-rated interconnector capacity. If competition is fierce, all of the capacity remuneration will end up with the interconnector operator. If providers expect this, they may not find it worthwhile to participate in the auction. Thus, it is uncertain how the capacity remuneration will be distributed in practice and how investment incentives for capacity in the foreign market will be affected.

Alternative models for cross-border participation

There are two alternatives to direct participation in capacity markets:

1. *Indirect participation*, where interconnectors explicitly participate in capacity markets. This model is easier to implement and solves several of the challenges associated with direct participation. Interconnectors receive the capacity remuneration, and providers benefit from effects in the energy markets. The main objections to interconnector models are related to the role of TSOs and the ability and incentives to manipulate flows.
2. *Implicit participation*, where cross-border contributions are merely taken into account by subtracting the expected import contribution from the domestic capacity requirement. No direct remuneration is paid and both interconnectors and providers benefit from effects in the energy markets.

A potential issue with interconnector models is that an appropriate share of the capacity revenues may not accrue to capacity providers. However, the extent to which this is the case, depends on the accuracy and efficiency of the definition of the capacity requirement and the de-rating, and the extent to which other market distortions are removed by the IEM and the implemented capacity mechanisms.

The efficiency of all models crucially depends on the capacity adequacy assessment and getting the capacity requirement right.

Framework for strategic reserves

We do not recommend that explicit cross-border participation is mandated in strategic reserves. For strategic reserves, *implicit* cross-border participation seems to be the preferable solution for a common framework.

In some cases, regional strategic reserves could provide an efficient solution if underlying challenges are similar or at least can be aligned across a region or between adjacent control areas.

The remaining question is if the increased prices when the reserve is activated provide sufficient incentives in market B to reach the initial assumed implicit participation. Common criteria for activation and pricing under activation should be developed.

The estimated benefits exceed the costs of cross-border participation

Costs of cross-border participation have been assessed via interviews with stakeholders. The benefits have been estimated using a special version of the PRIMES electricity sector model that simulates the behavior of investors depending on the uncertainty of future revenue streams. The model has been used to simulate a variety of market frameworks, among which cases that assume capacity mechanisms with and without explicit cross-border participation. It should be noted that implicit cross-border participation in capacity mechanisms is included in the definition of the demand function for capacity in all cases.

The analysis concludes that there are clear benefits in terms of reduction of costs for consumers from explicit cross-border participation compared to implicit cross-border participation in capacity mechanisms. This is owing mainly to the enhancement of competition, which leads to lower hurdle rates (desired rates of return) of investors, lower capacity auction clearing prices and lower wholesale market prices.

The range of benefits estimated by the model analysis clearly exceeds the estimated administrative cost range. While the cost savings from 2021-2030 are estimated at 87 BN€'13 in the case with capacity markets in all EU Member States, and at 35 BN€'13 in the case with capacity mechanisms in four major Member States, the NPV of administrative costs, for all stakeholders from 2020-2030, range from 2,7 to 138,3 million €'16 without harmonization. A common framework would mainly reduce costs for TSOs and regulators.

POLICY MAKERS' SUMMARY

One challenge with capacity mechanisms in Europe today, is that they are national in scope and highly diverse in their design, and thus not compatible with the integrated, cooperative, and harmonized European electricity market envisaged by the Energy Union strategy. Despite the provisions for cross-border participation in the current guidelines for capacity mechanisms, Member States have not given facilitation of cross-border participation a high priority or careful design. The Commission is therefore considering the options for possible changes to the current regime, imposing and describing an obligation to facilitate cross-border participation in local capacity mechanisms.

This report analyses two basic options for a common framework for cross-border participation in capacity mechanisms:

- Option 1: A harmonized EU framework for cross-border participation in individual capacity mechanisms
- Option 2: Further harmonization of the basic elements for different capacity mechanism models

The objective of such a framework is to provide effective and efficient cross-border participation in capacity mechanisms.

The options are compared to the current framework (baseline) and analysed according to:

- *Efficiency of cross-border investment incentives*, based on economic market theory, i.e., theory on market distortions and efficient regulation
- *Administrative costs* and the distribution of costs, based on a stakeholder and organization analysis
- *Quantitative market impacts and benefits*, using a special version of the PRIMES electricity sector model.

Introduction to cross-border participation in capacity mechanisms

Six basic types of capacity mechanisms have been identified.[1] In this analysis, we concentrate on three of them: The two most relevant market-wide mechanisms, namely centralized capacity auctions and decentralized obligation schemes – hereafter referred to as capacity markets – and targeted strategic reserves.

Capacity mechanisms are measures aimed at providing long-term capacity adequacy in terms of efficient investment incentives for generation capacity, storage applications, demand response, and interconnectors; locally and across the Internal Electricity Market. Hence, capacity mechanisms should reduce the probability of supply interruptions to acceptable levels, or restore acceptable capacity adequacy according to a given reliability standard.

Cross-border participation should reduce the overall costs of achieving the desired level of capacity adequacy in a market area by making optimal use of all available resources. The purpose is not to guarantee supplies or flows in a specific direction during stress situations, but to promote efficient investment incentives across the

[1] See "Final Report of the Sector Inquiry on Capacity Mechanisms".

interconnected market area. Hence, efficiency also implies that the short-term market functioning should not be distorted if a capacity mechanism is implemented.

The short and long-term market solution in an optimal energy-only market is used as the benchmark for the theoretical analysis. The theoretical analysis is based on the following assumptions:

- The Internal Energy Market (IEM) is fully implemented, in accordance with the Market Design Initiative.
- If a Member State implements a capacity mechanism, it must be approved by the Commission and hence, the need is substantiated
- The need is substantiated if one of two market distortions exist:
  - Missing money, because of inadequate scarcity pricing in the energy markets, e.g. due to price caps. Investment incentives are negatively affected if market participants expect peak prices to be capped in the future.
  - Missing markets, because risks cannot be efficiently managed or important externalities are not properly priced. Investment incentives are negatively affected if there is high uncertainty about future returns and correspondingly high costs of financing.

Distorted investment incentives in one market, denoted A, affect prices and spills over to an interconnected foreign market, denoted B. While a carefully designed capacity market in A should restore proper investment signals in A, price signals in B are not necessarily restored if peak prices in A are still capped. With missing markets, efficient investment incentives in B should be restored with an optimal capacity market in A.

Optimality requires that the import contribution from B is correctly taken into account. Merely adjusting the capacity requirement for imports is known as implicit cross-border participation. The efficiency of implicit cross-border participation depends crucially on the capacity requirement, the assessment of the import contribution, and the efficiency of the energy markets. Implicit participation is not expected to fully restore cross-border efficiency. In the remainder of the report we therefore discuss models for explicit cross-border participation.

Strategic reserves are not directly targeted at the relevant market distortions; and will not fit into the same framework as capacity markets. We therefore discuss a common framework for strategic reserves separately.

Criteria for the design of a common framework

The framework options should be assessed according to their effectiveness and their efficiency.

- By effectiveness we understand that barriers to cross-border participation are reduced or removed.
- By efficiency we understand promotion of economic efficiency in the provision of cross-border capacity, both in terms of the overall capacity volume and in terms of cost-efficiency.

Generally, we should distinguish between long-term and short-term efficiency:

1. **Long-term efficiency** implies that the market provides efficient investment signals, and that there are no barriers to investment. Capacity markets are directly

aimed at correcting market distortions or removing barriers related to investments. Efficiency also implies that the measure, i.e. the capacity mechanism, should be designed to correct these distortions without creating new ones. Long-term cross-border efficiency also implies that the measure does not reduce the incentives for investment in interconnection relative to generation, that domestic and cross-border capacity is treated fairly, and that the cost of ensuring security of supply is decreased through cross-border participation.

2. **Short-term efficiency** implies that the available resources (including demand side response) are utilized according to the merit order, and that short-term prices are set according to short-term marginal cost. If the short-term market is deemed to be efficient, capacity mechanisms should be designed so as to not distort short-term market signals. Short-term cross-border efficiency implies that cross-border dispatch should not be distorted, including the flows on interconnectors.

In addition, efficiency implies that the implementation and administration costs should be minimized, or balanced towards the benefits of the scheme. Hence, the measure should not be overly complex and costly to implement and operate.

Options for a common framework

There are several design elements pertaining to capacity mechanisms that may affect cross-border participation. When assessing whether a harmonized framework is sufficient, or whether basic elements of capacity mechanisms need to be harmonized, we have concentrated the discussion on centralized capacity auctions (like the UK model) or decentralized obligation schemes (like the French model).

The two options for a common framework have different implications:

- Option 1 implies designing a harmonized EU framework focussing only on cross-border participation. Within this framework, capacity remuneration and other elements of the overall mechanism would still be decided by each Member State, but rules for cross-border participation must be applied according to the framework.
- Option 2 implies that, in addition to common rules for cross-border participation, rules are set for the basic elements of each category of capacity mechanism, in order to further promote efficient cross-border participation.

The framework elements are discussed according to the issues raised by Appendix 2 in the sector inquiry (hereafter called the Appendix). Moreover, the starting point for the analysis is the model proposed in the Appendix, i.e. a model with direct participation by cross-border capacity providers with an availability obligation.

Capacity adequacy assessment and capacity requirements

The efficiency of a capacity mechanisms both in terms of its overall costs and cross-border market impacts, is crucially affected by the capacity adequacy assessment, which provides the basis for the capacity requirement. If the capacity requirement in A is set too high, the result is over-capacity, lower prices and weakened investment incentives in B. There are three main sources of too high capacity requirements:

- Over-estimated peak demand
- Under-estimated availability of generation capacity (conservative de-rating)
- Under-estimated import contribution (conservative de-rating)

Even with a perfectly efficient capacity mechanism design, including facilitation of cross-border participation, the mechanism will be excessively costly if the capacity requirement is set too high.

De-rating of the import capacity requires an assessment of the technical availability of interconnectors as well as an assessment of the capacity situation in B and the likelihood of simultaneous stress events. As the import contribution from B has to rest on assumptions about market dynamics, not only in B, but in the entire interconnected region, and circumstances are likely to change over time, de-rating of the interconnections should be updated at least with the same frequency as capacity adequacy assessments. In general, capacity adequacy assessment should be updated quite frequently to take into account changes in market dynamics such as e.g., fuel prices, economic growth and demand levels, and renewable capacity developments.

This de-rating approach implies that if the expected import contribution from B in times of stress in A, the interconnector capacity available for foreign capacity providers to participate the capacity market in A will be limited if the capacity in B is scarce, or if there is a high probability of simultaneous stress events. Hence, the exposure of A to uncertain contribution from B is already captured by de-rating.

Common rules should be established for de-rating and the capacity adequacy assessment. The common rules should apply to all capacity, i.e. domestic as well as foreign capacity. Moreover, efficient calculation of reliable import capacity implies a regional probabilistic approach, where capacity is de-rated according to the same principles in all markets, and where a common approach to scenarios for market developments is established.

The same principles would apply for centralized auctions and decentralized obligation schemes, and even for implicit cross-border participation.

Eligible capacity providers

All possible providers should be able to participate and be de-rated according to the same basic principles as domestic providers. Eligible providers should be identified via the same methodology as the one applied for the de-rating of the interconnector or import capacity. For practical reasons and in order to contain the costs, the geographic area of cross-border providers could be limited. Such limitation should however also be defined on the basis of the capacity adequacy assessment exercise from case to case. The "eligibility area" could be smaller or larger than the directly adjacent control areas.

Providers should be eligible to participate in several capacity mechanisms according to the set principles, including common rules for de-rating. It is the total capacity situation in B that determines its contribution to capacity adequacy in other markets. The regional approach should ensure that the assessment of simultaneity of stress events is not limited to a two-country analysis, but takes the correlations of several countries in an interconnected region into account. If B provides capacity to capacity mechanisms in country A and country C, the de-rating should reflect B's ability to export to both countries during stress situations. If not, the expected (probable) import contribution to both A and C should be reflected in the de-rating.

A common registry for eligible participants facilitates de-rating, certification, pre-qualification and testing, and should also facilitate secondary trading of obligations.

When it comes to eligibility, the same principles should apply for centralized auctions and decentralized obligation schemes.

Obligations and penalties

The obligation for cross-border provision should be availability. An obligation to deliver in the local market risks distorting the short-term merit order in market B, even when it is not possible to export more to A. A delivery obligation does not add any value to the solution, i.e. the handling of stress events in A, compared to an availability obligation.

Even though providers should be allowed to participate in several capacity markets, it is not necessary to harmonize other features of the obligation. The nature of the capacity adequacy challenge may differ between markets, and thus the obligations should differ when it comes to e.g. duration, frequency, notification time, etc.

Cross-border participation could have an availability obligation even if the domestic providers have a delivery obligation. In the domestic market, availability and delivery are basically equivalent: If a provider is available during stress, it will provide unless it is told not to do so by the TSO due to grid issues.

The availability obligation may be questioned by the capacity contracting party: Unlike for domestic providers, cross-border providers may comply with the availability option even in situations where imports are in fact not delivered because there is a scarcity situation in B as well or because the interconnector is not available. The fact that no-one is penalized for non-delivery may cast doubt on the comparability of domestic and cross-border capacity providers from the contracting party's point of view. However, if the interconnector has proper incentives to make capacity available during stress situations, this should not reduce the expected value of the cross-border participation (cf. the capacity adequacy assessment and de-rating of interconnector capacity).

Cross-border providers should face the same penalties for non-compliance as domestic participants.

The same principles should apply for centralized auctions and decentralized obligation schemes.

Competitive process to allocate interconnector capacity

Capacity adequacy in A depends on the capacity situation in B (the interconnected region) and the interconnector capacity. Direct cross-border participation is limited by the technical capacity of the interconnections, as well as by the market situation in B. The total capacity of eligible providers in B is likely to be (much) higher than the de-rated import capacity. The de-rated capacity should be allocated according to a competitive process, making sure that the most efficient capacity providers are indeed the ones participating in the capacity market in A.

In centralized capacity auctions, an implicit auction for interconnector capacity is likely to be more efficient than an explicit "admission" auction. The reason is that the explicit auction introduces an additional uncertainty for providers (basis risk), and thus is less efficient in allocating capacity remuneration between providers and the interconnector operators. Moreover, the providers that are successful in the admission auction may not be successful in the capacity auction. Thus, the cross-border contribution may turn out to be suboptimal.

In decentralized obligation schemes, implicit auctioning does not seem to be suitable, however. As trading of capacity certificates is continuous, there is a risk that simultaneous purchase of admission would just imply admission on a first-come, first-serve basis. An annual admission auction would probably be more practical, but would exposed to the basis risk as explained above.

Here, the same model should not be chosen for centralized auctions and decentral obligation schemes. A common framework for centralized auctions and decentralized obligation schemes would imply an obligation to organize admission auctions, although this is probably not the efficient solution for centralized capacity auctions.

Appropriate remuneration to interconnector operators

To the extent that interconnectors are the scarce resource, they should receive their appropriate share of the capacity remuneration in order to make sure that the incentives to invest in interconnector capacity is appropriate.

In an implicit auction for interconnector capacity, the difference between the capacity price in A and the marginal cost of capacity in B constitutes a "capacity congestion rent" which should be allocated to the interconnector.

Similarly, the revenues from an admission auction should accrue to the interconnectors. The basis risk introduced by the admission auction does however imply that a significant share of the risk is borne by the interconnector: The basis risk will make capacity providers more cautious in their bidding for admission. Thus the share of the capacity remuneration received by the interconnector owner is expected to be lower than in an implicit auction.

It is an open question how admission auctions will work in practice. For each foreign market, there is likely to be a large number of eligible providers, with a total capacity way above the de-rated import capacity. In theory, most of the capacity remuneration for provisions from B is likely to end up with the interconnector. Hence, the willingness to participate in the capacity auction may be muted if the participants expect that the stakes are low and uncertain, and in particular, if the costs of participation are high. Thus, it is doubtful that the interconnectors will be efficiently remunerated via admission auctions.

Similar concerns could be raised regarding implicit auctions: If the competition for provision from B is fierce, it is likely that most of the capacity remuneration will end up with the interconnector. If that is the case, the incentives for capacity providers to participate in the capacity auction in A may be weaker. There may not be a clear equilibrium price, and the allocation of remuneration may become random.

Models with interconnector participation (indirect cross-border participation) are likely to provide more efficient capacity remuneration to interconnectors. Although cross-border capacity providers do not directly receive capacity remuneration in this case, they should benefit from more efficient interconnector investments and thus price signals even in B.

Interconnectors could participate in both centralized auctions and decentralized obligation schemes according to the de-rated capacity level. Such indirect cross-border participation would avoid several of the complexities introduced by direct participation models. With interconnector participation, the same framework can apply to centralized auctions and decentralized obligation schemes.

Trading of allocated import capacity

Secondary trading should be allowed for explicit "admission" auctions.

In centralized capacity auctions, the admission tickets could be traded before the capacity auction. After the auction, it must be sold together with the capacity obligation. It should not be necessary to regulate such trade, as the ticket will not have any value if it does not give access to the capacity market.

In decentralized obligation schemes the admission tickets could be traded continuously.

Obligations and penalties on interconnector operators

The interconnector operators should have appropriate incentives to make interconnector capacity *available* during stress events, i.e. the availability of interconnectors should correspond to the assumptions made in the de-rating of imports.

Although interconnectors are not direct participants in the capacity market, they ideally receive a (potentially large) share of the capacity remuneration. One might therefore argue that they should also have corresponding obligations. The question is how such an obligation should be defined, and whether it provides an additional incentive to be available during stress events.

In this discussion, it should be kept in mind that both TSOs and merchant cables are subject to a number of regulatory requirements and incentive mechanisms that influence availability and maintenance decisions. This applies both to economic incentives and license requirements. For instance, a merchant cable must be available in order to earn revenues at all. A number of regulatory measures can be used to achieve similar incentives for TSO cables as well. As the revenues from interconnectors are expected to be high during scarcity situations, and the scarcity situations should be possible to predict, for example based on capacity adequacy assessments, incentives for timing of maintenance should not be a problem either.

Putting obligations and penalties on interconnectors in a generator model is not recommended. We cannot see that the incentives for making capacity available are strengthened significantly through further regulatory measures. Rather, there is a risk that penalties will weaken the long-term incentives to invest in interconnectors. Instead, the general regulatory framework for TSOs and other interconnector owners should be used to ensure availability.

Rules for influencing interconnector flows

In theory, the TSOs can influence flows in two ways:

- Directly, through changing the flow on DC interconnectors
- Indirectly, through the setting of capacity limits (ATCs), PTDF's and similar measures

It should be kept in mind that even if it is possible to influence the direction of flows, the TSO must also have incentive and means to do so.

Changing the flow on DC interconnectors is physically possible, but cannot be done without changes in the surrounding (AC) grid, i.e. without adjustments in generation and consumption. Short-term efficiency may be significantly distorted as a result. It is difficult to see that the interconnector operators, be it TSOs or merchant cables, would have the means to influence flows this way.

The volume and direction of flows could also be influenced by changing ATC values and internal congestion management. Only TSOs would have the means to do so. The evolution and implementation of the Network Codes and the Target Model, as well as the introduction of flow-based market coupling, should limit these possibilities significantly in the future. The general EU rules will also mean that the power is highly likely to flow to the system experiencing a scarcity situation. Hence, we do not see the need for specific rules to ensure flows in the right direction.

If the short-term market does not provide efficient flows, the conditional nomination model described in the literature could be applied. When it comes to simultaneous stress events, general rules for the allocation of interconnector capacity must apply anyway.

Allocation of costs of foreign provision to consumers

From an economic point of view, the main principle should be that the consumers in country A should pay the cost of the capacity mechanism regardless of whether the payments go to domestic or foreign generators (or interconnectors). Foreign capacity providers receiving the capacity remuneration will also benefit consumers in the foreign market. However, this will also be paid for by the foreign consumers through the ordinary market prices in the foreign market. Free-riding is thus less of an issue.

If the capacity mechanism in one market contributes to security of supply in another market, this should be visible from the regional capacity adequacy assessment. If there are capacity inadequacy issues in both (or several) markets, a common capacity mechanism should be considered, or, if one market does not opt for a capacity mechanism, rules for the use of resources in stress situations could be developed. In general, however, scarce resources should be allocated according to the willingness to pay or VoLL levels in the relevant markets. The capacity mechanisms only pay for import contributions to the extent that the capacity adequacy assessment shows that cross-border capacity contributes to security of supply in A.

Rules for TSO compliance

It is obviously crucial to develop the rules for the TSO conduct and responsibilities in any cross-border participation framework. The TSOs incentives and obligations are crucial for the trust in the cross-border contribution. As discussed above, we consider the incentives and obligations for making interconnector capacity available and ensuring correct flows to be adequate.

However, to ensure full compliance, a common set of EU rules, for instance founded in Network Codes or other Regulations, is desirable. A lack of common rules means that the enforcement of the cross-border regimes will depend on bilateral agreements which will not be as efficient.

Framework design or harmonization of elements?

The Table below sums up the framework regulations that could apply to both centralized capacity auctions and decentralized obligation schemes with direct participation, without interfering with the individual design choices.

The only limitations when it comes to the design of main elements, is that cross-border providers should have an availability obligation, and that capacity providers should be allowed to participate in several capacity markets.

Proposed common framework for capacity markets with direct participation

Element	Provision per element
Capacity adequacy, capacity requirement and de-rating	Based on common principles Regional, probabilistic approach
Eligible providers	All relevant resources, according to de-rated capacity Geographical limitation based on the regional assessment and grid constraints Providers should be allowed to participate in several capacity markets according to their de-rated capacity
Obligation and penalties	Availability obligation Same penalty as domestic providers
Competitive interconnector allocation process	Explicit "admission" auction (if general framework) Implicit auction for centralized auctions if different frameworks for centralized auctions and decentralized obligation schemes
Remuneration to interconnector operators	Auction revenues
Secondary trading	Should be allowed
Obligations and penalties for interconnector operators	Specific obligations should not be imposed in capacity markets with direct participation
Rules for influencing cross-border flows	Specific rules related to capacity markets with direct participation not needed
Allocation of costs	Domestic consumers in the capacity mechanism market should pay the cost of the capacity mechanism
Rules for TSO compliance	Rules regarding the TSOs role in different phases of implementation and operation of capacity mechanisms should be developed

The main weakness, in terms of possible efficiency losses, of the proposed framework, is the allocation of remuneration to interconnector operators. Admission auctions introduce a basis risk that may imply that the willingness to pay for the admission is reduced. The interconnector may end up bearing the bulk of the basis risk. Thus, the incentives for investments in interconnector capacity may be suboptimal if explicit admission auctions are set as the norm.

The analysis raises the concern that cross-border participation will not be efficient, as there is probably much more eligible capacity available in B than the de-rated interconnector capacity. The capacity remuneration in B will not be market-wide. Hence, there is a risk that the remuneration to capacity providers will be zero in an efficient auction cross-border auction, i.e., the entire capacity remuneration will accrue to the interconnectors according to the de-rated cross-border capacity. This in turn raises a concern over whether the providers in B will actually have an incentive to participate in the capacity auction. Consequently, the distribution of the capacity payment to B and the impact on investment incentives for capacity providers and interconnectors from explicit cross-border participation is very uncertain.

If separate guidelines are made for centralized auctions and decentralized obligation schemes, the main efficiency gain would be that interconnector capacity should be allocated according to an implicit interconnection auction, held simultaneously with the capacity auction in centralized auction schemes.

Another alternative is to require indirect cross-border participation, i.e. participation by interconnectors, for all capacity markets. In such a model (cf. the current UK scheme), the capacity rent will flow to the interconnector operator, and strengthen the incentives to invest in interconnector capacity. Such a model also simplifies some of the other issues related to capacity markets. If the capacity requirement is not carefully determined, i.e. if it is set too high, investment incentives for capacity providers in B will be suboptimal, although increased interconnector capacity will also benefit providers and investors in B.

Framework for strategic reserves

A harmonized EU framework for cross-border participation specific for strategic reserves should focus on the initial purposes of most strategic reserves in European Member States. Rather than relieving one of the market distortions missing money or missing market, strategic reserves in most cases fulfil a specific purpose. As targeted mechanisms they should only be implemented if need can be substantiated, for example the need to cover extreme winter peaks, resolve locational scarcity/congestions issues or bridging winters with unavailability of major capacities in the short term.

Consequently, solving long-term market distortions as discussed for capacity markets are not the main focus of strategic reserves, and *implicit* cross-border participation seems to be the preferable solution for a common framework. Given the focus on the technical availability and the activation triggered directly by the TSO in the implementing country, a framework with explicit participation would require extensive coordination among TSOs. An implicit participation model would provide a clearer solution. Based on periodical updates of the de-rating of the cross-border participation together with the assessment of the capacity requirements, the implicit participation model would allow for efficient accounting of the contribution from non-domestic capacity providers.

As an alternative, regional strategic reserves could provide an efficient solution if underlying challenges are similar or at least can be aligned across a region or between adjacent control areas. This could be implemented similarly to, for example, shared balancing reserves including rules for sharing as long as connections are not congested.

The key to efficient implementation remains, just as for capacity markets, correct de-rating independent of the chosen framework for cross-border participation. In line with periodically updated capacity requirements, also de-rating should be updated accordingly. As the recommendation points at the implicit cross-border participation, framework elements with respect to obligations, penalties, trading cross-border capacity are less applicable.

The remaining question is if the increased prices in market A during activation of the strategic reserves provide sufficient incentives in market B to reach the initial assumed implicit participation. Common rules for the activation of strategic reserves, and the pricing under activation, should be developed. The day-ahead price should be set at the price cap when the strategic reserve is activated day-ahead. This should contribute to more demand-response. Setting requirements for the share of demand response in the strategic reserve should also be considered in order to stimulate demand response in the long term, eventually potentially leading to strategic reserves being superfluous.

Market impacts and benefits

In order to assess the impacts of cross-border participation in capacity mechanisms E3MLab developed and applied an extension of the standard PRIMES electricity system model. The purpose of the new model is to estimate the impacts of uncertain revenues from wholesale markets and eventual capacity remuneration on plant investment and mothballing decisions. The benchmark scenario is based on the EUCO projection from the standard PRIMES model which assumes a well-functioning market that remunerates all costs of the optimum portfolio of generation.

As in reality investors seek ensuring economic viability for each power plant individually and as the assessment is surrounded by high uncertainty, the extended model had to include uncertainties about future market conditions and to be able to perform the economic viability assessment separately by plant. To estimate the likely earnings from wholesale markets, the new model simulates oligopolistic competition in these markets in order to mimic scarcity bidding. In addition, the extended model simulates competition and price formation in hypothetical capacity auctions, with and without cross-border participation. The revenues from these auctions involve less uncertainty compared to revenues from wholesale markets, in exchange for lower scarcity prices in the latter, based on reliability options.

The extended model calculates the uncertain revenues from the wholesale market and the capacity remuneration and then estimates the probability of mothballing (early retirement) for old plants and of the cancelling of investment for new plants. The list of plants as evolving in the future comes from the standard PRIMES projection for the EUCO scenario. It is logical that the uncertainty factors and the evaluation of economic viability by plant, in contrast to portfolio economics, will lead to reduced capacities compared to the standard PRIMES projection. The oligopoly model simulates again the wholesale markets including the capacity reductions to calculate total costs from a consumer perspective assuming that equal reliability standards are met.

The level of clearing prices and revenues in the capacity auctions depends on cross-border participation of generators and on the possibility of delivering power during stress events. Several cases are simulated for the period 2020-2050 regarding the origins of the revenues (i.e. wholesale market and/or the capacity mechanism) and the cross-border participation. The new model reports detailed information on early retirement of old plants and the cancelling of investment in new plants, relative to the capacity planning, from 2020 up to 2050, as issued from the projection using the standard PRIMES model for the EUCO scenario (which achieves low emission targets for 2030 and 2050), as well as the capacities of additional peak devices that the TSO will have to ensure to meet the same reliability standards as in the benchmark PRIMES scenario.

The modelling exercise examines the following cases: a) energy-only market, no capacity mechanisms, b) central capacity auctions in four Member States without explicit cross-border participation, c) a similar case allowing cross-border participation, d) central auction capacity mechanisms in all Member States without explicit cross-border participation, and finally e) a case similar to the latter, but allowing cross-border participation.

The modelling exercise aims to address whether cross-border participation would be more cost-efficient, in case capacity mechanisms were implemented in the EU, and not to analyse whether capacity mechanisms should be implemented. Other questions treated in this exercise are: what is the impact of harmonized vs non-harmonised capacity mechanisms on cross-border electricity trading and system costs, what is a cut-off distance in terms of the electric network beyond which the level of cross-border participation is insignificant, etc. Focusing on explicit considerations on the capacity mechanism design, and in particular in opening capacity mechanisms to cross-border participation, the analysis attempts to quantify the effect of allowing cross-border participation in a capacity mechanism if this enhances competition, and thus lower auction clearing prices. The estimation of total system costs under increased participation indicates the possible economic value to the consumers provided by cross-border participation.

Implicit participation in a national capacity mechanism takes place in the simulations through the consideration of imports in the definition of demand functions that the regulators approve for the capacity auctions. Consideration of imports shifts the demand curve and lowers auction clearing prices. Consideration of exports by an exporting country, which may auction capacity, would conversely increase prices, compared to when exports are excluded from the demand function. The amount of imports/exports that is taken into consideration is an assumption of the modelling. However, the aim of the modelling is to go beyond implicit participation of imports/exports in the capacity mechanism. The aim is mainly to analyse direct cross border participation of power plants in the capacity auctions and get a pan European view on this matter.

The simulation of capacity auctions takes into account the probabilities of effective cross-border delivery of capacities at stress times, taking the capacity of the electricity grid into consideration. These are quantified using a network EU-wide model and take the form of "deliverability functions" for every pair of countries. Cross-border participation modifies the competition conditions in the capacity auctions, therefore the potential participants need to take into account the likely impacts on revenues from participation. This is modelled using a simulator of capacity auctions and the output takes the form of "profitability functions" for each national capacity auction. By combining the deliverability and profitability functions, the simulator allows projecting auction clearing prices, the participation cross-border and the revenues in the capacity mechanisms, under various configurations of the capacity mechanism arrangements.

The implementation of stochastic decision making for investments take the form of complex Monte-Carlo samples of uncertainties surrounding future evolution of carbon prices, gas prices and demand net of variable RES. The simulation of investment behavior uses decision functions based on hurdle rates (minimum return on capital to decide positively for the investment). The modelling assumes heterogeneity of investors' behaviors captured by frequency distributions of the hurdle rates. Cross-border participation in capacity auctions is assumed to enhance competition, both in the auctions and in the energy market, leading investor to reduce hurdle rates compared to those considered in the context of national markets. Enhanced competition and reduction of hurdle rates are the main drivers of benefits of cross-border participation.

The overall results of the simulation of various cases indicate that there are clear benefits in terms of reduction of costs for consumers from explicit cross-border participation in capacity mechanisms. Implicit cross-border participation is assumed in all cases. Therefore, the benefits accrue due to considering explicit cross-border participation in capacity mechanisms in addition to implicit cross-border participation. As it will be shown in following paragraphs, these benefits clearly outweigh the costs of national authorities and TSOs of explicit cross-border participation in capacity mechanisms.

The benefits are owing mainly to the enhancement of competition that results from opening capacity mechanisms to cross-border participation. This in turn leads to lower capacity auction clearing prices, as well as lower wholesale market clearing prices. Sensitivity analysis, undertaken both in the context of capacity mechanisms and for the energy-only markets, show that fully exploiting interconnections through flow-based allocation methods using market prices is also of major importance for achieving low costs for the consumers. The analysis finds that electricity trade among countries is not affected by cross-border participation in capacity mechanisms. The analysis confirms free-riding impacts among countries, in terms of capacity costs and consumer costs, when few countries apply the Capacity mechanisms and others do not (asymmetric versus symmetric case assessment).

Cost savings of cross-border participation according to the modelling analysis, BN€'13, 2021-2030.

	Options with capacity mechanisms in all MS	Options with capacity mechanisms in 4 MS
Cost savings in load payments to CM	30	13
Cost savings in load payments to wholesale and reserve markets	56	22
Total cost savings	**87**	**35**

Driven by the uncertainties, the reduction of capacities relative to the EUCO projection is different by type of plant: old coal and old oil/gas plants are mostly affected and thus require capacity payments to reduce the risk of mothballing, CCGTs are hardly affected as the EUCO scenario context favors their use for balancing, as well as their position in the merit order. Nuclear plants do not see economic threats in the context of the EUCO scenario according to the model results.

The simulations of the operation of the wholesale market, as well as of capacity auctions, unavoidably have limitations due to assumptions and simplifications. The effect of cross-border participation for competition enhancement is uncertain. The impacts of implementing capacity mechanisms with different designs, and other than the stylised auctions assumed in the model, have not been studied. The simulation of investment decision-making under uncertainty could not be validated in reality and uses hypothetical behavioural parameters in the modelling. The consideration of the viability economics only at the level of individual plants, excluding any consideration of portfolio is an extreme assumption, which was made on purpose to contrast the results to the standard full portfolio optimisation of PRIMES.

Administrative costs

Capacity mechanisms involve costs for affected stakeholders. The main stakeholders are regulators, TSOs and participants. We have identified the following general administrative steps in setting up and operating a capacity mechanism:

- **Design:** Choice of capacity mechanism and detailing of rulebook and financing mechanism, including the production of consultation documents and external studies, if any. Involves, as a minimum, national regulatory authorities (NRAs) and TSOs.

- **Setting a capacity requirement:** Definition of a reliability standard, and calculation of the capacity requirement. Involves, typically, the TSO and possibly the NRA.
- **Eligibility:** Pre-qualification and de-rating of prospective participants, including documentation on and evaluation of technical and geographical data. Involves obviously the market participants, in addition to the party responsible for approval of eligibility (typically the TSO).
- **Allocation process:** Determining the amount of capacity to be delivered by the participants and the commercial terms, according to an auction or an administrative procedure.
- **Operation:** Monitoring and operation of the capacity mechanisms, such as activation of reserves, or monitoring of compliance and imposing penalties. Involves the TSO.

Based on interviews with stakeholders we have estimated the total cost ranges for the capacity mechanism options, based on the expected need for full-time employees (FTEs) and a normalized cost per FTE from 2021 to 2030. There is little experience data to build on, and hence considerable uncertainty about the costs. This is reflected in substantial cost ranges for the different elements.

We expect that development of a common framework for cross-border participation is likely to provide the largest cost reductions in the eligibility phase and in the compliance phase (operation). In a harmonized common framework (option 1), the difference between provisions in the national capacity markets may still be substantial, while with further harmonized elements (option 2) more of the basic elements are harmonized. But resources still have to be dedicated to pre-qualification and registration (the eligibility phase) and to monitoring, control, penalties, etc. (compliance phase). A rough guestimate is a reduction of the costs related to the eligibility phase and the control/compliance phase of 50 % in option 2, and 30 % in option 1. We do not expect the cost for participants to be significantly reduced.

The design phase constitutes a small share of total costs, and we expect the gains from harmonization in the design phase to be small.

The estimated aggregated cost savings associated with the different options are illustrated in the figure below, shown for both generator models and interconnector models. Although numerous examples are imaginable we have used the following (simple) assumptions:

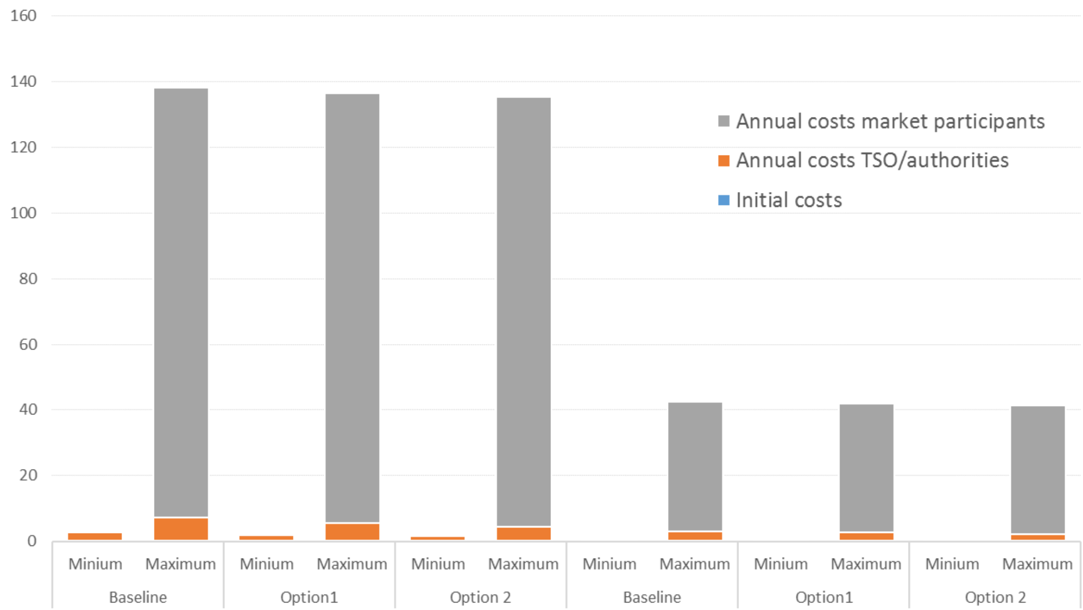
- 15 national capacity mechanisms in EU Member States
- All generator models: 10 cross-border participants per capacity mechanism
- All interconnector models: 3 cross-border participants per capacity mechanism

The number of 15 national capacity mechanisms is based on an average across years and scenarios of the number of countries with foreign participation observed in the modelling.

The significant cost ranges are mainly explained by the annual costs for market participants, i.e., the accumulated costs in 2021-2030. The maximum estimates should clearly be taken with a grain of salt, for several reasons:

- Estimates in terms of whole FTEs are very crude. Costs are likely to vary between participants.
- If the costs appear unreasonably high for market participants, the number of participants is likely to be reduced.
- The cost of participation could be reduced over time as participants gain experience. With more national capacity mechanisms, it is also more likely that participants can realize economies of scope/scale by participating in more than one capacity mechanism.
- With more national capacity mechanisms, some of the cross-border participants will already be eligible participants in their national capacity mechanism. Thus cross-border participation does not necessarily imply significantly increased efforts, particularly if the national capacity mechanisms are harmonized.

Estimates of max and min total costs for capacity mechanisms with direct and indirect participation, million €'16, 2021-2030.



Comparison of costs and benefits

Comparing the costs of national authorities and TSOs when it comes to initial costs and recurring costs, the range of benefits estimated by the model analysis clearly exceeds the cost range.

The range of benefits estimated by the model analysis clearly exceeds the estimated administrative cost range. While the cost savings from 2021-2030 are estimated at 87 BN€'13 in the case with capacity markets in all EU Member States, and at 35 BN€'13 in the case with capacity mechanisms in four major Member States, the NPV of administrative costs, for all stakeholders from 2020-2030, range from 2,7 to 138,3 million €'16 without harmonization. A common framework would mainly reduce costs for TSOs and regulators.

1. BACKGROUND AND PROBLEM DEFINITION

The European Commission's strategy for the European energy system is captured by the Energy Union strategy. The Energy Union aims to provide a European energy sector which is based on integration, cooperation, and an efficient and harmonized energy and climate policy framework. One of the focussed areas of the Energy Union is to "provide a truly European dimension to security of supply". At the same time, the electricity market is going through a profound transformation involving the introduction of a growing share of intermittent and weather-dependent renewable generation capacity and the phasing out of flexible and controllable thermal generation capacity.

Although there is currently over-capacity in most parts of the European electricity market, there is also a growing concern that the market will not incentivize investments in flexible and reliable generation capacity. Capacity mechanisms are aimed at strengthening the investment incentives for peak load capacity. One problem with capacity mechanisms in Europe today, is that they are national in scope and highly diverse in their design, and thus not compatible with an integrated, cooperative, and harmonized European electricity market.

Under the current regime, when designing capacity mechanism schemes, the Member States must adhere to the guidelines set out by the Commission, including the facilitation of cross-border participation. The experience till now is that cross-border participation has not been given a high priority or careful design. The Commission is therefore considering the options for possible changes to the current regime for cross-border participation in capacity mechanisms, by imposing and describing an obligation to propose a scheme for cross-border participation in each of the local capacity mechanisms proposed. The policy objective of such a provision is to establish a common scheme for more effective and efficient cross-border participation in capacity mechanisms.

The Terms of Reference set out two *basic options* for such a framework, which are to be compared to the continuation of the current framework, i.e. the Baseline (Option 0):

- Option 1: A harmonized EU framework for cross-border participation in individual Capacity Mechanisms
- Option 2: Further harmonization of the basic elements for different capacity mechanism models

Our overall approach is to base the analysis of the options on three pillars:

- Economic market theory, i.e., theory of market distortions and regulation, including a literature review, in order to describe and assess the efficiency of the investment incentives for the different options and models in principle
- Stakeholder and organization analysis in order to uncover the administrative costs and benefits, and distribution of costs and benefits among stakeholders, for the different options
- Quantitative analysis of the market impacts of the options compared to the baseline option, using the Primes model framework

The criteria for evaluation of the different options should be related to the policy objective of a common framework, which is to provide effective and efficient cross-border participation in capacity mechanisms.

- Effective: In terms of actually facilitating cross-border participation, i.e. removing or reducing the barriers for cross-border participation
- Efficient: Promoting economic efficiency by achieving cost efficiency across borders, implying both in terms of the overall capacity volume and cost-efficient provision of the procured capacity

2. Overview of Capacity mechanisms

In the Final Report of the Sector Enquiry on Capacity Mechanisms, the taxonomy of capacity mechanisms lists the following varieties:

Targeted mechanisms

- Tender for new capacity. The authorities put out a tender for new capacity investment according to set criteria. Several types of payments can be used, including power purchase agreements and contracts for differences.
- Strategic reserve. Generation capacity is contracted through a tender or auction and kept outside the ordinary market until specific criteria are met (for instance the inability of the market to clear). Strategic reserves may also include consumption through interruptibility schemes.
- Targeted capacity payment. A central authority sets a fixed price or a premium above the market price that is paid out to capacity that meets certain criteria.

Market-wide mechanisms

- Volume-based central buyer. The amount of capacity required is determined by a central authority and procured through a competitive process.
- Volume-based decentral obligation. Suppliers/retailers are obliged to purchase capacity to meet a share of demand from their respective end-users, for instance via a capacity certificate system. The relative capacity requirement is determined centrally, while the suppliers determines the absolute amount to purchase.
- Market-wide capacity payment. A central authority sets a fixed price or a premium above the market price that is paid out to all capacity in the market.

While the capacity mechanisms are all designed to strengthen capacity adequacy, their economic properties differ. Table 1 summarises the main properties of the different mechanisms, based on the Final Report of the Sector Enquiry on Capacity Mechanisms and our own assessment.

Based on the assessments, we consider that the capacity payment models are less relevant due to their poor economic efficiency compared to the alternatives. They are also difficult to align with the Target Model and State Aid guidelines.

Therefore, we concentrate on the targeted reserve (i.e. strategic or peak-load reserves) and the market-wide volume-based mechanisms in the subsequent analysis in this report. As *capacity markets* we denote the market-wide, volume-based mechanisms.

Table 1 Main properties of different capacity mechanisms

Capacity mechanism	Impact on capacity	Market impact
Tender for new capacity	Quick new investment in short term, but may be offset by negative impact on other capacity	Negative impact on profitability for non-subsidised generation due to lower market prices Incentives for strategic behaviour from investors Can lead to increased competition in the short term at least
Strategic reserve	Availability of capacity in the short term, but may be offset by negative impact on other capacity	Negative impact on profitability for non-subsidised generation, but may be mitigated by high price threshold for activation Incentives for strategic behaviour
Targeted capacity payment	Risk of over- or underinvestment if payment is set too high/too low Risk of negative impact on non-eligible capacity	Negative impact on profitability for non-subsidised generation due to lower market prices Distortion of technology choices Preservation of current market structure
Volume-based central buyer	Efficient procurement if competitive procedure is used, but potentially long lead times Can address local shortages Too high volume purchased in case of (excessive) risk aversion during the setting of capacity requirements and de-rating process	Facilitates new entry Model can be tailored to accommodate different technologies Model design can help reduce market power in the electricity market
Volume-based decentral obligation	Efficient procurement of capacity Sensitive for definition of capacity requirement, but less vulnerable for centrally made decisions Less suited for local shortages or specific generation capacities	Uncertainty about certificate prices influences investment incentives Vertical integration may reduce incentives for market entry unless mandatory exchange trading of certificates
Market-wide capacity payment	Risk of over- or underinvestment if payment is set too high/too low	Negative impact on profitability for non-subsidised generation due to lower market prices Preservation of current market structure

Source: Commission staff working document Accompanying the document Report from the Commission: Final Report of the Sector Inquiry on Capacity Mechanisms, European Commission (2016)

3. THEORETICAL BASIS AND KNOWLEDGE STATUS

Capacity mechanisms are measures directed at correcting market failures expected to imply that future investments in capacity will be insufficient to meet reliability standards if additional regulations are not introduced.

The discussion of capacity mechanisms over recent years has revolved around the causes of the market failure, the design of capacity mechanisms, and the cross-border effect of capacity mechanisms.

In this chapter we provide an overview of the discussion with an emphasis on the theoretical rationale for capacity mechanisms, the cross-border effects of individual capacity mechanisms, and proposed measures to facilitate cross-border participation in order to mitigate cross-border market distortions.

The benchmark is the efficient energy-only market, thus we start by explaining how the energy-only market should ideally deal with capacity adequacy.

Next, we elaborate on the causes of market failure in the energy-only market, and how the different causes distort cross-border trade and investments.

Then, we discuss how individual capacity mechanisms, directed at the various market distortions, may distort the locational investment signals and investments in interconnection in the integrated market, if cross-border participation is not facilitated.

In the second part of the chapter we provide an overview of the proposals that have been set forward for the design of cross-border participation in recent years.

3.1. MARKET DISTORTIONS MERITING MARKET INTERVENTION

3.1.1. BENCHMARK: THE ENERGY-ONLY MARKET

The EU has chosen an energy-only market design as an integral part of the target model for its electricity market (see text box). Capacity mechanisms are not part of the target model, but Member States may implement capacity mechanisms as a transitional measure if it can be demonstrated that the energy only market is not expected to provide a sufficient level of security of supply, or capacity adequacy, in the long term. The current guidelines require that individual capacity mechanisms facilitate cross-border participation in order to maintain and promote market-wide efficiency. Thus far, however, cross-border participation is not observed in most capacity mechanisms. This raises the concern that the European electricity system will not take the benefits of cross-border trade and sharing of resources fully into account, unnecessarily increasing the cost of electricity for consumers. Thus, the question is how a common framework for cross-border participation in capacity mechanisms could be developed in order to improve the long-term efficiency of such mechanisms.

The policy objective of a common framework for cross-border participation in capacity mechanisms is to establish more ***effective*** and ***efficient*** cross-border participation in capacity mechanisms. By effective we understand that barriers for cross-border participation are reduced or removed, and by efficient we understand that the framework promotes economic efficiency in terms of incentivizing efficient resource utilization.

Efficiency implies short and long term efficient resource utilization:

- In the short term, the available resources should be utilized according to merit order, i.e. by activating the lowest cost resources first, and ensuring that marginal costs equals consumers' marginal willingness to pay.
- In the long term, sufficient resources should be made available in terms of incentivizing profitable investments in generation capacity, demand-side response and interconnector capacity.

The purpose of capacity mechanisms is to contribute to the latter, i.e. capacity mechanisms are measures to achieve long-term adequacy more efficiently. Hence, one might say that efficiency implies that a framework for capacity mechanisms should promote cross-border participation in order to *reduce the overall costs of achieving a given level of security of supply in a market area, without distorting short-term market efficiency or jeopardizing security of supply in other market areas.*

In other words, the purpose of a capacity mechanism is to provide incentives to restore security of supply levels to acceptable levels. By strengthening the investment incentives in the market, the probability of scarcity situations is reduced.

This also implies that the main purpose is *not* to guarantee supplies or flows in a specific direction in stress situations. We will argue that these (short-term) situations should be tackled based on short-term efficiency criteria.

The benchmark for the analysis is the efficient energy-only market in general (see text box), and how the efficient energy-only market utilizes cross-border resources, specifically.

As energy market areas differ in terms of current generation capacity mix, demand structure and domestic energy sources, including weather-dependent energy sources such as wind, hydro and solar power, it makes good economic sense to share resources across borders in order to enhance the market-wide efficiency. The market should provide incentives to promote long-term locational investment efficiency, as well as short term efficient trade.

Thus, the locational element in electricity prices in the energy-only model is important. If an area is expected to experience increasing imbalances (deficits) and more frequent scarcity pricing, the long-term prices are expected to increase as well. This should incentivize new investments. Efficient investments imply a trade-off between investments in new generation capacity in the deficit (high-price) area, investments in demand flexibility or energy efficiency in the deficit area, or by strengthening the interconnector capacity between the deficit area and surrounding surplus areas. Thus, in the energy only market, long-term capacity adequacy may be provided by local investment or by increased import capacity from an adjacent surplus area.

In the energy-only market cross-border capacity is remunerated via energy prices only (although this is a simplification, see text box). As the scarcity increases in one market area, the market revenues accruing to *interconnectors* increase, depending on the reason for the increase in scarcity situations, i.e., the price structure. The increase in scarcity may also affect market prices in the interconnected area.

The European target model: Energy-only market design

The basic idea of the energy-only market is that providers get paid for the energy delivered. Due to the technical characteristics of the power system, the energy price varies due to

- *The need for momentary balancing of demand and supply, which means that the marginal cost of energy varies from moment to moment.*
- *The cost of providing energy depends on the planning horizon, i.e. the status of the system before the delivery hour.*

The design of the energy-only market in different time-frames or stages is a practical representation of this: The day-ahead market provides a relatively rough estimate of the hourly balances for the 24 hours next day. As we approach physical delivery, however, the system balance is corrected in the intraday market, in order to account for changes in expectations and unforeseen events, and in the balancing markets to take account of within the hour variations and unbalances occurring at short notice.

The remuneration to providers is also not for energy only, as TSOs often pay providers for the obligation to submit balancing bids. In addition, generators and consumers can be paid for providing various technical services to the system. These remunerations are mostly in the form of a capacity-based payment for the reservation.

Nevertheless, the main source of income for electricity generation in the energy-only market is typically the revenues accruing from the day-ahead market or wholesale contracts related to the day-ahead price formation.

Let us denote the country with the emerging scarcity country A, and the neighbouring country, country B. Country B does not have a current scarcity and has access to additional capacity that is competitive with new capacity in A. I.e., we assume that country B can potentially relieve some of the demand in A via interconnectors, and that it is potentially profitable (optimal) to increase the interconnector capacity between A and B.

To see the cross-border effects of an increasing scarcity in A in the energy-only market, we may distinguish between the following situations

- The price difference increases in hours where the interconnector is already congested. Then the prices stay the same in market B, but the congestion rent, accruing to the interconnector (IC), increases.
- The number of hours with congestion increases. Prices increase in B, and the congestion rent increases.
- The price increases in hours without congestion. There is no change in the congestion rent, but the price in B increases. (We also assume that the scarcity in A is partly met by increased generation in B, and thus, increased exports to A.)

As prices in A increase in scarcity situations, the revenues for all resources in A and B are likely to be affected. Here, the value of interconnectors and generation in B increases because these resources contribute to the balancing of supply and demand in A. Consumers' cost increase as well, and implicitly the value of demand response.

Correspondingly, the (expected) price increases affect investment decisions for all resources in A and B, including interconnector capacity between them. Depending on the situation, the market solution may be to expand interconnector capacity or to increase generation in B[2], or a combination of the two:

- If the increasing scarcity in A mainly increases prices when interconnectors are congested, the main effect will be to increase interconnector revenues, and thus strengthen the incentives to expand interconnector capacity. However, expansion of the interconnector capacity may increase the incentives for increased supply and reduced demand in B as well.
- If the increasing scarcity in A mainly increases imports, the main effect is to increase the value of investments in generation capacity or demand reductions in B. Subsequently this may lead to more frequent congestions, and hence increase the incentives for investments in interconnector capacity as well.

Clearly, the incentives to invest in A must also be taken into account. Investments are long-term and must be based on expected market developments. The main point is that in a well-functioning energy only market, cross-border contributions are remunerated via market energy prices, both in the short and long term. There may be several reasons why market do not function well, and several remedies to correct distortions.

In the next section, we discuss market distortions that justify capacity mechanisms and the cross-border implications of capacity mechanisms.

3.1.2. MISSING MONEY AND MISSING MARKETS

What is it that the capacity mechanism is supposed to fix, and how does the distortion and the solutions affect cross-border efficiency?

Capacity mechanisms may be implemented when for some reason the energy only market is not expected to provide sufficient capacity in the long term. Hence, the objective of capacity mechanisms is to remove some kind of market distortion.

According to Newbery (2015): *"If investment decisions could be solely guided by strictly commercial decisions and if markets were not subject to policy interventions or price caps, it is plausible that capacity adequacy could be delivered by profit-motivated generation investment without explicit policy guidance. For this to be the case, investors need confidence that the revenue they earn from the energy markets (including those supplying the ancillary services that the SO needs to ensure short-term stability) will be adequate to cover investment and operating costs.*

If this revenue is not adequate, there is a "missing money" problem (Joskow, 2013), but if it is adequate but not perceived to be so by generation companies or their financiers, then there is a "missing market" problem (Newbery, 1989). Missing

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[2] Or to increase demand side response. In the following, when we talk about generation, we imply demand-response as well.

money problems arise if price caps are set too low (below the Value of Lost Load, VoLL), or ancillary services, such as flexibility, ramp-rates, frequency response, black start capability, etc. and/or balancing services are inadequately remunerated, or transmission access charges are inefficiently high (important in distorting exit decisions), and/or, energy prices are inefficiently low. (…)

Missing markets create problems if risks cannot be efficiently allocated with minimal transaction costs through futures and contract markets, or if important externalities such as CO_2 and other pollutants are not properly priced. The concept of missing markets can be usefully extended to cases in which politicians and/or regulators are not willing to offer hedges against future market interventions that could adversely affect generator profits. These arguments have been extensively covered in the literature, recently in the Symposium on 'Capacity Markets', (Joskow, 2013; Cramton, Ockenfels and Stoft, 2013)."

Newbery argues that the missing money problem is overrated, while the missing markets problem is forgotten in the discussion of capacity mechanisms.

This is important, because the design of efficient measures depends on the problem that is to be addressed. The Final Report from the Sector Inquiry on Capacity mechanisms concludes that missing money problems can be caused by

1. Inelastic demand due to technical and regulatory barriers
2. Tools used by system operators that suppress market price signals in scarcity or stress situations
3. Price caps below VoLL
4. Uncertainty about expected future returns (high risk premiums and lacking hedging opportunities), associated with uncertain prices and operation hours
5. Public good features of reliability due to current technical characteristics of dispatching (non-rivalry: all enjoy the same reliability; non-excludability: it is not possible to selectively disconnect end-users)

Point number 4 and 5 are missing market problem, while 1, 2 and 3 are related and constitute a missing money problem. Inelastic demand is one reason why price caps are introduced and TSOs use tools to suppress market price signals, while price caps below VoLL mute both short- and long-term demand response. The public good features (point 5) of electricity supply should however become weaker with the removal of technical and regulatory barriers for demand response. One may also argue that security of supply is also ensured by the reserve products procured by the TSO.

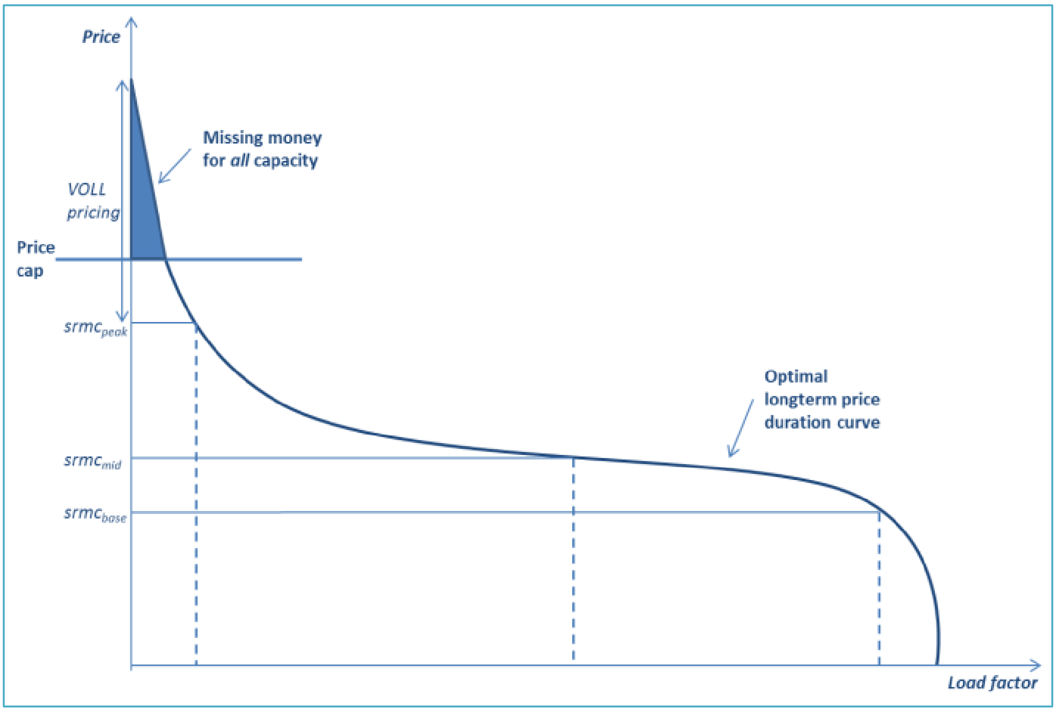
Newbery (2015) adds inadequate remuneration of ancillary and balancing services and high transmission charges that distort exit decisions to the list. Both should be more easily corrected by other measures than capacity mechanisms, though. Other market design initiatives should help moving the market in the right direction. However, the interim sector inquiry report states that such distortions will not be fully removed in the short to medium term.

Notably, low prices that do not cover capital costs are not a sign of missing money. On the contrary, they are a sign that the market is over-supplied and that a reconfiguration of the capacity, including decommissioning, should be done.

Thus, as a working hypothesis we assume that the missing money problem arises because proper scarcity pricing is not allowed due to technical and regulatory barriers, cf. the model below. Today, it is generally the case that prices very rarely reach the price cap in most markets in Europe. However, if market participants *expect* that scarcity prices will be capped in the future, the investment incentives are muted.

Figure 1 illustrates the missing money problem in the case of a price cap. The figure shows a stylized duration curve for hourly prices during a year. We show three different types of generators with different marginal costs: base load, with low variable and high capital costs, mid-merit capacity with higher variable costs and lower capital costs and peak load capacity with low capital costs and high variable costs. In an efficient market, the capacity should be composed so that all types of capacity cover their capital costs in hours when prices are above their marginal cost (srmc). The missing money problem occurs when peak load prices are capped. We observe that the missing money problem reduces the expected revenues for all types of generators in the market, according to the filled triangle in Figure 1, but that in terms of the share of required returns, it affects peak load capacity in particular.

Figure 1 Illustration of the missing money problem due to price caps



Now, if the problem was not missing money due to capping of prices, but *missing markets* in terms of uncertainty about peak pricing and missing hedging opportunities, the market effect would be different. Then scarcity pricing would eventually result in high peak prices, and should eventually attract investments. As investments would be delayed, and if we assume that demand response is still inadequately represented in the market, security of supply would not be at acceptable levels. Hence, missing markets is still a relevant basis for capacity mechanisms, but the impact on market prices is different from the impact in the missing money case.

Now the question regarding cross-border participation in individual capacity mechanisms arise because the distortion of price signals in one market spills over to other (interconnected) areas, who do not implement (or need) a capacity mechanism. The price effects of the distortion and the subsequent implementation of a capacity mechanism in one market, may depend on the nature of the distortion, i.e., if the problem at hand is that of missing money or of a missing market.

Let us assume that there are only two markets in the system. We denote the market with a missing money problem country A, and the market without a missing money problem country B. The two markets are interconnected, and thus, the distortion in A affects investments in A *and* in B. If the distortion is not corrected, the economics of interconnector capacity between the markets will also be affected.

- Investments in A will be too low and the price level in A is set to increase over time (more frequent scarcity situations), although scarcity prices will be capped.
- Higher price level in A will spill over to B, and (should) strengthen the investment incentives there. (However, the capping of scarcity prices in A could also mute investment incentives in B.)
- The economics of interconnections between the markets will be affected, but it is not obvious whether the interconnector capacity will be higher or lower (increased or reduced expected interconnector revenue)
- Prices in both markets will increase over time – in A due to scarcity, and in B due to increased generation due to exports (the expected price differences/congestion rent could be larger or smaller than without the distortion)
- The missing money problem in A affects the economics of interconnector investments as well

The extent to which investment signals are distorted in B, depends on trade between the markets and the impact on the interconnector capacity. It is possible to imagine a situation where, due to large shares of (subsidized) renewable generation capacity, prices in A are fairly low in most hours, while the price structure becomes more erratic with more frequent price spikes and stress situations.

If the incentives for investment in interconnectors are weakened, this will indirectly affect the investment incentives in market B (see also section 4.1).

3.1.3. Why Cross-Border Participation?

Now, assume that a capacity mechanism is implemented in A in order to address a missing money problem. The question is to what extent an individual capacity mechanism in A will correct the overall *missing money problem*, and specifically for this project, how the capacity mechanism in A should be designed in order to make sure that investment signals between A and B are not (further) distorted.

The first step is to define the proper level of the capacity requirement for the capacity mechanism in A:

1. Implicit participation: If cross-border participation is not allowed, the capacity requirement must be adjusted for the (expected) cross-border contribution to capacity adequacy in A (and from other non-eligible sources).
2. Explicit participation: If cross-border participation is allowed the capacity requirement should not be adjusted for the expected contribution from cross-border trade.

Table 2: Definition of capacity requirement

Total load during system stress + security margin
- Expected contribution from non-eligible sources
= Capacity requirement

We note that determining the proper level of the capacity requirement, or capacity mechanism volume, implies a regional approach to the capacity adequacy assessment, where all capacity is de-rated according to its estimated contribution during system scarcity, assessed with a probabilistic modelling approach.

Hence, there should be no difference between the (de-rated) interconnected volume included in the implicit or the explicit model.

The effects of implicit or explicit cross-border participation should rather be discussed in relation to the nature of the market distortion, i.e., missing money and missing market.

The next question is how a capacity mechanism without cross-border participation affects short-term price formation in market B, and thus the long-term investment incentives as well.

If we assume that the capacity level in A is set correctly, including correct de-rating of capacity contributions, the capacity mechanism should increase investments in A, and improve price formation. However, if the underlying *causes* of the missing money problem are not corrected, e.g. the price cap is still too low, the scarcity price formation will remain inadequate. (Cf. the figure above, only domestic suppliers will be compensated for the inadequate peak and scarcity pricing, and peak prices are still capped.) Hence, the missing money problem for interconnector capacity between A and B, and for generators in B is not removed by the capacity mechanism in A. Generators in A will have a competitive advantage towards generators in B.

Missing Money

Under the assumption of missing money in A, the remaining distortion is limited to peak and scarcity pricing. The effect of capped scarcity pricing in A on prices in B depends on the market situation B:

- If there is no scarcity in B and the price is lower than the price cap in A: The interconnector capacity, if available, should provide exports up to the capacity limit, and prices in B are set by the marginal cost or (or marginal utility/VoLL) in B. The congestion rent is however lower than in the optimal solution as the price difference is capped due to the price cap in A. As a result, there is no missing money for generators in B, but there is a missing money problem for interconnectors.
- If there is no scarcity in B, but the peak price is higher than the price cap in A: The market solution yields exports from A to B. If exports from A are not curtailed during scarcity in A, peak prices in B will be lower than in the efficient solution. However, exports from A are likely to be curtailed as a price equal to the price cap implies that the alternative is to curtail demand in A. If the transmission capacity is set to zero, A is also not utilizing the import opportunity from B, and prices in B are still too low. No

flows imply no congestion rent either. Without curtailment, congestion rent is distorted, but still positive (although the flow is potentially going in the wrong direction). Compared to the first situation, both generators in B and the interconnector are affected. The effect for the interconnector depends on the rules for curtailment, but can only be smaller than the optimal or even zero. In the context of the IEM and its harmonization, price cap differences are rare. Nevertheless, the rules for curtailing flows are of importance and treated in the discussion of the framework elements below.

- Simultaneous scarcity in A and B: If prices in both markets are allowed to increase to the price cap in A and according to VoLL pricing in B (since there is by definition no missing money problem associated with market design in B), the market price in A would be lower than the market price in B. According to prices power should be exported from A to B up to the maximum interconnector capacity. At this point generators are already fully utilized, hence demand must be administratively curtailed in A. Again, it is more likely that the flow over the interconnector (export) is curtailed, and demand is curtailed in both markets according to the local scarcity situation (in a administratively and in B according to DSR bids and VoLL). (If both markets were cleared according to demand-side response, or voluntary curtailment, prices could be equalized if the full interconnector capacity is not utilized.)

Hence, if the missing money problem in A prevails after a capacity mechanism is implemented, the investment incentives are still distorted both for interconnectors and the capacity in B. Investments are likely to shift to the market with the capacity mechanism, thereby increasing total costs and distorting cross-border trade. This also indicates the underlying competition of market areas with or without capacity mechanism for investment. The need for administratively curtailing demand will be a strong incentive to implement a capacity mechanism with beneficial conditions.

Missing Markets

If on the other hand, the problem is missing markets in A, proper scarcity pricing should be preserved by the capacity mechanism. In this case, we assume that prices are not capped (or price caps set at or above VoLL) in market A, but that investments are helped by introducing capacity remuneration which reduces the risk of investment. However, without cross-border participation, the capacity mechanism will reduce hedging costs for generators within A, but not for interconnector investments between A and B. Thus, if interconnectors compete for capital in the same market as generation in A, the trade-off between investments in interconnector capacity and generation capacity in A is still distorted. However, it may be argued that the need for hedging is smaller for interconnectors, due to two aspects:

- Interconnectors are often owned by TSOs who may be able to pass financial costs on to grid customers
- Interconnectors rely on the price difference between the markets, and as such prices in both markets, while generators in A are fully exposed to prices in A

Insights

The analysis implies that the distortion of investment incentives for interconnectors and generators in B, if A implements a capacity mechanism without cross-border participation, is larger if the underlying cause is missing money in A as opposed to missing markets in A.

Above, we have assumed that the capacity mechanism in A rests on a sound capacity adequacy assessment. The general outcome is different if the capacity mechanism in A triggers too high investments in A (compared to the optimal solution). Then the capacity mechanism results in too low prices in A. This will clearly spill over to B and affect investment incentives for interconnection between A and B, and for generation in B. While the interconnector might still benefit from a higher congestion rent, generators in B are clearly adversely affected. However, in this analysis we focus on the cross-border elements of capacity mechanisms, and assume that the framework for the capacity assessment is appropriately regulated.

The general insights from the above analysis, is that the distortive impact of individual capacity mechanisms without cross-border participation can be reduced by making sure that the capacity requirement takes import contributions duly into account, and that the general price formation in the market with capacity mechanism is not distorted by low explicit or implicit price caps.

We would also like to point out that while investments in interconnector capacity are beneficial from an overall economic point of view, as long as the social surplus is larger than the cost of an interconnector, investments in interconnector capacity are also crucial for the investment incentives for generation in B. The congestion rent from an interconnector accrues to the IC owner, whereas generation in the exporting area gain through higher prices and consumers in the importing area gain through lower prices. Higher prices incentivize investments in increased generation capacity (and demand response) in the exporting area. Hence, even though the direct revenues accrue to the IC owner, benefits accrue to market participants as well.

The distribution of benefits and costs depends on the economic regulation of interconnectors and TSOs, however. For instance, the regulation may give too strong or too weak interconnector investment incentives compared to the efficient level. Any distortion from capacity mechanisms must therefore be viewed in the right context. From a general point of view, it is nevertheless desirable that the incentives from capacity mechanisms are correct when viewed in isolation.

Even if authorities make sure that price caps and capacity requirements are sensible, individual capacity mechanism may still distort cross-border investment incentives. As we cannot be sure, even with careful capacity adequacy assessments and market design improvements, that proper investment incentives are restored, it is relevant to look into other appropriate measures as well. The core question in this project is how cross-border participation can be facilitated in order to restore proper cross-border investment incentives both for interconnection capacity and generation capacities. As a first step, we turn to the literature for proposals.

3.2. Suggested Models for Cross-Border Participation

Different models for cross-border participation have been suggested in the literature, and we present some of the recent contributions below.

3.2.1. Eurelectric

Eurelectric (2013)[3] proposes a model in which foreign generators participate in the capacity mechanism via a separate auction for capacity in the non-capacity

[3] Eurelectric (2013): Options for coordinating different capacity mechanisms.

mechanism market. Eurelectric's main concern is the risk that individual capacity mechanisms would distort the incentives to invest in IC capacity, which would eventually reduce trade between markets. The (de-rated) capacity on interconnectors limits the amount of capacity purchased in the auction. The TSO is responsible for the determination of the de-rated amount under regulatory supervision.

The idea is that the marginal bid in the separate pay-as-cleared auction determines the capacity remuneration for selected capacity in the non-capacity mechanism market. If the capacity remuneration in the non-capacity mechanism market is lower than the capacity remuneration in the capacity mechanism market, the difference accrues to the interconnector as an "IC scarcity rent". This way, the capacity remuneration is distributed between the IC capacity and the generation capacity. If the IC capacity is the main limiting factor for the adequacy contribution from the non-CRM market, the IC scarcity rent should be high, whereas if the generation capacity is the main limitation, the IC scarcity rent should be low.

The proposed model is based on the following main principles:

- All participants should fulfil the same requirements and market rules
- It should not be possible to participate with the same capacity in more than one capacity mechanism at a time and capacity providers should be able to "opt out" of their national scheme
- TSOs should bear the responsibility to propose the amount of cross-border IC capacity volume that can be offered to a capacity mechanism
- There should be a separate congestion rent for capacity mechanism cross-border capacity allocation
- There should be no cross-border capacity reservation for capacity mechanism

3.2.2. *FRONTIER ECONOMICS*

Frontier economics (2014a)[4] presents two different models in which IC owners participate directly in the capacity mechanism, and two models in which foreign generators participate. The same ideas are further developed in a report for DECC (Frontier Economics, 2014b)[5]. The latter focusses on cross-border participation in the UK capacity mechanism, i.e. in a centralized capacity auction model.

They discuss two models for direct interconnector participation, which are distinguished by the obligation:

1) The IC owner is obliged to deliver, and is penalized for non-delivery

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[4] Frontier Economics (2014a): IC participation in Capacity Remuneration Mechanisms. London, January 2014.

[5] Frontier Economics (2014b): Participation of interconnected capacity in the GB capacity market. London, September 2014.

2) The IC owner is obliged to be available, and is not penalized for non-delivery

In both cases, domestic participants are obliged to deliver. Delivery for interconnectors means physical flows in the direction of the capacity mechanism market. In the first model, the IC owner receives capacity remuneration according to its (de-rated) capacity and is penalized for non-delivery, in the same way as domestic generation/demand resources in the capacity mechanism market. In the second model, the IC owner is not penalized for non-delivery, it merely has to make the IC capacity available for trade.

Frontier prefers the first option of interconnector participation, as the absence of a penalty for non-delivery in the second option distorts competition between foreign and domestic capacity contributions. The contribution from the interconnector is not as valuable to the capacity mechanism market as domestic capacity, since it is not held responsible for delivery. This may lead to an overinvestment in IC capacity.

The two models for direct participation by foreign generators are similarly distinguished by their obligation:

1) Generators are obliged to deliver, and face penalties for their own or IC's non-delivery

2) Generators are obliged to deliver, but are not penalized for non-delivery by the IC

Frontier prefers the model where the capacity mechanism generators bear the risk of non-delivery, including for IC flows. Their main argument is that generators have a stronger incentive to ensure an efficient response to short term market signals, and that the investment efficiency is strongest where the full risk of non-delivery is placed on the generation capacity. In order to increase the probability that the flow on the interconnector is in the right direction, they expect that generators will purchase access rights to the IC, probably through Physical Transmission Rights (PTRs). By placing the responsibility on generators, they will have a stronger incentive to generate or be available in stress situations, and in addition, to do what they can to make sure that electricity flows in the right direction.

The idea is that a proper share of the capacity remuneration accrues to the IC through PTR or similar revenues. With a generator model in which the capacity mechanism generators are responsible for delivery to the capacity mechanism market, the demand for PTRs should increase, and provide the IC owner with an adequate incentive to make capacity available for trade. Via PTRs the IC owner would receive its proper share of the capacity value of the interconnected capacity (ICC, covering both interconnectors and cross-border capacity).

The generator model preferred by Frontier is similar to the Eurelectric model in many respects. The main difference is the explicit mechanisms by which parts of the capacity remuneration directly accrue to the interconnector in the Eurelectric model, and that the obligation of the capacity mechanism capacity is to be available, and not to deliver.

In the report for DECC (Frontier economics, 2014b) the discussion is taken a step further, and a number of different designs for cross-border participation in the GB capacity auction are discussed.

The report comes to the following recommendations:

- An *availability obligation* might be appropriate once the European Target Model has been implemented, as when short-term markets become more efficient, the delivery risk should be lower.
- The choice between *interconnector or generator obligations* depends on the weight put on the assessment criteria, and they do not recommend one rather than another.
- Generation should be *de-rated* according to their likely contribution to GB security of supply. This may imply zero de-rating for many generators in the internal market.
- An *implicit auction* is likely to be more efficient and equitable than a pure explicit auction.

They moreover, inter alia, comment on the following issues:

- De-rating of interconnected capacity (interconnectors and cross-border generation) should reflect expected physical availability and the likelihood of coincident stress events
- The award of longer-term contracts for interconnected capacity may be limited as the de-rating could be effected by market developments (and implementation of the internal energy market), and as long-term contracts may be less critical depending on the regulatory framework for interconnectors
- In an availability model, the delivery risk for interconnected capacity is transferred to GB consumers. This may represent an implicit subsid and could distort investment decisions.

3.2.3. Tennbakk and Noreng

Tennbakk and Noreng (2014) argue that an interconnector model is the most efficient solution. The criteria for the analysis of different models is their ability to ensure a proper distribution of capacity remuneration between interconnector and generator capacity, and to provide proper incentives to deliver during stress events.

They compare the market incentive implications of three types of models for cross-border participation:

- Interconnector models, where interconnectors participate in capacity mechanisms and receive the capacity remuneration directly
- Generator models, where cross-border providers participate in foreign capacity mechanisms and receive the capacity remuneration
- Combined model, where cross-border providers participate in foreign capacity mechanisms, but the remuneration is shared with interconnectors through a simultaneous auction for interconnector capacity

The main reason for the conclusion that the interconnector model is recommended, is that it is most likely to realize the optimal solution. Delivery depends on the market solution in the foreign market and not on the generation of individual generators. The model implies that the interconnector operator bears the full risk of non-compliance, i.e. insufficient delivery during stress events, and will be penalized accordingly.

However, the interconnector model may be backed up by the interconnector operator buying long-term capacity option contracts. This would be an *option* for the interconnector operator, which may be used to increase the probability of delivery and thus to reduce the de-rating of the capacity. Alternatively, the interconnector operator could purchase power in the intraday market if a stress event is called and the DAM solution does not provide delivery in the direction of the market with the capacity mechanism. Both mechanisms imply that some of the capacity remuneration is passed on to market participants in B, and should strengthen investment signals for generators (and DSR) in B. The point is that if the interconnector is penalized for non-delivery, the interconnector operator has an incentive to reduce the risk of non-delivery.

The difference between the two options is primarily related to the distribution of risks. In principle, the availability of generation and DSR in the non-capacity mechanism market should be the same in the two cases. The capacity option model mimics a capacity remuneration in the non-CRM market, i.e. the capacity mechanism option contract offers an up-front remuneration to generators for provision of capacity. None of the solutions requires that the interconnector operator participates directly in the intraday market, as if there is available interconnector capacity and a stress situation is called, intraday market trading should respond accordingly.

Without any allocation of the capacity remuneration, fulfilment of the obligation (delivery) rests with the DAM solution and subsequent intraday trades. Ideally, the non-capacity mechanism market participants should include the probability of such events in their investment decisions. However, with no short or long-term risk distribution, they may face a missing money uncertainty regarding such revenues. Hence, investment incentives in generation and DSR may be weaker in the non-capacity mechanism market if capacity mechanism options are not used.

Moreover, it may be beneficial for the interconnector operator's bidding in the capacity mechanism that the risk of non-compliance can be managed through capacity mechanism options.

Capacity mechanism option contracts may restore balanced incentives between the capacity mechanism and non-capacity mechanism market. The option would require that generators withhold capacity from the DAM and the intraday market until the deadline for calling a stress event is out. The capacity will however eventually be bid into the market:

- If a stress event is called, the capacity must be bid into the intraday market
- If a stress event is not called, the capacity will be released from the obligation and can be offered in the intraday market or in the balancing market
- If the DAM solution yields appropriate flows, the capacity can be released earlier.

For DSR providers, the obligation would merely be to be prepared to reduce consumption to a pre-specified level if the option is called. Hence, the practical solution also depends on other features of the obligation, e.g. the rules regarding notification times, maximum number of calls, duration, etc.

In theory, the interconnector operator may purchase short or long-term capacity mechanism option contracts, e.g. simultaneously with its participation in the capacity mechanism. Naturally, the interconnector operator should purchase such contracts via a competitive bidding process. The implication would be that the interconnector distributes some of the capacity remuneration to generation and DSR, which contributes to the capacity mechanism obligation.

Capacity mechanism option contracts are likely to affect the markets:

- If the probability of a stress event is low, the market will expect the capacity mechanism option capacity to be bid into the intraday market and adjust bids and offers accordingly
- Less capacity will be offered in the DAM, but the price impact depends on the expectations on the subsequent equilibrium in the intraday market

If there is a significant value of offering such "capacity mechanism option contracts", the expected revenues from the market will increase, and should strengthen the incentives to invest in new generation capacity as well.

Such a solution should not distort the allocation of investments between generators in the interconnected markets, or between generation and interconnector capacity. The interconnector operator is unlikely to bid into the capacity auction if it expects to pay more to ensure fulfilment of the obligation (or in penalties) than it can expect as capacity mechanism revenue. Alternatively, the interconnector bids will reflect its expected cost of fulfilling the obligation.

We note, however, that if there is ample capacity in the non-capacity mechanism market or the probability of simultaneous stress events is low, the value of such capacity mechanism options would probably be low (or zero), and the DAM and/or intraday market solutions should provide sufficient capacity to deliver according to the interconnector's obligation, provided that the interconnector capacity is available.

Commenting on the proposals by Frontier and Eurelectric, Tennbakk and Noreng (2014) put forward the following propositions:

- If an interconnector model is chosen, the efficient solution implies that the interconnector operator bears the full risk of non-delivery. The risk may be efficiently allocated to generators and DSR capacity via contracts for delivery in stress situations, preserving both short and long-term market efficiency.
- If a generator model is chosen, the capacity mechanism generators should bear the full risk of non-delivery in order to deliver on par with domestic generation. This would provide the generators with incentives to stimulate interconnector flows, but it is difficult to see how they would be able to do so. If the interconnector delivers flows in the right direction, capacity mechanism generators should not be penalized for not generating, because this could negatively affect dispatch in the non-capacity mechanism market.
- The combined (Eurelectric) model with separate capacity auction for foreign capacity ensures that a proper share of the capacity remuneration accrues to the interconnector. However, if capacity mechanism generation is only responsible for its own availability, no penalty will apply even if the (combined) interconnected capacity does not deliver during a stress event. As foreign capacity providers are not held responsible for non-delivery in all cases, its contribution is not treated on equal terms with domestic capacity. From the capacity mechanism markets' point of view, the interconnected capacity receives the same capacity remuneration as domestic capacity, but is not as reliable.
- From a theoretical point of view, the interconnector operator should be the party directly participating in the capacity mechanism. The interconnector operator has the means to efficiently utilize the resources available for the

provision of capacity during stress events in the capacity mechanism market. If necessary, the interconnector operator may enter into option contracts with generators and providers of DSR in the non-capacity mechanism market, thus increasing the incentives to invest in capacity there.

3.2.4. MASTROPIETRO ET.AL.

Mastropietro et.al. (2015)[6] argue that there are challenges related to mistrust in the fulfilment of article 4.3 in the Security of Supply Directive (2005/89/EC). Although the article says that member states shall not discriminate between cross-border contracts and national contracts, most Member States have national clauses that maintain that exports to other countries will be interrupted in the case of a domestic emergency of supply. This challenge would be overcome by stronger coordination and commitment amongst TSOs to remove such clauses and not discriminate.

The capacity mechanism under consideration is a reliability option model.

Mastropietro et.al. propose to implement a soft version of physical cross-border commitments in order to overcome the challenge that the automatic allocation of the entire transmission capacity is done through the short-term market clearing algorithm, where the flows through the interconnections are determined by the equilibrium between generation and demand in the different zones. The proposed model requires that the Price Coupling of the Regions (PCR) allows the declaration of a sort of "conditional nomination" associated to capacity mechanism contracts. This conditional nomination would allow agents to physically contribute to the supply of electricity to the system with the capacity mechanism during scarcity conditions. However, the "physical" supply from the reliability providers holding a capacity mechanism contract (both national and cross-border) should only be claimed under specific combinations of scarcity conditions and flows through the cross-border interconnection.

The proposal is illustrated by a discussion of the following cases:

- Non-scarcity: There is no need to claim capacity contracted in the capacity mechanism, the flow through the interconnection will be determined by the commercial considerations.
- Scarcity: The IC owner has to guarantee delivery of the capacity contracted in the capacity mechanism.

If the interconnection provides imports into the capacity mechanism system, no further benefit could be achieved from ensuring that cross-border reliability providers are supplying, because the maximum capacity is already flowing through the interconnection. There is no need to include a cross-border delivery check in the design of the capacity mechanism in this case.

If the interconnector exports from the capacity mechanism system, the TSO has to check if all capacity mechanism resources are delivering the contracted capacity and if this delivery is actually contributing to relieve the scarcity condition (in A). In the case of cross-border agents, the conditional nomination applies only as long as the interconnection is not congested in the export

[6] Mastropietro, Paolo, Pablo Rodilla and Carlos Batlle (2015): National capacity mechanisms in the European internal energy market: Opening the doors to neighbours. Energy Policy 82, 38-47.

direction. The conditional nomination allows agents in the regional market to "nominate" cross-border contracts that are to be exercised whenever the following two conditions are simultaneously met:

(1) A scarcity situation is declared in A, and

(2) There is free capacity in the interconnection (as determined by the price coupling of regions) in the direction towards the capacity mechanism-system

The second condition is the key to avoid ex-ante capacity reservation, and leaves much more space to the price coupling of regions (PCR) to efficiently assign transmission capacity in the regional market, both during normal operation and stress events.

The authors claim that if this type of "conditional nomination" contract is considered in the regional market design,

- There is no hurdle to the effective participation of foreign agents in the capacity mechanism of a system in the same regional market, and
- The short-term market efficiency is not distorted

The latter is based on the assumption that the reason why electricity flows in the wrong direction when the conditional nomination is activated, is that the short-term market signals are already distorted by the capping of prices in A. Therefore, the conditional nominations improve the short-term market solution by bringing the flows in the right direction. In the case that the scarcity prices are accurately represented, and prices are actually higher in B than in A in the scarcity situation, it is argued that the cross-border contribution via the conditional nomination contract could be sold back to B (by the holder of the reliability contract).

3.2.5. FINAL REPORT OF THE SECTOR INQUIRY ON CAPACITY MECHANISMS

The interim report contains an annex on the "participation of interconnectors and/or foreign capacity providers in capacity mechanisms", which provides a comprehensive discussion of a number of issues related to the design of cross-border participation in capacity mechanisms. Hereafter, this will be referred to as the Annex.

One conclusion from the analysis is that there is probably a value in developing common rules for cross-border participation in different mechanisms. The conclusion of the Annex presents a high-level approach to such common rules. Although a harmonized product is not necessarily a prerequisite for cross-border participation, a harmonized set of rules, including a common product, may be required to facilitate cross-border participation.

The Annex does not arrive at any clear recommendation, but lists a set of issues for consideration, and discusses a high-level approach to harmonization of cross-border participation in volume-based market-wide capacity mechanisms.

The Annex highlights several issues for consideration:

- Simply accounting for imports when establishing the demand for capacity mitigates some negative (cross-border) effects, but does not enable cross-border participation in capacity mechanisms

- Common rules for de-rating of cross-border resources and calculation of capacities for cross-border participation requires cooperation between TSOs
- Lack of trust about the potential for imports at times of concurrent scarcity requires common and transparent rules for Member State and TSO actions in scarcity and emergency situations
- Models with an availability obligation will probably not distort short-term market coupling, nor foreign markets (with the exception of required testing)
- In models with interconnector participation, it is not clear that appropriate revenues accrue to foreign capacity providers
- The most appropriate design may therefore be a model with availability obligation and direct participation of foreign capacity providers, rather than a model with delivery obligation on both the foreign capacity providers and the interconnector operator
- In order to avoid system-wide over-procurement, providers must be able to participate in more than one capacity mechanism in the same period

Hence, the tentative conclusion of the Sector Inquiry is a model with direct participation of cross-border capacity providers with an availability obligation, and where providers are allowed to participate in several capacity mechanisms.

The Annex then goes on to discuss features of a common approach to integrate volume-based, market-wide capacity mechanisms. These features are discussed in detail in Chapter 4.

3.2.6. SUMMARY OF MODELS FOR CROSS-BORDER PARTICIPATION

In summary, the proposed models have the following features:

Model	Obligation	Main features
Eurelectric combined model	Generators obligated for own availability No obligation for interconnector delivery	Separate auction for cross-border capacity – price difference accrues to interconnector owner Capacity not allowed to participate in multiple capacity mechanisms
Frontier generator model	Generators obligated for own delivery and for interconnector delivery (2014a) Availability obligation with ETM (2014b)	Generators expected to purchase PTRs in order to increase probability of delivery (2014a) Implicit auction (2014b)
Frontier interconnector model	Interconnector owner obligated for own delivery (2014a) Availability obligation with ETM (2014b)	
Tennbakk and Noreng interconnector model	Interconnector owners obligated for own delivery	May (on a voluntary basis) buy capacity mechanism options in order to strengthen investment incentives in the cross-border market
Mastropietro et.al. generator model	Generators obligated for interconnector delivery	Generators buy conditional nomination contracts (conditional PTRs)
Annex to the Sector Inquiry	Capacity providers (generators) with own availability obligation	Different options for allocation of interconnector capacity proposed. Possible to participate in several mechanisms.

All the models attempt to take into account the notion that the "reliability rent" should accrue to the resources providing the reliability.

4. DISCUSSION OF FRAMEWORK DESIGNS

Capacity mechanisms are not part of the EU Target Model, but individual Member States may implement capacity mechanisms if, *inter alia*,

a. the need for such a mechanism can be substantiated, and
b. the contribution from cross-border trade is taken into account, or
c. cross-border participation is facilitated.

Thus, we may assume that if a Member State does implement a capacity mechanism, the need is substantiated and the implementation is consequently approved by the Commission. In addition, we may assume that in other Member States, where a capacity mechanism is not implemented, there is no need, or the need cannot be substantiated.

However, the issue of facilitation of cross-border participation in capacity mechanisms has not been resolved, nor indeed the need for a common design of capacity mechanisms. The Commission is therefore considering the options for possible changes to the current regime, by introducing a common framework for capacity mechanisms, in order to promote more effective and efficient cross-border participation in capacity mechanisms.

In this chapter we will discuss each of the design elements listed in the Annex on cross-border participation in the sector inquiry on capacity mechanisms (hereafter referred to as the Annex). We will assess two different options for the design of the common framework:

- Option 1: A harmonized EU framework for cross-border participation in individual capacity mechanisms
- Option 2: Further harmonization of the basic elements for different capacity mechanism models

Option 1 implies designing a harmonized EU framework that focus only on cross-border participation in individual capacity mechanisms. Capacity remuneration and other elements of the overall mechanism would still be decided individually by each Member State. Current capacity mechanisms could stay as they are, but rules for cross-border participation must be applied in compliance with the framework.

Option 2 implies that, in addition to clarification of the rules for cross-border participation, the framework would set rules for the basic elements of each category of capacity mechanism models. The question is if such a framework could enhance the effective participation of foreign capacity.

Although there are several different types of capacity mechanisms (cf. chapter 2), we concentrate the discussion on capacity markets (centralized capacity auctions and decentralized obligation schemes) and strategic reserves.

There is however an important distinction between capacity markets and strategic reserves:

- Capacity markets are supposed to affect investment behaviour by directly correcting missing money or missing markets. The main criterion for efficiency of capacity markets is thus that they do affect market investments.
- Strategic reserves are not supposed to directly affect investments, but constitute a reserve in case the market does not provide sufficient

capacity. Consequently, the main criterion for good implementation of strategic reserves should be that they do not affect the market outcome.

These two varieties should (probably) be treated differently in the guidelines. Thus, we first discuss the possible framework elements for capacity markets, and subsequently the elements for strategic reserves in a separate section.

In the next section, we will discuss the possible harmonization of different framework elements. For each element, we will start the discussion with the assumption that we are looking at a centralized auction scheme, and then go on to discuss whether the same reasoning holds for decentralized obligation schemes. We also assume that the cross-border participants are capacity providers, not interconnectors. As we have seen in chapter 3, some argue that interconnectors should be the cross-border participants in capacity mechanisms, as is indeed the case in the UK capacity auction. The option that interconnectors are cross-border participants, is briefly discussed in section 4.1.9.

4.1. CAPACITY MARKETS

Framework elements

In order to establish a harmonized EU framework for cross-border participation the Annex proposes that a common framework contains rules for:

A) Calculation of the amount of imports that can be relied upon in times of scarcity (common methodology – regional approach)

B) Identification of eligible capacity providers in the neighbouring markets

C) Obligations and penalties applying to providers holding capacity contracts in neighbouring markets

D) A competitive process to offer the import capacity to eligible capacity providers

E) Trading of the allocated import capacity

F) Obligations and penalties applicable to the Interconnector operator, including enforcement of penalties across borders

G) The influence flows on interconnectors in the direction of the capacity obligation, in order to comply with obligations

H) Allocation of the costs of foreign provision to consumers

I) Remuneration for interconnection capacity that enables cross-border participation

J) Compliance by the TSOs

In the following sections, we discuss the implications of different ways of implementing common rules for each of these elements in an EU framework. We discuss each element according to the list above.[7]

[7] Here the elements are listed according to the order used in the introduction to section 5.1 in the Annex. In the subsequent discussion in the same section in the Annex, the order is slightly different, as element d) has become element f) and e) and f) above consequently d) and e).

Assessment criteria

The framework options should be assessed according to their effectiveness and their efficiency.

- By effectiveness we understand that barriers to cross-border participation are reduced or removed.
- By efficiency we understand promotion of economic efficiency in the provision of cross-border capacity, both in terms of the overall capacity volume and in terms of cost-efficiency.

Generally, we should distinguish between long-term and short-term efficiency:

1. **Long-term efficiency** implies that the market provides efficient investment signals, and that there are no barriers to investment. Capacity markets are directly aimed at correcting market distortions or removing barriers related to investments. Efficiency also implies that the measure, i.e. the capacity mechanism, should be designed to correct these distortions without creating new ones. As pointed out by Frontier (2014b), long-term cross-border efficiency also implies that the measure does not reduce the incentives for investment in interconnection relative to generation, that domestic and cross-border capacity is treated fairly, and that the cost of ensuring security of supply is decreased through cross-border participation.

2. **Short-term efficiency** implies that the available resources (including demand side response) are utilized according to the merit order, and that short-term prices are set according to short-term marginal cost. If the short-term market is deemed to be efficient, capacity mechanisms should be designed so as to not distort short-term market signals. Short-term cross-border efficiency implies that cross-border dispatch should not be distorted, including the flows on interconnectors.

In addition, efficiency implies that the implementation and administration costs should be minimized, or balanced towards the benefits of the scheme. Hence, the measure should not be overly complex and costly to implement and operate. Costs related to cross-border participation in capacity mechanisms are further analysed in chapter 5.

4.1.1. A) CALCULATION OF RELIABLE IMPORT CAPACITY

According to the Final Report from the Sector Inquiry, the Energy Union strategy "states that the Commission will establish a range of acceptable risk levels for supply interruptions, and an objective, EU-wide, fact-based security of supply assessment addressing the situation in Member States. This will take into account cross-border flows, variable renewable production, demand response and storage possibilities."

A crucial step in implementing a capacity mechanism, be it a capacity market or strategic reserves, is to set the capacity requirement. Adequate representation of cross-border participation is necessary in order to make sure that the capacity requirement is not too high, thus resulting in general over-capacity. In a capacity market without cross-border participation, the de-rated import contribution should be excluded from the capacity requirement (implicit participation), while in a capacity market with explicit cross-border participation the de-rated import contribution should be included in the capacity requirement. In both cases, it is good practice to also de-rate the cross-border capacity.[8] De-rating of cross-border

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[8] Models with voluntary de-rating may also be an option, i.e. where it is up to the participants to weigh the probability of their contribution in stress or scarcity

capacity should be based on the same criteria as the de-rating of domestic capacity, i.e., according to the expected contribution during stress events, taking into account:

a. the technical availability of the interconnector,
b. the expected flow, or reliable import contribution, during stress events.

De-rating of capacity should be done according to common criteria, and according to the probabilistic approach that is also applied in the capacity adequacy assessment. In other words, the reliable import contribution should already be clarified via the regional capacity adequacy assessment that forms the rationale for the capacity mechanism. As capacity adequacy assessments are by nature assessments of long-term consumption and generation expectations, this implies a common approach to the development of appropriate scenarios, including what level of investment and demand flexibility the market is likely to deliver without specific capacity remuneration.

The de-rating of import capacity implies that

a. If there is a high probability of simultaneous scarcity on both sides of an interconnection, the expected import contribution and the de-rated capacity will be low, compared to the technical capacity on the interconnection.
b. If there is a low probability of simultaneous scarcity on both sides of an interconnection, the expected import contribution will be high, compared to the technical capacity on the interconnection.

De-rating is a complex exercise that needs to rest on a number of assumptions. There is an important difference in the de-rating of cross-border capacity and the capacity of domestic generators. Domestic thermal generation can be de-rated mainly based on technical data, while wind and solar is de-rated based on technical data, weather data, historical generation data, and their correlation with demand. In a regional assessment, foreign capacity should be de-rated according to the same principles. But the de-rating of the interconnector *flows* also depends on the expected market developments in B. Hence, the de-rating of the import contribution must take the expected market developments in interconnected region into account.

Consequently, the capacity adequacy assessment also needs to rest upon scenarios for market developments, including expected renewables deployment and demand growth, and to what extent the market can be expected to provide sufficient investments in reliable capacity without additional capacity remuneration. Hence, the initial probabilistic assessment must take a number of probable scenarios into account. As market dynamics and fundamentals change over time, adequacy assessments, including import contributions, should be regularly assessed and revised. Both general market developments and far-reaching events, such as new

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situations. An example is the reliability options model proposed by C. Vazquez ; M. Rivier ; I.J. Perez-Arriaga in the paper "A market approach to long-term security of supply" in 2002 http://ieeexplore.ieee.org/document/1007903/. The French mechanism implies voluntary de-rating. It does however not seem to be an option that is considered for a European framework.

interconnections in the region, could change the de-rating of interconnections between markets.

It should be noted that this approach implicitly also takes into account how the reliability of the flows of one interconnection is related to all the other regional interconnectors.

A particular concern may arise if the regional assessment shows that the neighbouring market B should also implement a capacity mechanism according to the adequacy assessment. However, if market B may face an adequacy challenge in the future, this should already be reflected in the de-rating of the interconnection capacity, i.e. the de-rated interconnector capacity would be low.

Similarly, the analysis may show that B may develop an adequacy challenge over the time-horizon of the assessment, and thus, is expected to make a decision on whether to implement a capacity mechanism later. Or in general, the capacity situation, and hence, the expected import contribution (during stress events) may change over time, depending on market developments.

We also note that there is a bit of a circular argument here: The import contribution is limited (de-rated) based on an assessment of the investment behaviour, while an efficient capacity mechanism should affect investment behaviour even in B. In the regional assessment, one basically has to determine what level of trust to assign to the (energy-only) market in B and the markets beyond B. More specific guidelines for this exercise clearly needs to be developed.

Observation: It is important to realize that the de-rating of import capacity, if expected flows are taken into account according to a probabilistic modelling approach, already reduces the risk related to insufficient cross-border provision. As there is likely to be a regulatory bias towards overestimation of the capacity requirement and at the same time towards overrating the uncertainty associated with cross-border flows, the capacity mechanism should expect a high reliability of the de-rated flows. This also means that there should be a very high likelihood that the flows will indeed materialize, and in most situations exceed expectations. Thus, even if you have a well-designed capacity mechanism, but an over-estimated capacity requirement, the outcome will not be efficient and long-term investment incentives will be distorted.

Unnecessarily strict de-rating is clearly a barrier for cross-border participation.

From the purchasing countries' point of view, in order to trust the cross-border contribution, it is also crucial that the de-rating of the cross-border contribution rests on a commonly agreed and open approach. However, even in a model with implicit participation, the market with the capacity mechanism is exposed to the uncertainty regarding the cross-border contribution via the adjustment of the capacity requirement according to the estimated cross-border contribution.

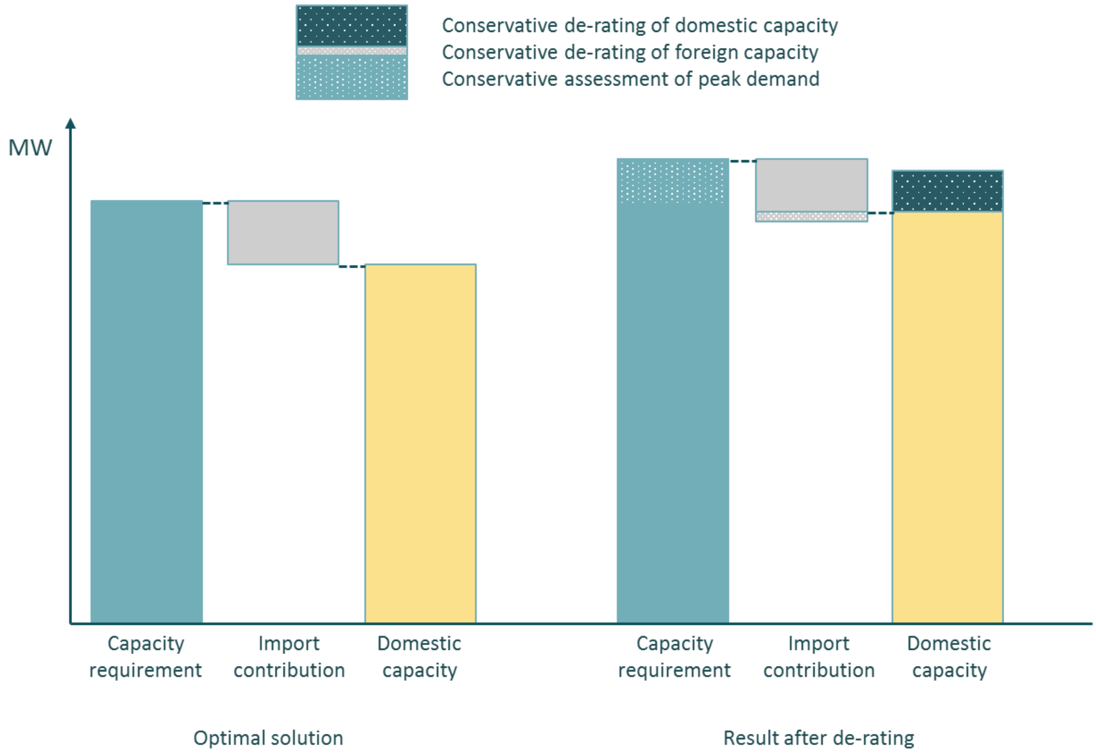
If the capacity requirement is set too high, and the de-rating of providers is too conservative, the result is likely to be too much investments in total, and distorted location of investments in favour of market A. In summary, and as illustrated in the figure below, there are three possible sources of over-estimation of the capacity requirement:

- Conservative assessment of peak demand, leading to an overall too high capacity requirement
- Conservative de-rating of foreign capacity, leading to a too strict de-rating of the import contribution

- Conservative de-rating of domestic capacity, leading to an actually higher than expected domestic capacity

In the figure, the optimal solution is shown on the left. The blue bar shows the expected peak-load requirement, the grey bar shows the expected import contribution, and the yellow bar the required domestic de-rated capacity. The perils of the bias towards conservative assessment is shown on the right. First, the expected peak-load requirement is set too high (over-estimated demand/under-estimated demand response), then the import contribution is set too low due to strict de-rating of foreign capacity, and third, the actual domestic capacity contribution is higher than expected, due to (the same) strict de-rating of capacity.

Figure 2: Sources of over-capacity in capacity mechanisms



The bias towards setting the capacity requirement too high or de-rate the import contribution too strictly could be mitigated by relatively frequent, e.g., annual updating of the capacity adequacy assessment and consequently revising the de-rating. That way, new market developments and changing market dynamics can be taken into account, which allows the TSO to be less conservative when de-rating the import contribution and setting the (annual) capacity requirement. Frequent de-rating also implies that some of the de-rated import capacity should probably be reserved for annual capacity contracts, in order to keep some flexibility for the annual adjustments of the capacity requirement.

The de-rating of import capacity implies that direct cross-border capacity remuneration will be limited to the de-rated import capacity. The impact on the investment incentives in B, does however depend on the accuracy of the capacity requirement in A: If the capacity requirement (including de-rating) is accurately determined, the capacity mechanism in A should also remove distortions related to market price uncertainties for interconnectors. But if the capacity requirement in A is set too high, the investment incentives in B are likely to be weakened due to overcapacity in A.

Recommendation

Efficient calculation of reliable import capacity implies a regional probabilistic approach for generation adequacy assessment. Capacity should be de-rated according to the same principles in all markets and a common approach to scenarios for market developments should be established. As an outcome, a common methodology for de-rating should be established. The common rules should apply to all capacity, both domestic as well as foreign capacity.

De-rating should be updated with at least the same frequency as capacity adequacy assessments in order to take changing market developments into account and mitigate excessive risk aversion in setting the capacity requirement.

The same principles would apply for centralized auctions and decentralized obligation schemes.

4.1.2. B) IDENTIFICATION OF ELIGIBLE CAPACITY PROVIDERS

The main questions regarding eligible capacity providers is how cross-border participation should be spatially limited, e.g. according to grid bottlenecks or simply to adjacent control areas.

Spatial limitation

Generally, all potential cross-border capacity providers should be able to participate, i.e. all providers who potentially contribute to capacity adequacy in stress situations in market A. As emphasized above, prospective cross-border providers should be de-rated according to the same methodology as the one used in the regional capacity adequacy assessment, and for de-rating of domestic capacity. If there are bottlenecks in the grid, however, the possible contribution from providers in a grid area once removed, will be limited in the same way as the import contribution. This implies that participation does not have to be limited to the adjacent control areas only, and that it could even be smaller than adjacent control areas due to internal bottlenecks in the adjacent markets.

It is an empirical and technical question where a limit should be set (see text box for an example). A general recommendation is that the limitation should be set according to the results of the capacity adequacy assessment. For small contributions from very distant market areas, the cost of facilitating participation may however exceed the additional benefit of eligibility. The estimates provided in chapter 5 and 6 shows that the cost of participation can be substantial. The modelling also shows that providers in grid areas once removed from the capacity mechanism may be as important for capacity adequacy in A as providers in adjacent areas. Thus, the limitations on eligibility should be carefully assessed.

Example: Cross-border participation via the NSL interconnector

The Nordic electricity market is well integrated with ample interconnector capacity. Moreover, the combined market is characterized by a high share of flexible hydro power generation, a high share of relatively flexible industry demand, and a relatively comfortable capacity situation.

The combined market area of Finland, Norway and Sweden has interconnectors to Russia, the Baltic States, Poland, Germany, Denmark and the Netherlands. Additional interconnectors are planned, both to existing and new markets, notably Great Britain (GB), and Germany. The extensive trade between the Nordic market and other markets is based on the differences in both generation and demand patterns, which makes trade particularly valuable.

The Nordic countries have a substantial potential to increase the generation capacity relatively cheaply. The potential for capacity expansion in flexible Norwegian hydro power stations is perhaps particularly interesting, but the Nordic countries also have considerable resources in wind and biomass. This potential can only be made available to the European market via interconnectors.

How will the Nordic market be affected if different capacity mechanism schemes allow direct cross-border participation from the Nordic market? Let us use the planned North Sea Link (NSL) between Norway and GB as an example. The NSL is so far the only Nordic interconnector directly to a market with a capacity mechanism under EU jurisdiction.

The direction on the flow from Norway to GB on the NSL will depends not only on the capacity adequacy in the Norwegian market, but also on the situation in Sweden and other interconnected markets as well. Thus, it seems obvious that the contribution of the NSL should be de-rated on the basis of the correlation between the GB market and the aggregated balance in the entire Nordic market.

Cross-border participation in the GB capacity market may have implications for capacity not only in Norway, i.e. the country control zone where the NSL is physically connected. Even Swedish and Finnish generators (and DSR resources) should be allowed to participate in a separate auction.

Participation in several capacity markets

Whether participation should be limited to one capacity mechanisms, is another issue. In the absence of concurrent scarcity situations, it is obvious that capacity in one market contributes to capacity adequacy in other markets as well. This is also what happens in the energy-only market. It is only in the case of perfect correlation of scarcity situations, that foreign capacity does not contribute to stress situations in more than one market. Hence, limiting the participation to one capacity mechanism, would distort investment incentives as long as the foreign capacity provider contributes to capacity adequacy in more than one market with a capacity mechanism.

Consider the situation where it is (fundamentally) profitable to build a power plant in B (or to postpone decommissioning), and where the adjacent market, A and C, both have implemented capacity markets. Due to missing markets in A and C, the investment will not happen without capacity remuneration. Now, assume further that stress situations in A and C are not perfectly correlated. The capacity remuneration is to compensate the missing money (missing market cost) situation in A and C. If the provider in B has to choose between participation in A or C, it will have to bid according to the missing money or total cost of missing markets associated with the combined market distortions in A and C. If the provider is able to participate in both capacity mechanisms, it should allocate this sum between the mechanisms according to the amount of missing money from each of them. If it has to recover all of the missing money from one mechanism, it will not compete on an equal basis with domestic providers and the cross-border distortion would not be corrected.

In principle, the eligible providers should be able to make their own decision about how much to offer in different schemes, depending on the penalties and the nature of the obligation, as well as the de-rated capacity. It should also be kept in mind that de-rating of the import capacity and spatial limitations, as discussed above, implies that the possibility to participate is limited to the relevant markets and the relevant providers. The actual ability to contribute to capacity adequacy in more than one market in a given period would be reflected in the de-rating of interconnections and in taking grid bottlenecks into account.

Allowing participation in more than one capacity market obviously requires a comprehensive and common de-rating covering the relevant market area or region. But, as emphasised above, this analysis is crucial in any case in order to arrive at the proper de-rating values even in models with implicit participation. A de-rating analysis that covers only two adjacent countries at a time will be misleading, and risks overestimating the available foreign capacity.

One may also question whether the ability to participate in several mechanisms gives opportunities for strategic behaviour. As long as the penalty system is properly designed (see other sections below), the de-rating is done according to a regional procedure, and there is sufficient competition, we cannot see that there will be any more opportunities for gaming than already present (if at all) with participation limited to one mechanism. In the event that a capacity provider tries to bid in his capacity at the full "missing money" amount in several mechanisms (i.e. double payment), he risks not to be selected in the auction.

Participation in more than one capacity mechanism rests on an adequate regional approach to capacity adequacy assessment. The de-rating must take proper account of the regional situation. If the de-rated import contribution does not take the regional situation and correlation between stress events into account, there is a risk of mistrust between markets with the result that import capacity might be de-rated too strictly if participation in multiple schemes is allowed.

Under the assumption of adequate regional assessment, however, the efficient solution should allow participation in several mechanisms.

Recommendations

Eligible providers should be identified via the same methodology as the one applied for the de-rating of the interconnector or import capacity, and de-rated according to the same methodology as domestic providers. For practical reasons and in order to contain the costs, the geographic area could be limited. The limitation should also be defined on the basis of the capacity adequacy assessment, and could be smaller or larger than the directly adjacent control areas.

Providers should be eligible to participate in several capacity mechanisms according to the set principles, including common rules for de-rating.

A common registry for eligible participants facilitates de-rating, certification, pre-qualification and testing, and also facilitates secondary trading.

The same principles would apply for centralized auctions and decentralized obligation schemes.

4.1.3. C) OBLIGATIONS AND PENALTIES

The rules for cross-border participation should not discriminate between domestic and cross-border resources. Above, we have argued that rules for de-rating and eligibility should be based on the same principles for domestic and foreign capacity, in order to create a level playing field and ensure efficiency. From the same logic, it follows that the obligations and penalties should also be the same. If the obligations and penalties are more lenient for cross-border capacity, the investment incentives in the market with capacity mechanism will be distorted, while if the obligations and penalties are stricter for cross-border capacity, the opposite distortion will occur (similar to too strict de-rating of cross-border capacity).

The basic principle is that obligations and penalties should be the same, as long as domestic and foreign capacity provides the same contribution in terms of capacity adequacy in A.

Availability or delivery obligation – short term efficiency

When it comes to obligations, there is a basic choice between availability or delivery. Availability implies that the capacity is obliged to bid in the market, and delivery that the capacity is obliged to inject during a stress event. Other features of the obligation, such as the period of the obligation, the nature of the obligation, notice period, limitations and testing, may also differ.

In the Annex, the Commission recommends "a relatively simple availability obligation" in order to mitigate potential distortions of short-term efficiency. Moreover, "careful design of the availability obligation and no or very limited exceptions to it, along with a clear set of procedures for cooperation (and any appropriate remuneration) between TSOs for testing capacity resources would be required to ensure the reliability of contracted resources…"

Testing is required because in theory, technical availability is not necessarily ensured although the capacity is offered in the market. There may be a risk that unavailable capacity is just offered at a very high price, with providers speculating that it will not be dispatched anyway. On the one hand, this implies remuneration to capacity that is not able to comply physically, and on the other hand, it increases the probability that the capacity is in fact not available should a simultaneous stress situation occur. In the latter case, penalties will apply, but the damage, in terms of interruptions and weakening of security of supply, will already be done. Such behaviour will undermine the legitimacy of the scheme.

In the market with a domestic capacity mechanism, the distinction between a delivery obligation and an availability obligation is not significant. Capacity is made available by placing bids in the day-ahead or intraday market. In a scarcity situation the capacity will be dispatched, and thus deliver, unless delivery is impossible due to grid constraints.

For cross-border capacity providers, availability and delivery is not the same. In *non-simultaneous scarcity situations*, the capacity will not necessarily be dispatched in the local (foreign) market solution, because the market, including exports, is served by other, cheaper capacity. Imposing a delivery obligation would then distort the merit order in the foreign market. Thus, this model is in breach of the short-term efficiency criterion. Frontier (2015b) does however argue that this situation is not likely to occur, and thus, the efficiency loss should be small. Basically, this is an empirical question, but the fact remains that this possible distortion can be avoided if an availability obligation applies.

Consider the situation where there is a *simultaneous scarcity situation*, and the flow on the interconnection is not going in the right direction according to the market solution. All resources in B generate up to their de-rated capacity, whether the obligation is to be available or to deliver. However, A does not receive the corresponding flow. Still, no penalties apply. It is clear that the obligation on providers in B (be it availability or delivery) does not represent comparable value in terms of security of supply for market A. For A, the provision from foreign providers seems to be worth less than the provision from domestic providers. Again, it could be argued that this situation is not very likely to happen in reality. (See discussion on the likelihood of conservative de-rating in section 4.1.1.) If there is a significant probability of non-delivery from B, this would be reflected in the de-rating of the interconnection capacities. Even for domestic providers, availability or delivery is not guaranteed in all scarcity situations. However, domestic providers will be penalized in the case of non-delivery (even with an availability obligation), while no-one will be penalized for non-delivery cross-border (as long as the availability obligation is fulfilled).

The availability obligation could in principle affect the planning of maintenance, i.e. instead of planning maintenance only based on expectations for the domestic market, successful providers would take the probability of a stress event in A into account, even if it would not affect the likelihood of imports to A.

The model proposed by Mastropietro et.al. associates the penalty with the actual delivery from B to A. Their proposal implies that the penalty only applies if the interconnection flow is in the wrong direction (or not up to the full de-rated cross-border capacity obligation) and the cross-border provider is not delivering. Moreover, they argue that whenever the flow is in the wrong direction during a stress event, this must be due to some market distortion: If there is a stress situation in A, and the flow is going in the opposite direction or the interconnector capacity is not fully used for imports to B, while there is available unused capacity in B, the market solution must be inefficient. Then, their conditional nomination model implies that if the capacity is available, this distortion will be corrected. The obligation should incentivize participating generators in B to activate the conditional nomination and to increase generation. Now the question is, who will be the participating generators in B? A generator who is likely to generate during a stress situation in A, cannot expect to increase its generation if a stress situation is called. Hence, participation will be beneficial mainly for the generators who may expect to fall victim of the market distortion. (In principle, a generator who is generating at full capacity, may pay other generators to increase their generation, e.g. by buying in the intraday market.)

The original distortion (stress event in A with flow in the wrong direction) does however rest on the assumption that the price cap in A is too low. If scarcity pricing is not capped in A, i.e., if the distortion is missing markets (e.g. for hedging) this situation should not occur, according to Mastropietro et.al., unless there is a simultaneous stress event in A and B.

Hence, we conclude that the obligation should be availability, as this does not risk to jeopardize the short-term efficiency of the local market, while it should not affect the probability that the interconnector flow is in the right direction during scarcity.

However, this does not solve the challenge that the cross-border provision is not comparable to the domestic provision.

Unless the capacity remuneration due to cross-border participation strengthens the incentives to invest in B in an efficient manner, A is paying for generation that would flow from B to A even in an implicit participation model. In that case, the criterion that cross-border participation should reduce the costs of the capacity mechanism for consumers in A is also not fulfilled.

Moreover, the penalties should also be designed so as to reflect the capacity requirement and the corresponding VoLL, for both domestic and foreign capacity.

Long-term efficiency

According to the discussion above, the real test of the efficiency of cross-border participation is its impact on investments in B. Will the capacity remuneration stimulate (the right) investments in B? Here it should be noted that the participation is limited by the interconnection capacity between A and B and the *expected* import contribution. The less the expected import contribution, the fewer providers will receive capacity remuneration in B. Will it be the right providers who receive the remuneration? We discuss this further in section 4.1.4 and 4.1.9.

As mentioned above, a number of design features may differ when it comes to the obligation, whether it is to be available or to deliver. As the security of supply challenges may differ between markets, it makes sense that the obligations differ between the markets as well. As the capacity adequacy assessment and de-rating of interconnections would show the nature of the challenges, and the possible concurrence of situations, there should, from an efficiency point of view, be no reason why these features should be harmonized between capacity mechanisms. The capacity mechanisms should incentivize both the right capacity mix and the right level of total capacity. If providers have to choose between different capacity mechanisms, or divide their capacity between capacity mechanisms, the long-term investment signals would be distorted, and the result may be too much capacity and an overall suboptimal capacity mix.

Recommendation

The obligation for cross-border provision should be availability, with appropriate testing of participants.

Providers should be allowed to participate with the same capacity in more than one capacity market. Proper regional de-rating should cater for efficiency in this respect.

Providers should face the same penalties for non-compliance as domestic participants.

The same principles would apply for centralized auctions and decentralized obligation schemes.

4.1.4. D) Competitive Process for Allocation of Import Capacity

Once the de-rated cross-border capacity and the eligible providers are defined, the actual cross-border providers must be chosen. The total capacity of the eligible providers will per definition (according to the principles for de-rating) be larger than the de-rated import capacity, which constitutes a cap on the total capacity provision from B. The efficient solution would be to base the choice of providers on a market mechanism, where the providers bid for the import capacity. This scheme should also be seen in connection with the remuneration to the interconnector operators (section 4.1.9).

According to the Annex, there are two possible models for allocation of the import capacity in a centralized auction scheme:

- Explicit auction, where the de-rated import capacity is auctioned in advance of the capacity procurement process (capacity auction in A). In the admission auction, the bidders in B receive a "ticket" giving admission to the capacity market in A. The revenues from the admission auction accrue to the interconnectors.
- Implicit auction in centralized auction model: Foreign providers bid directly into the capacity auction in A, but a separate price is established for each zone according to the import limitation (de-rated import capacity) and the marginal bids. The interconnectors receive the implicit "capacity congestion rent" according to the difference between the marginal capacity prices in A and B.

The Annex concludes that an implicit admission auction is likely to be the most efficient solution since it eliminates any "basis risk" associated with the "ticket" model., i.e. the risk associated with having to guess the outcome of the capacity auction in A, and the risk that market conditions change between the admission auction and the capacity auction. The higher the risk, the lower the admission price, and hence, the remuneration to the interconnector owner.

Short-term efficiency implies that admission is allocated to the cheapest resources. Below we discuss the incentives to bid for admission in the different auctions.

Explicit "admission" auction

First we assume that a competitive auction for the admission ("ticket") to the cross-border capacity mechanism is held in B. The auction is limited to the de-rated import capacity (supply). Successful bidders in the admission auction are eligible to participate in the capacity auction in A. The income from the admission auction accrues to the interconnector as a capacity congestion rent. The obligation for successful bidders is to be available (bid) during stress events in A. We assume that availability is demonstrated by placing active bids in the day-ahead or intraday market. In order to determine whether to bid, the potential providers must assess the value of participation in the capacity mechanism in A. The de-rating of the interconnector capacity reflects the expected exports from B to A during stress events.

The cross-border contribution, or likelihood of imports to A during stress events, depends on the market solution in B. We expect that all reliable providers would bid for import capacity corresponding to their (de-rated) capacity, and subsequently would want to offer that capacity in the capacity market auction in A. Depending on the details of the obligation (period, nature, notice, etc.) it is to be expected that base-load capacity, and capacity which is easily activated, in general, runs the lowest risk of non-availability, and hence, exposure to penalties. So, we could expect that these resources would be willing to bid the highest price for the admission to the capacity auction in A. The expected value of participating in the capacity auction in A is equal to the willingness to pay for admission, $WTP_{admission}$:

$$E(p_{CM}) - CP_i - E(P_i) = WTP_i^{admission}$$

Where $E(p_{CM})$ is the expected capacity price (in A), CP_i is the participation cost and $E(P_i)$ the expected penalty for provider *i*. $E(P_i)$ is a function of the probability of non-compliance.

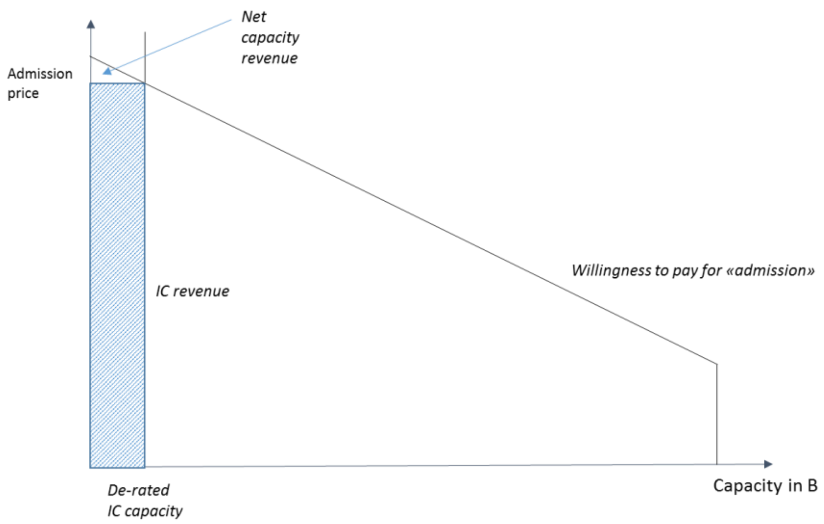
The de-rating reflects the reliability of the provider. For example, if there is a 20% chance that the capacity will be available, the risk exposure of participating is reduced by the de-rating (only 20% of capacity can be offered), but the provider can also expect to be unavailable in 4 of 5 stress events and thus be liable for the penalty. An 80% de-rating on the other hand reflects that the capacity will be available in 4 of 5 stress events, and only liable for penalty in 1 of 5 events. Hence, in theory the demand function for the de-rated interconnector capacity will reflect the de-rated capacity of the prospective providers, the expected per MW capacity remuneration and the expected penalty.

The expected penalty depends on the subjective probability that the penalty will apply. If the de-rating is perceived as too strict and the capacity requirement perceived as too high, the provider may expect a lower probability for penalty than what is implied by the de-rating.

If, on the other hand, the participants perceive the risk to be high related to the capacity remuneration, i.e. the result of the actual capacity market auction (i.e., the basis risk mentioned in the appendix to the sector inquiry), they may reduce their bids accordingly. The result will be that a lower share of the revenue accrues to the interconnector operators. In essence, the interconnector owner bears the cost of uncertainty.

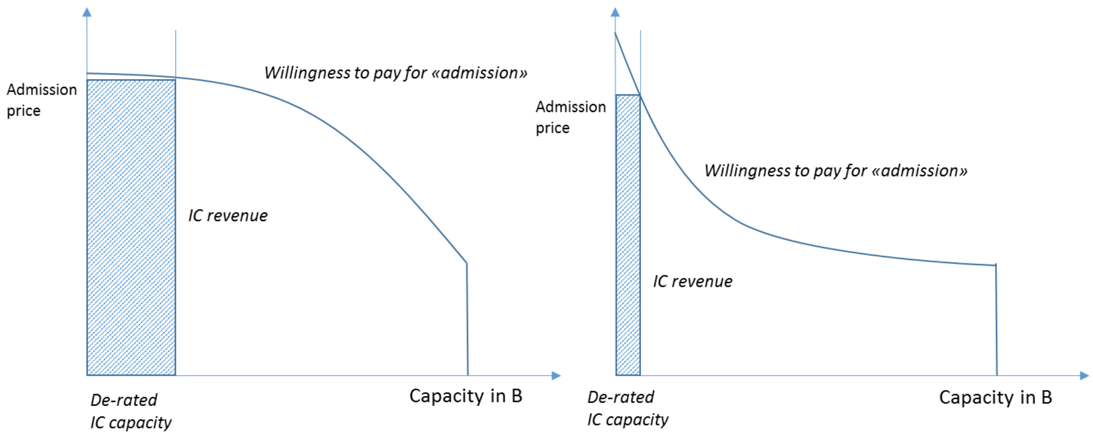
In a competitive market, we expect the admission price to be settled according to the marginal bid, and that the revenues from the auction will accrue to the interconnector operator. Figure 3 below illustrate two possible market solutions.

Figure 3: Illustration of theoretical price formation in an explicit "admission" auction



The net capacity remuneration to providers depends on the shape of the wtp-curve. If there is a lot of capacity, or a lot of capacity with similar cost and availability characteristics in the market, compared to the de-rated interconnection capacity, the capacity remuneration is likely to be smaller. Hence, the shape of the wtp-curve affects the net capacity remuneration. The impact of the shape of the wtp-curve is illustrated in Figure 4. The panel on the left-hand side represents a situation with a low probability of simultaneous scarcity in A and B, while the panel on the right-hand side represents the situation with a higher probability of simultaneous scarcity in A and B. This is also reflected in the de-rating of the IC capacity.

Figure 4: Price formation in explicit "admission" auctions with different de-rating and wtp curves



The shape of the wtp-curve is an empirical question, but we argue that the capacity situation in B is likely to affect both the de-rating of the import capacity and the bidding for admission:

- If the capacity situation in B is expected to be ample during stress in A, the probability of imports during stress events is high, and the de-rating of cross-border capacity should be close to the technical availability of the interconnector (wider bar). Correspondingly, the competition for the available capacity should be fierce (flat demand curve), as many providers in B expect to be available during stress in A.
- If the capacity situation in B is more likely to be scarce during stress in A, the probability of imports during stress events is lower, and the de-rating of cross-border capacity is lower (thin bar). Correspondingly, there may be fewer providers in B that have a high probability of being available during stress in A (steep demand curve).

In both cases, the de-rated interconnector capacity is small compared to the total de-rated generation capacity in B. It is difficult to imagine that this would not be the case in real-life situations.

Implicit auction

In an implicit auction, the providers offer their capacity into the same auction as domestic providers, according to their de-rated capacity. However, the cross-border provision is capped by the de-rated interconnector capacity. If the market is competitive, the providers should offer their capacity at the minimum price. The minimum offered capacity remuneration should equal the cost of participation plus the expected penalty for non-compliance, i.e.

The (annual) profit for the provider in B if it does not participate in the capacity auction is

$$\Pi_i = (p_B - c_i)X_i$$

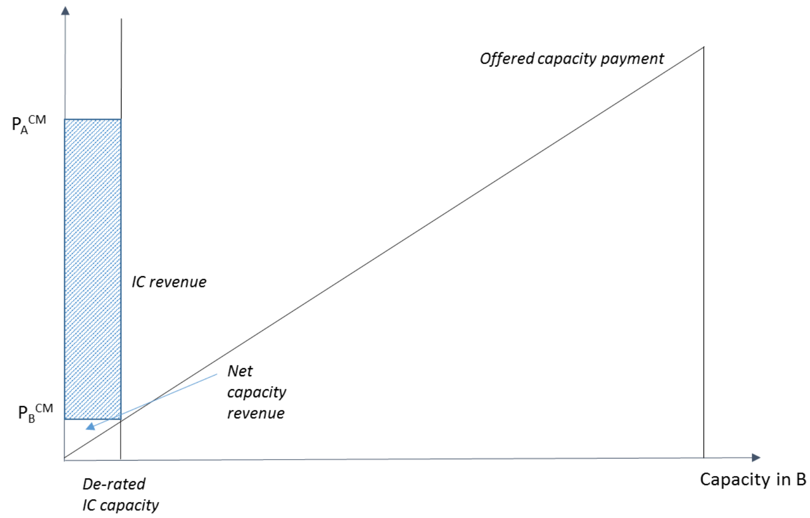
Where Π_i is the profit of generator i in B, p_B is the annual revenue per MW, c_i is the annual operation cost per MW, and X_i is the capacity of generator i.

In order for generator *i* to be willing to participate in the capacity auction, its expected annual revenue must be higher than the expected costs associated with the capacity mechanism, i.e. the capacity offer of generator *i* is

$$CM_{bid} \geq CP_i + E(P)$$

For existing providers, the bid would again depend on the expected penalties, as in the "admission" auction. In this set-up however, the providers would not bear the uncertainty regarding the expected capacity price. Hence, the revenues accruing to the interconnector should be higher in this case. As in the explicit admission auction, the bidders who expects the lowest (per MW) penalty are more likely to be successful bidders.

Figure 5: Illustration of theoretical price formation in implicit cross-border capacity auction



Again, the result depends on the shape of the bid curve, which is an empirical question. The "basis risk" should however be removed in the implicit auction. Hence, there is a higher probability that the appropriate share of capacity remuneration accrues to the interconnector owner.

Hence, for the long-term efficiency of the capacity mechanism, it is crucial that appropriate revenues accrue to the interconnector, and that the capacity remuneration affects the willingness to invest in an appropriate manner.

Investment incentives

The next question is if the cross-border capacity remuneration would strengthen security of supply, i.e. strengthen investments signals in B. If so, the de-rated cross-border capacity should increase over time. This could happen because more interconnector capacity is built between A and B, or because more generation capacity is built in B, than without cross-border participation.

In the case with ample provision from B (cf. the bullets above), assuming a competitive solution, the capacity revenues would accrue to the interconnector owner, and the incentives to invest in interconnectors should ideally be strengthened. In the case with a tighter capacity situation in B, the remuneration to the interconnector will be lower, as the import capacity is de-rated more strongly. The revenues accruing to the interconnector is correspondingly lower. This is efficient, as in this case, the de-rating reflects that the scarce resource is capacity provision in B.

If there is a large volume (MW) of low-cost providers in market B (low cost in terms of high availability), and the competition can be expected to be fierce (left hand side of Figure 4), there may however be a risk that eligible providers will be reluctant to bid for the admission. The market perception may be that no one will make any money from the auction anyway. On the other hand, if the admission cost is low or zero in the first auction, more bidders may be attracted to the next auction, thereby increasing the price.

There is however a risk that no stable equilibrium can be established. This may also imply that the interconnector revenue is reduced compared to the efficient solution.

In the second case (cf. bullets above), where generation capacity is the scarce resource in B, few providers will correspondingly receive the capacity remuneration. Thus even in this case there is a risk that most of the capacity remuneration will accrue to the interconnector owner, thus failing to incentivize efficient capacity investments in B. As long as they do not face a penalty for not meeting the obligations, i.e. associated with flows from B to A during stress, all providers with a high probability of being available are likely to be willing to bid, even if they are already profitable based on prices in B.

Let us look at the incentives for new investments. Would the cross-border capacity remuneration incentivize new investments in B? A new capacity provider (investor) would offer its capacity at

$$CM_i^{bid} = I_i + C_p + E(P) - E((p_B - c_i)X_i)$$

Where I_i is the annual investment cost (cost of capital).

We assume that the provider would not invest without the capacity remuneration. Hence, for this provider, the bid will be higher than the costs associated with the capacity auction, as it will not, per definition, cover its investment costs based on the revenues from market B only. The bidder will be successful if the required capacity revenue is lower than the net capacity revenue bids from the existing providers.

If new investors are successful in the capacity auction in A, the net capacity in market B will increase. With this expectation, the de-rated cross-border capacity should increase, and so should the net capacity revenue.

Now it should be clear that the de-rating of cross-border capacity and the assumptions made about the available capacity in B (and the relevant market region) in the capacity adequacy assessment, has a significant impact on the outcome. The assumptions about the investment climate in B, and the probabilities assigned to decommissioning and investment behaviour, plays a crucial role and must be carefully designed.

If cross-border participation in capacity mechanisms does affect investments in B, it will also affect market prices and trade, and not only in scarcity situations. The new investments may crowd out other capacity, but there should be a net benefit as the new capacity is all in all more profitable than what is crowded out.

The effects on investments depend on the capacity mix, the de-rating, the penalty structure, and a number of other design parameters. There is a real risk that the clearing price for capacity in B in the implicit capacity auction will be zero or close to zero, in which case the interconnector owner is likely to reap almost the whole benefit of the capacity remuneration. In most markets, a large portion of the existing capacity would have a high probability of being available during stress events in A. Capacity with a low probability of being available, would have a low level of de-rating and a high probability of being penalized. For most generators, however, the risk of being penalized is probably very small as long as the stress situations are predictable, and the only requirement is to bid into the market.

Decentralized obligation

For decentralized obligation schemes, the Annex proposes two alternative models as well:

- Implicit auction: An auction is held in which foreign capacity providers offer their capacity and domestic suppliers offer to buy it, for example via an exchange.
- Direct selling to suppliers: Foreign capacity providers offer their capacity directly to suppliers. Exchanges may be able to help limit trade to the maximum import capacity – for example if foreign capacity providers were required to trade on exchanges.

The difference between the two models seems to be that in the first one, specific auctions for foreign capacity provision are organized, e.g. once a year or more frequently, and the total volume is limited to the de-rated import capacity. In the second one, the capacity (certificates) are traded continuously, but each trade has to be notified to an exchange or other body to make sure that the de-rated import capacity is not exceeded. Both models would facilitate cross-border participation. If domestic capacity is traded continuously, foreign capacity should probably be so as well.

The remuneration to foreign capacity could be different in the two models:

- In an implicit auction, the foreign providers would directly compete to sell capacity to domestic suppliers, while the domestic suppliers will be willing to pay up to the expected price of domestic capacity certificates. It would depend on the design of the auction how the price will be determined. Also, there would be a sort of "basis risk" in this model, as the price bid would be affected by domestic suppliers' expectation about future certificate prices.
- In the direct selling model, foreign providers may expect to get the domestic price, as the domestic suppliers should not be biased towards buying domestic certificates.

It is however not clear, in any of the models, how remuneration will accrue to the interconnectors. In principle, market prices could be registered, thereby signalling the value of increased interconnector capacity.

In the direct selling model, an explicit auction may be held to allocate the import capacity to foreign providers, in the same manner as in the centralized auction scheme, i.e., in order to sell capacity to domestic suppliers, the providers may be required to first purchase an admission "ticket". This way, the ticket revenues could accrue to the interconnector owners. However, the risk would be higher than in an implicit auction, cf. the discussion above.

If the ticket auction is only held for example once a year, the "basis risk" increases, while if auctions are held frequently, the number of participants in the auction, and the auctioned volume, may be too small to provide efficient pricing.

Without auctioning, it is difficult to see how capacity revenues could accrue to interconnectors. However, the explicit auction is not likely to yield an efficient distribution. Thus, in this model, the capacity remuneration to foreign providers may be too high, not fully reflecting that the interconnector is the scarce resource.

Recommendations

It seems clear from the discussions above, that the implicit capacity auction is likely to be more efficient than the explicit "admission" auction. The reason is that the explicit auction introduces an additional uncertainty for providers, and thus is less efficient in allocating capacity revenues between providers and the interconnector operators.

Here, the same model should not be chosen for centralized auctions and decentral obligation schemes. Implicit auctioning of import capacity does not seem to be suited for a decentralized obligation scheme. For decentralized obligation schemes, an explicit "ticket" auction could be used to allocate revenues to the interconnector owner.

4.1.5. E) TRADING OF THIS INTERCONNECTOR CAPACITY ONCE ALLOCATED

The recommended allocation of interconnector capacity does not give access to the interconnector per se, but is a ticket giving providers in B admission to the capacity mechanism in A. In the implicit auction, there are no "tickets" to trade, as the allocation is made as a part of the capacity auction in A. The rules for trading the capacity obligation should in this case be the same as for domestic providers in A.

Hence, the trading of interconnector capacity applies to the implementation of explicit auctioning, which we recommend for the decentralized obligation scheme. With the different timing of the admission auction and the selling of the capacity certificate, it may be that holders of "tickets" are for some reason not successful in selling their capacity certificate, perhaps because they expected a higher price at the time of the auction, or because they find that they will not be able to meet their obligation. In that case, they should be able to sell the "ticket" to another prospective cross-border provider.

As noted in the Annex, some kind of registry or notification procedure is probably required to enable secondary trading of admission "tickets" and to keep track of who holds certificates. This should be possible to organize together with the certificate registry. Trade could be limited to prequalified providers, but could also be open to speculative trade.

Recommendation

Secondary trading should be allowed for explicit "ticket" auctions, and could be open for speculative trading.

4.1.6. F) OBLIGATIONS AND PENALTIES ON INTERCONNECTOR OPERATORS

In a generator model, the interconnector does not participate, and the interconnector will not have the ability to influence flows (see also the discussion in section 4.1.7). However, concern has been raised about the interconnector owners' incentives to make the connection available during stress events. The question is whether interconnector owners should be treated as involuntary participants and be subject to penalties in the event of non-availability.

We discuss this question for three different cases:

- Merchant cables
- Merchant cables subject to a cap and floor regime
- TSO-owned interconnectors

We start out by discussing merchant cables as this case is relatively straightforward compared to the regulated TSO case.

A merchant cable will earn revenues from congestion rents and other income from physical trade of electricity, e.g. exchange of balancing services and remuneration related to generators' participation in cross-border capacity mechanisms. The general incentives for being available are therefore in place. Also, a cable that tends to be unavailable will be penalized through the de-rating procedure (provided that de-rating is updated frequently). A penalty related to cross-border capacity mechanisms is therefore not likely to influence the overall availability of the interconnector.

The timing of maintenance and other operational decisions is another issue. In principle, a penalty mechanism may influence these. However, we consider that the likelihood and timing of stress events will be predictable or known in advance, for instance from capacity adequacy assessments carried out by the TSOs. These events will typically yield a high value of interconnectors through high price differences, assuming energy markets are coupled and efficiently designed. The interconnector owners will therefore have incentives for optimal timing of maintenance and being available at times of system stress.

Another issue is the impact of a penalty for interconnectors on the incentives to invest in interconnectors. Expected penalty remuneration under a cross-border capacity market will reduce the profitability, *cet.par.*, i.e. constitute an implicit risk premium that reduces interconnector investments compared to the efficient level.

Also, licence conditions as well as regulatory and technical requirements may limit the degrees of freedom on the part of the interconnector owners, reducing the potential incentive effect of a penalty even further.

A final complicating factor is the EU regulation of interconnector revenues as set out in Regulation 714/2009. According to Article 16,

> "Any revenues resulting from the allocation of interconnection shall be used for the following purposes:
>
> (a) guaranteeing the actual availability of the allocated capacity; and/or
>
> (b) maintaining or increasing interconnection capacities through network investments, in particular in new interconnectors.
>
> If the revenues cannot be efficiently used for the purposes set out in points (a) and/or (b) of the first subparagraph, they may be used, subject to approval by the regulatory authorities of the Member States concerned, up to a maximum amount to be decided by those regulatory authorities, as income to be taken into account by the regulatory authorities when approving the methodology for calculating network tariffs and/or fixing network tariffs."

It would seem reasonable to assume that revenues from cross-border capacity mechanisms accruing to interconnectors would be subject to the same regulatory requirements as e.g. congestion rents. For a merchant cable, the regulation means that there may be an implicit cap on total revenues which means that the marginal availability incentives are zero. Revenues in excess of costs may be used for new interconnector capacity and thus create incentives for more investment when viewed in isolation. However, the cap on revenues will also alter the risk/reward perception of a merchant cable investor and create disincentives. The net effect of the regulation on interconnector investment incentives are therefore not possible to assess on a general basis.

In sum, we consider that the basic incentives for availability in stress situations are in place, although there are several complicating factors. The negative investment incentives from penalties levied on interconnectors should also be taken into consideration.

For a merchant cable subject to a cap and floor regulation (such as BritNed) the basic incentive mechanisms are similar to the pure merchant cable case discussed above. However, under a cap and floor regulatory system the congestion rents are capped, while there is a minimum level of congestion rents also (through transfers from the TSO). In the event that the cap or the floor are binding, the marginal incentives for the interconnector owner are zero. This does not alter our conclusion regarding the total incentive effects, which are the same as for pure merchant cables.

For a TSO-owned interconnector, expected penalties may influence the decision to invest in more interconnector capacity depending on the investment criteria and the overall regulatory framework.

For a regulated TSO, the availability incentives depend on the regulatory model applied:

- The extreme case would be full pass-through of all costs, including any penalties for unavailability, meaning that the TSO has no incentives at all. This is increasingly an unrealistic scenario, although the incentives may not be much stronger with other regulatory regimes.
- Under a more developed regulatory system, revenues from capacity mechanisms to an interconnector owner are likely be treated symmetrically with other congestion revenues, cf. Regulation 714/2009. The TSO may then in practice be indifferent to the revenues from a capacity mechanism that arise directly or indirectly from the participating generators. The incentive to ensure availability would then only be affected by any penalties imposed on the TSO in case of non-availability. These incentives will depend on the general incentive power of the system (the degree of pass-through of penalty costs and revenues from capacity mechanisms), i.e. the length of the regulatory period, efficiency requirements etc.
- However, one could also include IC availability in an incentive mechanism in the regulation. Some TSO regulatory regimes include similar mechanisms for outages that can be used as a starting point for designing incentive mechanisms for interconnector availability as well (GB and Norway are two specific examples, Sweden also).
- The TSO will however also be subject to licence requirements and other technical regulations that reduce the risk of unavailability. Furthermore, the regulator should be able to monitor interconnector availability and operations, reducing the risk of suboptimal behaviour by the TSOs.
- Finally, weak incentives to make the cable available during stress events should also be reflected in the de-rating of the interconnector capacity.

With regard to availability incentives, we draw the same conclusion for TSO-owned interconnectors as for merchant cables.

An issue regarding penalties on interconnectors in a generator model is the cross-jurisdictional aspect. Assume that country A (with a capacity mechanism) applies penalties to an interconnector owner in B because generators in B do not meet their obligations in A. In order to ensure that penalties will actually apply across borders, provisions would be needed through binding agreements between the participating countries or through a set of EU-wide rules that oblige TSOs to pay penalties when applicable.

Recommendation

Putting obligations and penalties on interconnectors in a generator model is not recommended. We cannot see that such penalties provide significantly stronger incentives for making capacity available. Rather, there is a risk that penalties will weaken the long-term incentives to invest. The general regulatory framework for TSOs and other interconnector owners should be used to ensure availability.

4.1.7. G) RULES FOR INFLUENCING INTERCONNECTOR FLOWS

The question we discuss in this paragraph, is whether there is a need for rules for influencing interconnector flows in order to ensure that power flows physically to the market with a capacity mechanism in the event of scarcity. The general rule is clearly that the short-term efficiency should not be distorted, i.e. flows should be determined according to the short-term energy market solution and not be influenced by the capacity mechanism.

First, we note that a merchant cable cannot influence flows in any case. Thus, we move on to discussing the TSO case. The TSO cannot make consumers reduce their consumption or generators increase their generation except through the use of different types of balancing products, and then only to solve specific issues in daily system operations (i.e. manage security constraints and handle internal bottlenecks). This will in normal circumstances not influence the flows. In general, the TSOs can influence flows in two ways:

- Directly through changing the flow on DC interconnectors and using phase shifting transformers
- Indirectly through the setting of capacity limits (ATCs), PTDF’s and similar measures

Changing the flow on DC interconnectors is physically possible, but will have significant impacts on the underlying physical markets as generation and consumption will have to adjust through the price mechanism either in the energy-only or the intraday market. Short-term efficiency may be significantly distorted as a result.

With regard to the ability to influence flows indirectly, the main tool would be the setting of capacities internally, i.e. moving bottlenecks to the border and similar measures. This could impact both the volume and the direction of flows. We expect the evolution of the Network Codes and the implementation of the Target Model, as well as the introduction of flow-based market coupling, to limit these possibilities significantly in the future. The general EU rules will also mean that the power is highly likely to flow to the system experiencing a scarcity situation. Hence, we do not see the need for specific rules to ensure flows in the right direction.

Another issue is what distribution of exports from B should be expected across different interconnectors during stress events (provided that there is scarcity in more than one market). A lot of the discussion on cross-border participation is concerned with these simultaneous stress events. However, there will always be a chance of such events happening, and they will eventually have to be handled outside the market. No capacity is guaranteed, and the penalties for non-compliance should yield the proper incentives to manage the risk of capacity inadequacy. Basically, a capacity mechanism does not pay for guaranteed delivery, but for a reduced risk of stress or scarcity. If stress events occur according to the reliability standard, it means that the capacity mechanism has delivered according to the remuneration paid. This does not mean that it is not relevant to clarify what happens in the case of a simultaneous stress event and how resources are to be allocated.

The model assessments should determine the flow in simultaneous stress events as well. It should be noted that VoLL estimates, if different, should enter the picture from an efficiency point of view. From an overall efficiency stand-point, the scarce resources should be allocated to the uses with the highest value, as reflected by VoLL. In practice, the same principles should apply to scarcity situations with or without capacity mechanisms.

It could be argued that in case one market has paid for the capacity (via a capacity mechanism), it should also have some kind of priority in case of scarcity. However, implementing a capacity market does not imply that capacity adequacy is guaranteed in real time, but that the probability (risk) of inadequacy is reduced in the longer term. Hence, what is crucial, is that the capacity market incentivizes increased investments in domestic and/or cross-border capacity. A capacity market does not pay for capacity per se, it pays for increased security of supply. From a legal point of view, it is also very complicated to impose obligations on foreign TSOs to curtail loads in their own country during a simultaneous stress event, as this measure will be subject to national law. Technically it will also be difficult to alter flows across an interconnector even on a DC cable, as it necessitates significant changes in generation and/or consumption.

In the event that power flows from the market with a capacity mechanism during simultaneous stress, the conditional nomination method suggested by Mastropietro et al. (2015) could form the basis of rules for allocating the available transmission capacity. The assumption would then be that the short-term market signals are distorted at the outset (i.e. too low price cap in the country with the capacity mechanism), as discussed in chapter 3.

Recommendation

The general EU framework for market coupling in the energy-only market, as well as Network Codes on inter alia Electricity Balancing, should be adequate to ensure optimal power flow in stress situations. The flow on interconnectors should follow from short-term efficiency considerations. If the short-term market does not provide efficient flows (cf. the example provided by Mastropietro et.al.), the conditional nomination model could be applied. When it comes to simultaneous stress situations, general rules for the allocation of interconnector capacity must apply anyway.

4.1.8. H) Paying for foreign capacity

This issue is related to the allocation of the costs of the capacity mechanism and the issues that may arise if the consumers in the country with the capacity mechanism pay for foreign capacity that may also benefit foreign consumers.

From an economic point of view, the main principle should be that the consumers in the country with the capacity mechanism should pay for the capacity costs regardless of whether the remuneration goes to domestic or foreign generators (or interconnectors). This can be viewed as an implementation of the polluter pays principle.

Clearly, any foreign capacity benefitting from the capacity mechanism will also benefit consumers in the foreign market. However, this will also be paid for by the foreign consumers through the energy and balancing markets. As such, we consider that any free-rider problems will be small or non-existing.

Assuming that the capacity requirement is set correctly, the allocation of costs should not be an issue. If the capacity mechanism in one market contributes to security of supply in another market, this should be visible from the regional capacity adequacy assessment. If there are capacity inadequacy issues in both (or several) markets, a common capacity mechanism should be considered, or, if one market does not opt for a capacity mechanism, rules for the use of resources in stress situations (in B, spilling over to A) could be developed (cf. the previous paragraph).

At the same time, any penalties paid by foreign capacity providers should go into the financing system and in practice be refunded to the consumers in the country with the capacity mechanism.

Recommendation

We recommend that the consumers in the market with the capacity mechanism pay the costs of capacity remuneration to foreign providers, and that penalties paid by foreign providers are refunded to the market with the capacity mechanism.

4.1.9. I) APPROPRIATE REMUNERATION FOR INTERCONNECTOR CAPACITY

The remuneration to interconnectors in generator models have been discussed in above, in particular in section 4.1.4.

The discussion implies that the model most suitable for efficient allocation of the capacity remuneration in generator models, is the implicit auction where the "capacity congestion rent" accrues to the interconnector. Whether this will work in practice, depends on the incentives for cross-border capacity providers to place efficient bids in the auction. For each foreign market, there is likely to be a large number of eligible providers, with a total capacity way above the de-rated import capacity. In theory, most of the capacity revenue is likely to end up with the interconnector, although the revenue will be limited by the de-rating of the import capacity. Hence, the willingness to participate in the capacity auction may be muted if the participants expect that the stakes are low and uncertain, and in particular, if the costs of participation are high.

In the decentralized obligation scheme, it is doubtful that the interconnectors will be efficiently remunerated, as an implicit auction is not compatible with the capacity market design.

An alternative approach would be to let the interconnectors participate directly in the capacity mechanisms, as in the interconnector models proposed by Frontier (2014a, 2014b) and Tennbakk and Noreng (2014). Interconnectors could participate both in centralized auction schemes and decentralized obligation schemes. Interconnector models may display several advantages:

- It is easy to identify the eligible participants
- The capacity revenues accrue directly to interconnector capacity, and should strengthen the incentive to invest in new interconnectors if profitable
- The interconnector operator has a clear incentive to make the capacity available under stress
- With a delivery obligation on the interconnector it is straightforward to compare the import provision with the provision from domestic participants
- Increased interconnector capacity improves cross-border price signals, which benefit all capacity providers in the foreign market (or market region)
- Participation would naturally be limited to the interconnectors providing import capacity to A

One main objection to interconnector models is the role of TSOs and interconnector operators as market participants, and the risk that they will have an incentive to manipulate short-term flows on the interconnector, i.e. that the short-term market solution will be distorted. This may be particularly relevant with a delivery obligation. Obviously, it is important that this does not happen and that appropriate rules and penalties are developed.

Another objection is that in interconnector models an appropriate share of the capacity revenues may not accrue to capacity providers. However, the extent to which this is the case, depends on the accuracy and efficiency of the definition of the capacity requirement and the de-rating, and the extent to which other market distortions are removed by the IEM and the implemented capacity mechanisms.

Finally, it should be noted that the incentives to invest in interconnectors depend on several factors, not just the revenues from the capacity mechanisms. In general, investment will depend on the overall costs and benefits and the link between benefits, costs and TSO (or merchant cable) revenues through the regulatory regime, cf. the discussion under F) above. This includes any limitations on the use of congestion rent or capacity remuneration payments.

Recommendations

In general, implicit admission auctions should allocate capacity remuneration to interconnectors more efficiently than explicit admission auctions in models with direct cross-border participation. Implicit admission auctions are however difficult to organize in de-centralized obligation schemes.

In order to make sure that interconnectors are properly remunerated, however, models with indirect participation should be considered.

4.1.10. J) RULES FOR TSO COMPLIANCE

It is obviously crucial to develop the rules for the TSO conduct and responsibilities in any cross-border participation framework. The TSOs' incentives and obligations are crucial for the trust in the cross-border contribution. As discussed under F) and G) above, we consider the incentives and obligations for making interconnector capacity available and ensuring correct flows to be adequate under the general regulatory framework.

However, to ensure full compliance, a common set of EU rules, for instance founded in Network Codes or other Regulations, is desirable. The lack of common rules means that the enforcement of the cross-border regimes will depend on bilateral agreements which will not be as efficient (neither with regard to costs nor the level of compliance achieved). We have not looked into the details of such a compliance regime, but such a regulation should be developed.

Recommendation

We recommend that a common set of EU rules for ensuring TSO compliance with the rules for cross-border capacity mechanisms is developed and integrated as far as possible in existing Network Codes and other Regulations.

4.2. COMMON FRAMEWORK VS. HARMONIZED FRAMEWORK ELEMENTS

Based on the discussion under each of the framework elements above, we can now assess how the two options for a common framework for capacity markets can be carved out:

- Option 1: A harmonized EU framework for cross-border participation in individual capacity mechanisms
- Option 2: Further harmonization of the basic elements for different capacity mechanism models

Option 1 implies designing a harmonized EU framework that focusses only on cross-border participation in individual capacity mechanisms. Capacity remuneration and other elements of the overall mechanism would still be decided individually by each Member State. Current capacity mechanisms could stay as they are, but rules for cross-border participation must be applied in compliance with the framework.

Option 2 implies that, in addition to clarification of the rules for cross-border participation, the framework would set rules for the basic elements of each category of capacity mechanism models. The question is if such a framework could further enhance the effective participation of foreign capacity.

4.2.1. OPTION 1: A COMMON FRAMEWORK FOR CAPACITY MARKETS

Table 3 sums up the framework regulations that could apply to both centralized capacity auctions and decentralized obligation schemes with direct participation, without interfering with the individual design choices.

The only limitations when it comes to the design of main elements in national capacity markets, is that cross-border providers should have an availability obligation, and that capacity providers should be allowed to participate in several capacity markets.

Table 3: Option 1: Proposed common framework for capacity markets with direct participation

Element	Provision per element
Capacity adequacy, capacity requirement and de-rating	Based on common principles Regional, probabilistic approach
Eligible providers	All relevant resources, according to de-rated capacity Geographical limitation based on the regional assessment and grid constraints Providers should be allowed to participate in several capacity markets according to their de-rated capacity
Obligation and penalties	Availability obligation Same penalty as domestic providers
Competitive interconnector allocation process	Explicit "admission" auction (if general framework) Implicit auction for centralized auctions if different frameworks for centralized auctions and decentralized obligation schemes
Remuneration to interconnector operators	Auction revenues
Secondary trading	Should be allowed
Obligations and penalties for interconnector operators	Specific obligations should not be imposed in capacity markets with direct participation
Rules for influencing cross-border flows	Specific rules related to capacity markets with direct participation not needed
Allocation of costs	Domestic consumers in the capacity mechanism market should pay the cost of the capacity mechanism
Rules for TSO compliance	Rules regarding the TSOs role in different phases of implementation and operation of capacity mechanisms should be developed

The allocation of remuneration to interconnector operators via explicit admission auctions is in particular a source of inefficiency in this framework. Admission auctions introduce a basis risk that may imply that the willingness to pay for the admission is reduced. The interconnector may end up bearing the bulk of the basis risk. Thus, the incentives for investments in interconnector capacity may be suboptimal. This should be seen in relation to the obligations and penalties for interconnector operators.

If separate guidelines are implemented for centralized auctions and decentralized obligation schemes, the main efficiency gain would be that interconnector capacity should be allocated according to an implicit interconnection auction, held simultaneously with the capacity auction in centralized auction schemes.

Another alternative is to require *indirect* cross-border participation, i.e. participation by interconnectors, for all capacity markets. In such a model (cf. the current UK scheme), the capacity rent will accrue to the interconnector operator, and strengthen the incentives to invest in interconnector capacity. Such a model also simplifies some of the other issues related to capacity markets.

With indirect participation, the capacity providers in B will not receive explicit capacity remuneration. The premise for our analysis is however that the energy-only market should be efficient if market distortions related to missing money or missing markets are corrected, and that these market distortions are only present in some markets (the need for a capacity mechanism is substantiated). If the distortion in A is not corrected, investment incentives in B will be distorted as well. But if the distortion *is* corrected in A, it is implicitly also corrected in B. Hence, if the capacity remuneration is efficient in A (implying optimal de-rating and setting of the capacity requirement), investment incentives for capacity in B should not be distorted any more (based on the revenues from the energy market). This line of reasoning rests on the assumption that *the target model is basically efficient* if missing markets and missing money problems are removed.

Moreover, this underlines the crucial importance of the capacity adequacy assessment and getting the capacity requirement right. If the capacity requirement is not carefully determined, i.e. if it is set too high, investment incentives for capacity providers in B will be suboptimal, although increased interconnector capacity will also benefit providers and investors in B.

In general, the analysis raises the concern that explicit cross-border participation will not yield an efficient outcome, as the capacity of eligible capacity providers in B is likely to be much higher than the de-rated interconnector capacity. As the remuneration of capacity providers is limited by the de-rated interconnector capacity, the capacity remuneration in B will not be market-wide. Hence, there is a risk that the remuneration to capacity providers will be zero in an efficient auction cross-border auction, i.e., that the entire capacity remuneration will accrue to the interconnectors according to the de-rated cross-border capacity. This in turn raises a concern over whether the providers in B will actually have an incentive to participate in the capacity auction. Consequently, the distribution of the capacity remuneration to B and the impact on investment incentives for capacity providers and interconnectors from explicit cross-border participation is uncertain.

However, the setting of the capacity requirement is crucial for the efficiency of capacity markets in general. If the capacity requirement is set too high, investment incentives in B will be distorted even in models with direct participation.

4.2.2. OPTION 2: HARMONIZATION OF FRAMEWORK ELEMENTS

The common framework suggested above leaves most of the basic design elements of the capacity markets – centralized or decentralized auction, product definition, details of the obligation and penalties – to the discretion of Member States. The question is whether further harmonization of the basic design of capacity markets could remove barriers for cross-border participation and increase the efficiency and effectivity of capacity markets further.

As we see it, there are two main candidates for further harmonization

- Harmonization of capacity products
- Harmonization of eligibility and compliance regulations

According to market theory, it is a barrier to efficient cross-border trade if products are not comparable. For example, different definitions of balancing products are a barrier to efficient exchange of balancing resources across borders. One might therefore think that different definitions of the capacity product may be a barrier to cross-border participation in capacity markets.

However, capacity markets are different, as they address different challenges (demands) in different markets. The capacity product will typically be defined by the obligation period, the nature of the obligation, limitations on use, and testing. Limiting these features only with the purpose of standardizing is likely to reduce the efficiency of capacity markets and could imply that capacity requirements must be set higher than with tailor-made product definitions.

Basically, standardization of the capacity product features could reduce barriers by reducing the cost of providers who are eligible to participate in more than one capacity mechanism, and for regulators and TSOs in the implementation and operation of the scheme.

Cf. section 5.2, we assess that some cost reductions may be achieved even in the design phase, but these costs are generally relatively low. The main cost reductions are likely to be achieved in the eligibility phase and the operational phase:

- The eligibility phase implies pre-qualification of participants, i.e., documentation of technical and geographical requirements, beyond what is required for the de-rating associated with the capacity adequacy assessment. This phase implies costs both for providers and for TSOs. In general, the costs would be reduced if the capacity was pre-qualified according to the same criteria and procedure.
- The operational phase implies that the responsible authority, typically the TSO, must monitor that the capacity providers act in accordance with the capacity obligation(s), and impose penalties in case of non-compliance. Testing of technical availability may also be a part of the operation of the schemes.

Hence, we conclude that benefits could be realized by imposing common rules and standards for

- The features of the product definition, i.e. that a standard set of features should be defined, including the obligation period, nature of the obligation, notice period, and limitations on use. In other words, a set of standard products that cover the different needs should be defined, rather than having each TSO or regulator defining country-specific products. Hence, although the values would differ according to the specific capacity adequacy challenge, the definition of the capacity product should be described according to a common structure. This would make it easier for providers to analyse and compare the risks and rewards related to participation in several capacity markets, and reduce the costs for TSOs in the eligibility phase and the compliance phase. If participation in several mechanisms should not be allowed, standard product definitions will still be important to enable providers to assess where their capacity will have the greatest value. Standard definitions may also save some costs in the design phase, although these costs are expected to be small in total (see chapter 5).
- The requirements regarding documentation of technical data, testing procedures, and coordination of the latter, in order to reduce the administrative costs for TSOs. The TSOs in a region should coordinate the testing of capacity, and a set of common principles should be developed. If one capacity mechanism requires more frequent and elaborate testing than the other, this may constitute a barrier to cross-border participation. Moreover, a lack of coordination would increase the risks related to cross-border participation, in particular for providers participating in several capacity markets.

- A common rule-book for the application of penalties, applying to all providers, and with specified procedures for the imposition of penalties cross-border related to the general framework should be developed. Without a common rulebook, the cost of imposing penalties can be high, and uncertainty and the prospect of lengthy disputes could deter cross-border participation. For instance, different countries will typically have different appeals procedures which will result in costly processes both due to the fact that the relevant jurisdiction would have to be identified and due to the need for TSOs and market players to handle different sets of legal rules. A common EU penalty and appeals system would bring benefits.

4.3. STRATEGIC RESERVES

General approach

A harmonized EU framework for cross-border participation specific for Strategic Reserves should focus on the initial purposes of most Strategic Reserves in European markets. Rather than relieving one of the distortions missing money or missing market, Strategic Reserves in most cases fulfil a specific purpose. As targeted mechanisms they are implemented to cover for example extreme winter peaks, resolve locational scarcity/congestions issues or bridging winters with unavailability of major capacities. The main focus during the development is therefore put on technical availability and controllability by the system operator of the market together with the regulator. Providing clear and perceivable incentives for investments are only a design result by reducing the distortion to the market prices during activation with a high enough activation price.

Nevertheless, a correct determination of capacity requirements together with a correct de-rating is important to avoid oversizing the Strategic Reserves. This goes in line with TSO tending to choose too conservative volumes and de-ratings. In case the capacity requirement is too large and the incentives are too strong for capacity providers to step out-of-the-market to get into the strategic reserves, additional inefficiencies may occur. This may also happen as an ongoing process and referred to as slippery slope. The resulting reduced capacity in the market A would lead to more often activated strategic reserves. As a consequence, unnecessarily high prices in the market of the strategic reserves materialize. This issue however is more linked to the discussion of state aid rather than a cross-border participation. The threat of earlier retirement of capacity to be included in the strategic reserves is not inherent to the design and not reduced by cross-border participation.

Given the focus on the technical availability and the activation triggered directly by the TSO in the implementing country, a framework with explicit participation of generators seem difficult and would require a strong coordination of the TSOs of all affected control zones beyond the coordination already taking place in practice. On the one hand this would include the tracing and verification of capacity in the Strategic Reserves and not active on markets. On the other hand, during activation of the cross-border Strategic Reserves, the TSO of A must be allowed to activate assets in another TSO' control zone to resolve specific issues in its own control zone. A conflict of interest among the affected TSO might reduce the efficiency of the Strategic Reserves. The case of the German strategic grid reserve discussed in the next chapter illustrates some of the practical challenges with a model for strategic reserves based on explicit participation (the German grid reserve has the same fundamental characteristics as a general strategic reserve).

We argue that in case of Strategic Reserves an implicit participation model would provide a clearer solution. Based on periodically update of the de-rating of the cross-border participation together with the assessment of the capacity requirements, the implicit participation model would allow for accounting for the contribution and at the same time limit the need for coordination with respect to the Strategic Reserves. A close inclusion of neighbouring markets and especially TSOs as done in the generation adequacy assessment would further improve the de-rating of the cross-border participation. An alternative approach would be regional Strategic Reserves if underlying addressed challenges are similar or at least can be aligned. As an example, reserves for balancing in real-time have the same purpose in interconnected markets and are therefore more and more regionalized based on a coordination agreement of TSO. There are rules for sharing as long as connections are not congested.

The benefits for the interconnector and the capacity providers in the neighbouring countries are difficult to assess for implicit participations models. As argued above, explicit cross-border participation should be subject to strong coordination among the involved TSOs. In what follows we discuss the relevant framework elements for both implicit and explicit cross-border participation.

Discussion of framework elements

With respect to the framework elements the following recommendations can be summarized:

A) **Calculation of reliable import capacity:** As emphasized above, correct de-rating is crucial for the efficiency independent of the chosen framework for cross-border participation. Just as the periodically updated capacity requirements, de-rating should be updated accordingly.

B) The **identification of eligible capacity providers** is not applicable for implicit participation. In case of explicit cross-border participation or a regional strategic reserve the same rules should be applied for all capacity providers.

C) **Obligations and penalties:** Similar to the rules for identification, penalties and obligations are only applicable for explicit participation. Implicit cross-border participation does not require an obligations and penalty system for foreign capacity providers.

D) **Allocation of import capacity:** In order for cross-border participation to function in the strategic reserves model with explicit participation, implicit auctioning of interconnector capacity under coordination of the TSOs is preferable. The implicit auctioning of capacity should be done simultaneous with the contracting of the strategic reserves by the TSOs. The assessment of eligible cross-border capacity must include the specific contribution to the targeted problem. In case of implicit cross-border participation additional rules during the contracting are not necessary. During activation, TSOs operating the strategic reserves for specific targets should have control over the cross-border flows to resolve the targeted challenge. However, we have discussed in the previous section that this should be in line with Network Codes and guidelines for short-term operation of the system (cf. discussion 4.1.7).

E) **The trading of interconnector capacity** is not applicable. Once the strategic reserves are contracted the control and decision over the activation is with TSOs. A trading of interconnector capacity would require that the capacity providers could also exit the strategic reserves which is not foreseen in current designs.

F) For **obligations and penalties for interconnectors** the same reasoning as in c) applies. Implicit cross-border participation would not require a ruleset for obligations and penalties for interconnector operators. In case of explicit cross-border participation, strong TSO coordination is required, hence, the obligation and penalty system should be organized along the guidelines for coordination.

G) **Influencing interconnector flows:** The same reasoning as for the capacity markets applies. In case of simultaneous scarcity, contracted capacity in market B should be able to contribute in the strategic reserves of market A. Challenges of controlling flows would be subject to the coordination of the affected TSOs. We discussed (cf. section 4.1.7) that in scarcity situation outside the market, operational solutions based on TSO coordination might overrule the interconnector flows. Again, this very specific situation should be handled under the default Network Codes and guidelines. No additional rules should be put on top.

H) The **remuneration to the foreign strategic reserve** should be easy to implement in practice in line with the general approach discussed for capacity markets. In addition, foreign generators benefit in case of implicit cross-border participation from the increased cross-border flows up to the congestion of the interconnector. Market-based capacity in market A will not increase in the short-term as capacity contracted in strategic reserves would be out-of-the-market anyhow. In case of over-sizing the capacity requirements, market-based capacity could even reduce. Cross-border flows increase because of limited market-based capacity in A resulting in higher prices. During activation, prices in A will also be higher. Expected benefits however are minimal, most revenue will go to the interconnector representing the value of the constraining resource. The strategic reserves are contracted on behalf of the consumers in A. Capacity that has been decided to go out-of-the-market in B is kept operational for consumers in A. As such, the same principle as for capacity markets should apply, hence, the consumers in A should pay.

I) **Remuneration to interconnectors:** In case of implicit cross-border participation, more flows and higher price differences between markets because of limited market-based capacity and elevated prices during activation of strategic reserves could be observed. If so, the valuing of interconnectors increase based on increasing congestion rents. We assume contracting strategic reserves cross-border is only done if there is a high probability that this reserves can be activated and benefit the capacity situation in A under stress. This means that there must be ample/excess interconnector capacity between the two market areas during stress events that is not already used. On the other hand, if the contracting of capacity in B for strategic reserves in A compromises the capacity situation in B, then the probability that B will export under normal conditions to A is reduced. As a consequence, the contracting should be subject to approval by the TSO in B, according to some common principles. Activation is only relevant if there is a simultaneous stress event in A and B. In case of activation in A but no scarcity in B, the interconnector capacity should be fully utilized for exports from B to A based on market outcome.

J) **TSO compliance:** The TSOs already play a crucial role in strategic reserves, compliance with rules is clearly in the own interest of the domestic TSO to have strategic reserves available for addressing the specific challenges. For the foreign TSO, the incentives may not be as clear. We consider that the appropriate rules and compliance measures can be handled through a general EU framework as discussed previously.

Important for the market impact of strategic reserves, and in particular for the incentives for interconnectors, is the **rules for activation** of the strategic reserve. It is to be expected that whenever a strategic reserve is activated, all import opportunities are exploited. Thus, it is likely that prices differ between markets due to the scarcity in A. Then, the market price in B should not be affected by the activation. However, the congestion rent on interconnectors between A and B will be affected.

It seems rational that the price during activation should be set at the market price cap in the day-ahead market, as congestion rents are determined by day-ahead price differences. The possible gaming behaviour related to a common price target should be a lesser concern when demand-side participation becomes more active in the market. More active demand-side participation should also imply that holding a strategic reserve becomes less relevant over time.

5. COSTS RELATED TO CROSS-BORDER PARTICIPATION

5.1. INTRODUCTION

Different models for cross-border participation in capacity mechanisms will have an impact on stakeholders and may be subject to a number of practical barriers for implementing cross-border participation, including administrative costs. In order to assess the administrative costs and other barriers, we have carried out case studies supported by interviews with regulators, ministries and TSOs in selected Member States with experience from designing, operating and participating in different types of capacity mechanisms. The analysis is both qualitative and quantitative, however, only to the extent that the input allows for quantification of effects. Furthermore, the descriptions of countries' capacity mechanisms are based on publically available information and interviews with selected key market participants. The descriptions are illustrative and serve as a basis to estimate the costs for the different phases related to cross-border participation, and are not meant to provide a comprehensive overview or an economic assessment of the different mechanisms.

There are generally six types of capacity mechanisms (see above). To describe the administrative costs, we have grouped the types into two categories; targeted mechanisms ("the amount of capacity required and the amount expected to be brought forward by the market are identified centrally"[9]) and market-wide mechanisms ("all capacity required to ensure security of supply receives remuneration, including both existing and new providers of capacity"[10]). Capacity mechanisms within of these two categories have similar distinguishable phases in their design and operation.

In this part, we discuss the administrative barriers and costs that can be attributed to cross-border participation in capacity mechanisms. We start out by describing a generic administrative framework before presenting some general observations on the expected administrative costs. We then describe the case studies. Finally, we sum up the results from the analysis of administrative costs.

5.2. GENERIC ADMINISTRATIVE FRAMEWORK

We have identified the following general administrative steps in setting up and operating a capacity mechanism:

- **Design:** This step involves the decision on a capacity mechanism model and the detailed rulebook and financing mechanism, and may include the production of consultation documents and external studies. The stakeholders involved depends on the process, but will as a minimum involve national regulatory authorities (NRAs) and TSOs.
- **Setting a capacity requirement:** This involves defining a reliability standard and calculating the need for capacity that will be required under the mechanism (i.e. the demand for capacity). This will typically be done

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[9] The definition and grouping here follows p. 37 in the Final Report of the Sector Inquiry on Capacity Mechanisms.

[10] Ibid, p. 38

by the TSO, possibly with approval by the NRA, periodically. In some cases, the requirement may actually be determined as part of the design.

- **Eligibility:** This refers to the pre-qualification of participants in the capacity mechanism, including documentation of available capacity and fulfilment of technical and geographical requirements. The process of de-rating would also be a part of this phase. The market participants will be highly active in this phase, along with the party responsible for approving eligibility (typically the TSO). This process is also repeated periodically.
- **Allocation process:** In this step, the amount of capacity to be delivered by the participants and the commercial terms are set. The allocation process can be an auction open to the eligible participants or an administrative procedure. Fixed remuneration may be collected and distributed in this phase.
- **Operation:** In this phase, the responsible authority, typically the TSO, will monitor the need for capacity and act in accordance with the capacity mechanism. This may include activation of reserves or monitoring of compliance (delivery or availability), depending on the type of capacity mechanism chosen. Imposing penalties in case of non-compliance is another activity in the operations. Also, additional remuneration is paid.

Table 4: Main design elements of targeted capacity mechanisms

	Design	Setting capacity requirement	Eligibility	Allocation process	Operation
	Design phase			Operational phase	
Definition	Determine capacity mechanism model and write rulebook Financing mechanism	Define reliability standard and make capacity adequacy assessment	Prequalification of parties eligible for participation in the capacity mechanism	Auction or administrative procedure Cost allocation between parties	Monitoring of capacity needs Activation of capacity (if relevant) Impose obligations and penalties Payments
Stake-holders involved	Ministry NRA TSO Commission ACER (Power market participants)	Ministry NRA TSO	Ministry NRA TSO Generators Consumers Interconnectors	TSO Power exchanges Generators Consumers and DR providers Interconnectors Foreign generators and consumers	TSO Power exchangers Generators Consumers and DR providers Interconnectors Foreign generators and consumers
Type of costs	Administrative costs – FTE External Services	Administrative costs - FTE External Services	Administrative costs – FTE Eligibility costs External Services	Administrative costs – FTE IT-support External Services	Administrative costs - FTE IT-support External Services

*FTE: Full-Time Employee

The administrative cost elements will typically be manpower measured in full-time employees (FTEs), costs of external assistance (lawyers, consultants etc.) and IT systems for carrying out the allocation process, operating registers of obligations etc. The money paid out to market participants for providing capacity is not considered part of the administrative costs.

Table 4 outlines the main elements in the design and operations of capacity mechanisms that can be categorized as targeted mechanisms. In this category, the design phase covers the actual design of the capacity mechanism, the capacity setting, and defining eligibility. The operational phase generally covers an annual allocation process and daily operation. Note that the costs in the table refer to the administrative costs for the different stakeholders, and not the costs of procuring and activating the reserves.

Table 5: Main design elements of market-wide capacity mechanisms

	Design	Setting capacity requirement	Eligibility	Allocation process	Operational phase
	Design phase	Operational phase			
Definition	Determine capacity mechanism model and write rulebook Financing mechanism	Define reliability standard and make capacity adequacy assessment	Prequalification of parties are eligible for participation in the capacity mechanism	Auction or administrative procedure Cost allocation between parties	Monitoring of capacity needs Activation of capacity (if relevant) Impose obligations and penalties Payments Verification and monitoring
Stake-holders involved	Ministry NRA TSO Commission ACER (Power market participants)	Ministry NRA TSO	Ministry NRA TSO Generators Consumers Interconnectors	TSO PX Generators Consumers Inter-connectors Foreign generators and consumers	TSO PX Generators Consumers Interconnectors Foreign generators and consumers
Type of costs	Administrative costs - FTE External Services	Administrative costs - FTE External Services	Administrative costs – FTE Eligibility costs External Services	Administrative costs – FTE IT-support Operational costs External Services	Administrative costs - FTE IT-support Operational costs External Services

Table 5 shows an outline of the main elements in the design and operations of capacity mechanisms that can be categorized as market-wide mechanisms. In this category, the design phase often covers just the actual design of the capacity mechanism, whilst the operational phase generally covers the capacity setting, definition of eligibility, annual allocation process and daily operation.

While the details of the administrative procedures will depend on the type of capacity mechanism considered, the above elements are representative of the general framework for market-wide capacity mechanism.

5.3. Overview of barriers related to cross-border participation

There are several possible reasons why cross-border participation in capacity mechanisms can be challenging. In the following, we distinguish between three main types of barriers:

- Economic, i.e. transaction costs and administrative costs
- Legal
- Political

A major driver for transaction costs is the extent to which negotiations between Member States (including about allocation of related costs) are needed. Depending on the design, the negotiations will include issues such as harmonization of requirements, certificate registers, etc. Such costs come in addition to any challenges related to the difference in requirements regarding availability or delivery. Another issue for the negotiations is related to the definition of the geographical scope for eligible generators, and the challenge of verification and availability checks by a TSO or other authority outside the capacity mechanism control zone.

The rationale for any capacity mechanism is the need to enhance the power system's ability to provide sufficient capacity adequacy in the long term, but this issue is often viewed from a national perspective. Therefore, individual designs will also be affected by a Member State's national assessment and valuation of adequacy and security of supply. Correspondingly, Member States who are concerned with capacity adequacy, may be prone to first remedy the need with national measures, and only later look at possibilities to include cross-border participation. Adding cross-border participation at a later stage may, however, be more complex than accommodating such an option at the outset.

The choice of model for cross-border participation will also have an impact on the direct administrative costs in the operational phase. For example, with a generator model, the number of participants in a capacity mechanism increases significantly compared to an interconnector model, possibly leading to a large number of contracts and potentially large costs related to checking eligibility and fulfilment of obligations.

Other drivers of transaction costs are time constraints and integration compatibility. When designing a capacity mechanism, there are often time constraints due to political pressure, system needs or other reasons. This may in turn lead to suboptimal solutions that require redesign and extra administrative work at a later stage. The capacity mechanism design should also allow for implementation into the existing market structure. Not all models fit easily with existing market models, which may then require extensive adjustments to the existing models.

Cross-border participation in capacity mechanisms will inevitably also come with legal challenges. The type and extent of these challenges will depend on the design of the mechanism, its purpose, the cooperation between countries, eligibility criteria and contractual conditions. It is not within the scope of this study to analyse in detail the effects and possibilities to overcome legal barriers. However, we discuss some of the possible legal barriers that can be distinguished in the following paragraphs.

In this study, we make a rough distinction between legal barriers that are governed by public law (the part of law which governs relationships between individuals and the government, and in particular administrative law) and legal barriers that are governed by private law (laws concerning relationships between individuals).

Legal barriers that are governed by public law are mostly of jurisdictional nature. With jurisdiction, we mean the power to make and enforce legally binding decisions and judgements. Cross-border participation implies that market actors that are governed by foreign jurisdictions (i.e. that fall under the laws and regulations of another country) participate in a capacity mechanism in the host-country. This can result in (legal) jurisdictional barriers in case of requirement-setting, national regulations that prevent participation, cross-subsidization and/or enforcement. Technical requirements can differ amongst countries, even whilst taking into account EU's Internal Market and regulatory harmonization. This can result in challenges for setting uniform eligibility (de-rating) criteria and/or other technical requirements. The regulatory authorities in the hosting countries cannot compel market actors in other countries to have the similar technical requirements. However, participation is often voluntary, so it is up to the participating actor to fulfil the demands of the host country. Notwithstanding, this does require that the regulatory authorities cooperate to facilitate participation.

Additionally, national regulation can prevent participation in a capacity mechanism or, opposite, result in double benefits for the participating actors. In order to prevent cross-subsidizing, the agency responsible for the mechanism in the host country needs to be informed of the credibility of the information provided and there might be a need for the participating entity to receive a certificate that is recognised by a national agency.

A main legal barrier in relation to cross-border participation is the enforcement of decisions and/or penalties. Since the responsible agency in the host country does not have jurisdiction in the other country, it cannot enforce penalties, or start legal proceedings in case the foreign operator does not comply to its legal obligations.

Legal barriers that are governed by private law are mostly contractual in nature. In general, cross-border participation can require contracts and requirements to be in various languages and that have similar representations in different legal frameworks. The agreements are not limited to other generators or providers of demand response, but also cooperation agreements with other operational entities should be in place, i.e. between TSOs, NRAs and governments.

Other considerations that have to be taken into account in the design of a capacity mechanism, are the political dimension and the social dimension. The costs for the capacity mechanism are often born by the final consumers. A major factor in its acceptance is to explain to the people paying for the capacity mechanism that they are supporting generation capacity in other countries. Another barrier might be social acceptance of different generation types, e.g. non-renewable or nuclear.

5.4. CASE STUDIES

Table 6 lists the countries selected for the capacity mechanism case studies. The selection is based on design (covering both targeted mechanisms as well as market-wide mechanisms), the (possible) inclusion of cross-border participation and/or general experience with capacity mechanisms.

To assess the different potential barriers, we have conducted a series of interviews with relevant stakeholders. As the table shows, the interviewees are Ministries and TSOs. We have also used their contributions to test our assumptions and hypotheses.

Table 6: Overview of selected case studies

Country of case study	Description / reason for choice of case study	Interviewees
Great Britain	Market-wide capacity auction, allowing interconnector participation. They have considered other models for cross-border participation as well.	Ministry, foreign TSO
Germany	Strategic (grid) reserve, allowing cross-border participation from Austria, Italy, and Switzerland.	Ministry
France	Market-wide capacity obligation scheme, allowing cross-border participation in principle, but perhaps not in practice.	TSO
Sweden	Strategic (peak load) reserve, with only national participation. Has long experience with strategic reserves within the context of a highly interconnected regional market with extensive cooperation on system operations and network planning, and cooperation with Finland regarding activation of reserves.	TSO
Ireland	Market-wide capacity payment mechanism that was available to interconnectors, conventional generation, renewable generation and demand-side resources. However, no international participants were ever contracted. Intends to replace the existing capacity mechanism in 2017 with a volume based capacity mechanism based on centralised reliability options.	NRA
Greece	Previously, a model with capacity payments was in use until 2014. In 2016 a temporary capacity mechanism entered into force that aims at providing flexibility, i.e. short-term generation response. A new and permanent mechanism is due to come in place in 2017. Cross-border participation is not foreseen as possible.	NRA
Belgium	Currently implemented a Strategic Reserve mechanism. Emergency capacity is contracted by the TSO in a yearly procurement process. Capacity must be located within the Belgian control zone.	TSO

It is a methodological challenge that, with the exception of GB and the German strategic grid reserve, the existing or planned capacity mechanisms are national in scope. As part of the GB case study, we have therefore interviewed the Norwegian TSO Statnett in order to get more information on the administrative issues related to cross-border participation from an external stakeholder perspective. Statnett is one of the owners of the North Sea Link interconnector between Norway and GB which will be eligible for participation in the GB capacity auction when completed.

5.4.1. *GREAT BRITAIN*

Great Britain (GB) has implemented a market-wide capacity auction. The capacity mechanism's main purpose is to incentivize investments in future generation and optimal use of existing assets (bringing forward new investment while maximising current generation capabilities). The capacity obligation is delivery during (notified and defined) stress events. Cross-border participation is allowed, in terms of an interconnector model (with current participation from interconnectors to Ireland, the Netherlands and Belgium). Interconnectors, just as other participants are paid according to their de-rated capacity and must deliver energy during stress events or face penalties and over-delivery payments in order to true up their performance against the de-rated capacity.

Design framework

From the GB perspective, the design phase includes design and analysis of improvements to the wholesale market, basic decisions on the methodology for determining the capacity to be procured, eligibility, allocation, obligations and penalty regime, ensuring compatibility with state aid guidelines.

In designing the cross-border provision in the GB capacity mechanism, the interconnector model was preferred because it was easier to integrate in the existing model at the time. There were time constraints and the interconnectors already are the main scarce resource from the GB perspective. Additionally, there was a lack of precedence when the GB model was introduced, and there was little information or experience in how to de-rate foreign plants. Moreover, there would be jurisdictional challenges related to the enforcement and imposition of penalties, and probably a need to make cooperation agreements with foreign TSOs.

In the early stages of the design phase, the GB governments (i.e. Ministry) hired external services to analyse the different options and possibilities for a capacity mechanism as part of the Energy Market Reform. This type of cost can be recurring in cases of evaluation of the capacity mechanism.

In the design phase, costs for stakeholder engagement were relatively considerable. The stakeholders' process allowed for input from international stakeholders in different stages of the design, increasing the costs for execution of the process. The additional costs for the cross-border participation element in the stakeholder process are relatively low, considering that the national processes had to be carried out in any case.

Although difficult to make an estimate on the costs for designing the capacity mechanism, it is estimated that Ministry used approximately 20-25 FTEs in the design phase. The TSO used a small design team, whilst for the regulator there were no estimates available.

In the GB experience, cross-border participation was integrated into the current design rather seamlessly and as such, did not increase the administrative burden or administrative expenditure significantly.

Operational phase

From the GB perspective, the operational phase contains the annual process and includes several steps; e.g. determination of the capacity requirement, pre-qualification, determination of de-rating factors, the auction/payments, monitoring and testing, implementation of the penalties regime, etc.

Capacity requirement

Part of the TSO's role is to carry out the detailed modelling and analysis that is used to inform the responsible Ministry, so that the right decisions can be made on how much capacity to procure in the auction. This results in a demand curve for capacity that is used in the auction process. The administrative costs for the TSO consist of modelling and analysis responsibilities, e.g. running of the prequalification process, testing, auctioning, and milestone checking of new projects, etc.

Eligibility

Eligible participants in the capacity mechanism need to prequalify the generation or demand side resources before entering into a Capacity Agreement. Generators or DSR suppliers who receive carbon support, have long-term contracts to provide short-term operating reserves, and non-GB capacity, are excluded from the auction. Interconnectors are eligible to participate since 2015.[11]

The main costs related to eligibility are those of the prequalification and those of capacity providers preparing their application. The number of interconnectors to GB is limited, hence the additional costs in relation to cross-border participation for eligibility are marginal.

Allocation process

The main costs in relation to the allocation process are the FTE's working in operation of the auction platform, services of the auction monitor and the costs of capacity providers for the preparation of bids. There are no estimates for these costs at hand.

Administrative costs

The Ministry employs around 10 FTEs in the operational phase. The TSO has a larger team dedicated to operation of the capacity mechanism. The tasks comprise mostly the modelling and analysis responsibilities of the TSO. The NRA has also dedicated resources to operation of the capacity mechanism. It is difficult to estimate the additional resources needed for cross-border participation. In case of cooperation, some of the costs can be shared with the foreign TSOs.

Table 7: Summary of case study – Great Britain

Country of case study	Administrative costs / barriers	Interviewees
Great Britain	• Design phase: > 25 FTE (TSO, Ministry and NRA) • Operational phase: > 20 FTE (TSO, Ministry and NRA)	Ministry and foreign TSO

5.4.2. SWEDEN

Sweden has implemented a strategic reserve. The Swedish TSO, Svenska Kraftnät (SVK), is legally obliged to procure a certain amount of capacity for the Peak Load Reserve (PLR) for each winter. The PLR has been implemented as a transitory measure, but its end-date has been postponed several times. The end-date was recently extended for five years, from 2020 to 2025. SVK has been operating the

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[11] https://www.emrdeliverybody.com/capacity mechanism/Prequalification.aspx

strategic reserve of up to 2 GW since 2003. It is designed to ensure that sufficient capacity is available to cover peak load during the winter (mid-November to mid-March).

Design framework

The Swedish PLR is set out in a separate Law on the Peak Load Reserve, and is adopted and adapted by the Swedish parliament following ordinary legislative procedures. The TSO and market participants will give input to the process, and may also be active in the public debate on capacity needs and mechanism design (as may other stakeholders).

Capacity requirement

The maximum capacity requirement is 2000 MW as set out in the Law on the Peak Load Reserve. Currently the requirement is set at 1000 MW.

Eligibility

Generators/producers with reserve power plants and consumers (demand side response) are both eligible for participation in the PLR. There is a minimum size requirement of 10 MW for generators and 5 MW for consumers. Consumer participants are allowed to be unavailable 5 per cent of the time without any need for justification.

SVK has the legal obligation to have contracted at least 25% of the capacity reserve from the demand side.

Only national actors can participate, and no cross-border participation is allowed and or foreseen.

Allocation process

The allocation process is handled through a tendering procedure operated by the TSO. Producers selected in the procedure are compensated with a fixed fee and an activation price, while selected loads are compensated with an administrative fee for each hour of registered availability in the regulating power market and an activation price.

Operational phase

In case of a capacity shortage, the TSO can activate or deactivate bids through direct contact with the owner of the capacity. The capacity owner is guaranteed at least one hour of compensation for the activation according to the individual bids. Reserve production is bid into the Nord Pool spot market by the TSO, while the consumption is activated through the regulating power market, which the loads participating in the PLR are obliged to be bid into.

There is a form of cooperation with Finland, that also has a strategic reserve in place, but this cooperation entails mostly information sharing and coordination of the pricing of the PLR during stress situations.[12] Under the current rules, the PLR is bid into the market at 0.1 EUR/MWh above the highest variable commercial bid.

[12] P. 44 EUC Interim report of the sector Inquiry.

The PLR has only been activated on a few occasions (see TemaNord, 2015)[13].

Administrative costs

The costs of the Swedish PLR are generally considered to be low. Some additional costs will accrue due to a recent change in the environmental regulation of the PLR which imply a reassessment of the design (eligibility criteria). The costs are reimbursed via a fee levied on the Balance Responsible Parties (BRPs) in the Swedish wholesale market. Excess fees are paid back to the BRPs. Reimbursement is the norm as the activation of the reserve has been less frequent than typically anticipated.

Table 8: Summary of case study – Sweden

Country of case study	Administrative costs / barriers	Interviewees
Sweden	• Small number of FTEs, usually less than 1 • Some more activity when rules are reviewed and if necessary changed	TSO

5.4.3. FRANCE

France is currently the only European country that is implementing a market-wide decentralized obligation scheme. Additionally, France has proposed a tender for a new capacity scheme for a combined cycle gas-fired power station in Brittany. The latter is currently pending approval from DG Competition and will be left out of this case study.

Design framework

The French decentralized obligation scheme is a capacity auction scheme in which the obligation is assigned to the electricity suppliers who have to submit a number of capacity guarantees (or certificates). The obligation is set in relation to the actual consumption of their customers during peak periods.[14] Fulfilment of capacity guarantees can be based on own resources (production or demand response) or purchases in the capacity market.

The individual obligations are set for a period of four years in advance of the year of delivery and reflect the consumption data measured during the delivery period within the supplier’s portfolio. After the peak periods the effective usage will be measured and deviations will be settled financially. The main purpose of the scheme is to incentivize future investments. The current design is not open to participation by interconnectors or foreign capacity. However, initial results from a recent consultation on the potential for direct interconnector of foreign participation in future indicate that cross-border participation will most probably be allowed.[15]

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[13] Capacity adequacy in the Nordic market, TemaNord report 2015-560.

[14] French law 2010-1488 of 7 December 2010 on reform of the electricity market (NOME), codified in articles L. 335-1 et seq. of the Energy Code. Decree 2012-1405 of 14 December 2012.

[15] P. 50 Interim report sector inquiry.

Capacity requirement

The capacity adequacy assessment is done by the TSO. The capacity obligation is based on the supplies. The obligation is assigned to suppliers based on the actual consumption of their customers during peak periods (usually in winter). To meet its obligation, the supplier will have to secure capacity guarantees. The parameters for calculating the obligation are determined four years ahead of time. Thus, the methodology for setting the obligation is known, but not the exact obligation as it depends on actual supplies.

The TSO already has the legal obligation to make an adequacy assessment, hence there are no additional costs in relation to the setting of the required capacity.

Eligibility

Participants on the demand side of obligations in the French capacity mechanism are the electricity suppliers that have to submit a set number of certificates in order to fulfil their commitment. Their costs for eligibility are included in the tariffs. The supply side of the obligations are generators and demand response providers.

Allocation process

The French capacity mechanism is a decentralised market. The main tasks in the allocation process for the TSO is to run a register for capacity certificates. The TSO uses a standard protocol for market functioning, similar to systems used for energy trading. The TSO has therefore low marginal cost for the allocation process of the capacity mechanism market. There is no indication that the costs would increase for the allocation process if opened up for cross-border participation.

Operational phase

The main responsible actor for operation of the capacity mechanism is the TSO. The TSO checks availability of certificate receivers. DSOs are also involved in the certification process and operational processes.

The costs related to the operation of the capacity mechanism are generally low, for two reasons. Firstly, the design phase was used well to ensure that the choices made led to a minimum of administrative costs in the operational phase. Secondly, the costs for operation of the IT systems are low, since the TSO can use similar IT tools for the capacity mechanism as they use for the other markets.

Administrative costs

There is a trade-off between the administrative costs in the design/investment phase versus the administrative costs in the operation phase. More time and costs used in the design phase can result in lower operational administrative costs, and vice versa. The design phase includes the development of the capacity mechanism and the necessary systems, and consultations with stakeholders. The market department at the French TSO estimates that it has used approximately 3 FTEs for a period of 3 years in the design phase.

Costs related to investment in IT systems (or support) for all processes are negligible, because they can be synergized with other systems (or support) that are in place to support other TSO tasks and responsibilities. Responsible parties should in the design phase include the need for necessary systems to support more than one function. Investment in the IT systems used for e.g. certificate trading are relatively low, since ample existing software is available.

The total additional cost for cross-border participation depends on the type of capacity mechanism. The main benefit of any type of harmonization at EU or regional level would be in the design phase. Additional cost might however be associated with complicated solutions, as you need to interact with foreign TSOs, for instance to check the availability. It is also not obvious that foreign demand response can participate as easily, since it is not part of French energy market at the outset. However, current estimated costs for cross-border participation are small compared to the potential benefits.

Table 9: Summary of case study – France

Country of case study	Administrative costs / barriers	Interviewees
France	• Trade-off between design and operational phases • Design phase: 3FTE (TSO) • Allocation / operation: low marginal costs due to synergy with other responsibilities • IT-infrastructure: low marginal costs operation of a certificate-trading-platform (existing software)	TSO

5.4.4. GERMANY

Germany has planned/proposed a strategic capacity reserve for which approval by DG Competition is currently pending. No cross-border participation is foreseen under this capacity reserve. This strategic capacity reserve is excluded from this case study. However, Germany currently has a strategic grid reserve (Netzreserve) in place. DG Competition has classified this reserve as a capacity mechanism (cf. the Final Report of the Sector Inquiry). The legal basis for the strategic grid reserve is the Reserve Power Plant Ordinance (Reservekraftwerksverordnung (ResKV, s.4)).

Design framework

The grid reserve is to address grid bottlenecks between generation in the north of the country and demand in the south. The reserve consists primarily of power plants that have signalled their intention to close down but have been prohibited from doing so because they are deemed crucial for the maintenance of system stability ('system relevance'). These plants are moved into the grid reserve, activated when there is insufficient network capacity to send power from north to south ('mandatory part'), and reimbursed for the costs that result from the statutory intervention with the rights of the plant operator.

In case the combined capacity of the power plants that have been prohibited from closing is insufficient to satisfy the identified need for the network reserve, a tender is organised to attract additional reserve capacity (the 'voluntary part'). In practice, this additional need is satisfied by power plants located in Austria and Italy. The network reserve differs from other strategic reserves not only because of its regional nature, but also because its activation is not triggered by a non-clearing market. Rather it is an instrument for the TSOs in Southern Germany that allows them to maintain grid stability when there is insufficient transmission capacity to flow power to the south of the country (additional capacity available for "redispatch"). A review of the grid reserve is currently ongoing.[16]

[16] P. 44 EUC interim report sector inquiry.

Generally, costs in relation to the design of the grid reserve and inclusion of cross-border participation are low.

Capacity requirement

The ResKV prescribes that the four German TSOs have to carry out a joint system analysis every year to determine the reserve power plant capacity necessary for future grid stability using redispatch. The German national regulator (Bundesnetzagentur) examines this system analysis and reports on the need for reserve generation capacity on the first regular business day in May of each year.[17]

The costs for setting the capacity requirements are low. The TSOs already have a legal obligation to execute (future) system analysis. This analysis is now used to set the capacities for the grid reserve.

Eligibility

The TSOs publish the concrete requirements for the plants as well as the application documents required. Each TSO is competent/responsible for plants in its control zone and for plants in adjacent neighbouring countries. Details of the specific prerequisites and requirements for the plants and/or plant operators, including the geographical network region in question and the technical parameters involved, are included in these documents.

Plants in (Southern) Germany are eligible for contracting, as well as international plants in Switzerland, Austria, Northern Italy and Eastern France. General eligibility requirements are laid down in ResKV and require e.g., that the plant is relevant for the overall system (minimum size, and technical specifications).[18] German operators have to commit to no longer use the plant on the power market even after the expiration of the contract. This does not apply to operators of foreign plants. In addition, in the case of participation by foreign plants, it is required that the authorities responsible according to the national law of the affected country, cannot raise any objections to the plants' participation. The operators of foreign plants will have to submit a written confirmation from the relevant authorities. Moreover, the foreign plants should provide a guarantee of the contractual commitment across the time period, explicitly including the procurement of the necessary cross-border transmission capacities as early as possible.[19]

The costs in relation to the eligibility are considered low. Most costs related to eligibility are borne by the participating (foreign) plants. Participation is voluntary, so there is no 'additional' cost factor, only for the plants that are willing to participate. The eligibility costs for NRAs and TSOs are low.

Allocation process

The TSOs are responsible for the operation of the grid reserve. The Bundesnetzagentur has a control function by approving and publishing system analysis, and by publishing the requirements of the necessary plants in cooperation with the TSOs.

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[17] § 3 para 1 ResKV.

[18] § 5 para 2-3 ResKV.

[19] Application document; http://www.amprion.net/en/EoI-2015-for-2015-2016.

Annually, TSOs have to jointly make a system analysis to determine the reserve power plant capacity necessary. TSOs have to set the requirements and publish the documentation for application. The TSOs each have responsibility for the analysis of their respective control zone and for specified areas of adjacent countries. After the application process (first an expression of interest phase, followed by an application phase), the TSO will have to select, according the set criteria, the eligible plants they will contract and negotiate with them the details of the contract. The negotiating of the contract in this phase, for example due to different technical standards in the various countries, can be very time consuming.

The administrative costs in the allocation phase are relatively high. Especially, the costs of the time needed to renegotiate the contracts with foreign plants can be considered high. However, the costs are low in relation to the benefit the grid reserve and the cross-border participation represent.

Operational phase

The operation of the grid reserve means the invocation of the contractual obligations of the participating power plants. As far as is possible to say, these costs are low.

Administrative costs

The operational costs are far greater than the design costs. The costs for operation, e.g. IT infrastructure, are small. The TSOs responsible for their respective control zone carry the financial burden for any IT infrastructure.

International harmonization can lead to lower costs. In this case there is no need to harmonize any documentation for capacity mechanisms, but rather the technical requirements so that eligible plants have similar prequalification. This would lessen the negotiating time considerably and relieve the highest costs factor.

Table 10: Summary of case study – Germany

Country of case study	Administrative costs / barriers	Interviewees
Germany	• Design phase: low costs • Allocation / operation: 3 FTE at NRA, 2-8 FTE with TSO (mostly renegotiation of contracts) • IT-infrastructure: are low • The eligibility costs for the generators is low	Ministry

5.4.5. IRELAND

The Single Electricity Market (SEM) was established in Ireland and Northern Ireland in 2007 by the Regulatory Authorities in Ireland and Northern Ireland (NRAs) of the all-island electricity market.[20] The SEM design included a market-wide capacity payment mechanism aiming to secure required new non-incumbent capacity and to reduce risk for new investments. This capacity mechanism was available to interconnectors, conventional generation, renewable generation and demand-side resources. However, no international participants were ever contracted.

[20] When referring to Ireland, we mean the geographical territory of Ireland and the Republic of Northern Ireland.

In 2007, the NRAs set out their plan to implement the European electricity target model, in the Integrated SEM (I-SEM). To assess the needed market design, SEM NRAs executed a cost-benefit analysis that concluded that the qualitative and quantitative assessments support the retention of an explicit capacity mechanism. The assessment concluded also that the most beneficial solution is to change to a volume based capacity mechanism based on centralised reliability options. The study concluded that, in line with the recent Final Report of the Sector Inquiry executed by DG Competition, a hybrid system would be the ultimate aim, but due to time and cost constraints an interim interconnector model was chosen.[21]

Design framework

As described, Ireland intends to replace the existing price-based capacity mechanism in 2017 with a volume based capacity mechanism based on centralised reliability options. The CBA (cost-benefit analysis) conducted in name of the NRAs includes a cost estimate for the total costs that are need to change from the current capacity mechanism to the new capacity mechanism. The total costs for the regulatory design for the authorities would be around € 2 million and would require an average of one full-time employee (FTE) extra. The one-off system implementation costs were estimated to be around € 16 million for the central agencies and an additional two FTEs. The market costs were estimated at € 33.000 per market participant.[22] However, these cost estimates do not refer to costs for cross-border participation, and filtering out the cross-border costs would be challenging.

Capacity requirement

The capacity requirement is based on the reliability standard as implemented by the TSO in the form of reliability options.

Eligibility

The new capacity mechanism is intended to be open to all potential capacity providers including both new and existing resources, and demand response. Rules for foreign capacity participation are not yet developed, but the stated intention is to enable foreign participation. The costs for eligibility for cross-border participation are not assessed. Cooperation and information exchange on e.g. de-rating and qualification requirements can be seen as an additional cost in relation to cross-border participation. A capacity mechanism in neighbouring jurisdictions and uniform technical standards can result in synergies.

Allocation process

The capacity requirement is based on the reliability standard as implemented by the TSO in the form of reliability options. A reliability option (RO) is a one-way call option that incentivizes participants to adjust their load/generation in times of high market price, typically materializing during system stress. ROs are awarded

[21] Integrated Single Electricity Market (I-SEM) SEM Committee Decision on High Level Design
Impact Assessment SEM-14-085b, 17 September 2014.

[22] See Annex 4 of the Integrated Single Electricity Market (I-SEM) SEM Committee Decision on High Level Design Impact Assessment SEM-14-085b, 17 September 2014.

through an auction mechanism to determine the price of capacity, with TSOs determining the quantity to be auctioned with NRA's oversight.[23]

Operational phase

The capacity mechanism is planned to commence in 2017. It is therefore too early to make any estimates on the costs for operation, other than those following the CBA referred to above. However, those costs do not filter out the specific costs for cross-border participation. It is in line of expectation, that monitoring and enforcement responsibilities might lead to additional costs. Think, for example, on the costs needed for TSO to assess and monitor whether the foreign capacity is available, and the need to have a foreign TSO to check and carry out tests.

Administrative costs and barriers

The administrative costs for cross-border participation on the part of the authorities are small and challenging to estimate. The general costs for the design and operation are included in the CBA. At this stage, administrative costs are not considered to be a significant barrier to cross-border participation. Non-monetary barriers such as the need for technical TSO cooperation and monitoring are much more important.

Table 11: Summary of case study – Ireland

Country of case study	Administrative costs / barriers	Interviewees
Ireland	• Only total cost estimates for capacity mechanism (not cross-border) • € 2 million for regulatory design for the authorities • € 16 million for the central agencies for system implementation • €30.000 per market participants (recurring)	NRA

5.4.6. *GREECE*

Greece is currently in the process of introducing legislation to reform the electricity market design, including the introduction of a new capacity mechanism. A temporary capacity mechanism was proposed in 2015 and approved by the EU in March 2016, and has been passed into law by the Parliament in May 2016 as part of larger electricity legislation package, with the legislation for a permanent mechanism under development. The permanent mechanism is due to come in place in 2017. The temporary mechanism is intended to provide a smooth transition to the permanent mechanism, so the description below is also to a certain extent relevant for the permanent mechanism. Previously, a model with capacity payments was in use until 2014.

Design framework

The temporary capacity mechanism is aimed at providing flexibility, i.e. short-term generation response.

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[23] See also, http://ec.europa.eu/competition/sectors/energy/capacity_mechanisms_working_group_8.pdf.

Capacity requirement

The capacity requirement is based on the reliability standard as implemented by the TSO, and is as such not part of the capacity mechanism process. The need for flexibility services is assessed by the TSO.

Eligibility

Generators must meet specific technical requirements to be able to participate in the capacity mechanism. When the TSO issues an order to the capacity providers, they must be able at 3 hours' notice to increase their generation by at least 8 MW per minute for a period of 3 hours. Eligible generators are gas turbines (open cycle and combined cycle), hydropower and CHP.

Cross-border participation is not possible.

Allocation process

The flexibility services will be procured through annual auctions and the compensation determined as the clearing price of the auction. In the temporary mechanism, the compensation for generators is set at EUR 45/kW, up to a total of EUR 15 million per generator unit. The total cap for the mechanism is set at EUR 225 million. The costs are covered through TSO charges on consumers.

Operational phase

The TSO will monitor the need for activating flexibility resources.

Administrative costs and barriers

The administrative costs on the part of the authorities are small. The capacity mechanism design is handled by a group of 5 FTEs, but the capacity mechanism work is not full-time. Stakeholder costs depend on the degree of involvement. Administrative costs are not considered to be a significant barrier to cross-border participation. Non-monetary barriers such as the need for technical TSO cooperation and monitoring are much more important.

Table 12: Summary of case study – Greece

Country of case study	Administrative costs / barriers	Interviewees
Greece	• Administrative costs low • The eligibility costs are not considered to be significant	NRA

5.4.7. Belgium

Belgium has currently implemented a strategic reserves mechanism. Emergency capacity is contracted by the Belgian TSO Elia in a yearly procurement process. The strategic reserves are intended to keep capacity that announced to leave the market, due to end-of-lifetime or non-profitability, available to cover peak demand levels during the winter period spanning from 1st November to 31st of March. Additionally, demand response can be contracted as part of the strategic reserves. In both cases, the capacity must be located within the Belgian control zone.

Design framework

The design of the strategic reserves in Belgium follows the general design concepts of a strategic reserves mechanism. Emergency capacity is contracted by the system operator who can activate the reserves to ensure system operation. The strategic reserves are intended to ensure the upward adequacy during peak demand levels in the winter months. Due to concerns about the availability of nuclear capacity because of unplanned technical problems, the start of planned nuclear phase-out, the announced closure of significant shares of gas-fired generating units, the government initialized the implementation of strategic reserves as one measure to address the threat of scarcity. In order to avoid scarcity, i.e. insufficient capacity to meet the demand, and to avoid interruptions in the electricity supply, the Belgian authority has decided to introduce strategic reserves as from the winter period 2014/15. The implementation of the Belgian strategic reserve was brought forward for the first time by the Plan Wathelet in June 2012, as a larger plan to ensure the Belgian security of supply.

The system operator contracts capacity originating from generation units or demand response in a yearly tendering process. During operation in the winter months, the activation of the capacity is triggered by an economic and/or technical trigger.

Capacity requirement

The capacity requirement for the strategic reserves is assessed every year as starting point of the tendering process by the TSO. An analysis regarding the security of supply, is conducted by the system operator. The analysis determines the required volume of capacity to reach the reliability criteria enforced by the law, Loss of Load Expectation (LOLE), under different scenarios and sensitivities. The scenarios include the expected closures of generating units which have to be announced by the 31st July in the year before the actual closure. Based on the study, and after advice on the necessity and volume by the Federal Public Service (FPS), the Federal Minister of Energy instructs the TSO to constitute the strategic reserves for the upcoming one to three winter periods by Ministerial Decree.

The contracting of the strategic reserves is split into two categories, namely the Strategic Generation Reserve (SGR) and Strategic Demand Reserve (SDR). Within the capacity requirement specific targets for the contribution from demand response are set.

The process of assessing the capacity requirements is made transparent by the TSO and the involved stakeholders are invited to provide feedback on the used methodology and achieved results. The costs related to the assessment are considered low and the process uses the methodology of the overall adequacy assessment by the TSO.

Eligibility

Capacity, both from generation or demand response, must be located within the Belgian control zone. The technical requirements are defined during the stakeholder involvement process at the start of the yearly tendering process and written down in the procedure of constitution as well as the functioning rules of the strategic reserves. The technical requirements involve among others requirements for the minimum response time between notification and delivery to ensure the operation, i.e. sufficient flexibility to follow the desired demand by the TSO during activation.

All generation units that announce the closure or mothballing by the 31st July in the year before the actual closure are obliged by law to submit a bid to the TSO for the participation in the strategic reserves. The bids are approved by the Belgian NRA and can be revised if the submitted costs are considered unreasonable. So far, the bids for the strategic reserve for generation originated mainly from gas-fired units that fulfil the flexibility requirements.

Demand response has similar technical requirements in terms of flexibility or response time as the generation. However, different sub-products for demand response exist that differ in for example maximum duration of activation or determination of contributed capacity. Additional rules for metering and sub-metering are defined in the above mentioned functioning rules to ensure the verification and tractability of activation.

The costs related to the eligibility are considered low. Generation units that announce closure are obliged to submit a bid to the tendering process. Technical parameters of contracted generation units are known and tested during the winter period to verify. Demand response requires an interaction with individual providers of flexibility, i.e. aggregators, and/or contracted consumers. Main costs are related to the setup of rules for metering and the installation of the required infrastructure for newly developed demand response sites. Eligibility and allocation process are treated in the same stage as they are both part of the procurement process of SDR and SGR

Allocation process

The allocation process is done via a tendering of capacity organized by the system operator after the capacity requirements are defined and the functional rules are fixed. All bids are checked and approved by the regulator prior to the selection process. The selection process is done mainly based on the economic parameters of the bids but also take into account the technical characteristics of the offered capacity.

Generation bids (SGR) involve among others a description of the technical characteristics of the unit as well as economic cost parameters for the contracting (€/MW*a) and activation (€/MWh).

Demand response (SDR) can offer two different services, either drop to and drop by. In case of drop to, the offered capacity is the commitment of the supplier to reduce its demand to a predefined capacity. It is determined by a lower shedding limit representing a minimum consumption of the SDR supplier. In case of drop by, the offered capacity represents a fixed bandwidth that the supplier reduces its consumption based on the initial schedule consumption profile.

For both services, two sub products with different specifications exist. This is done to attract different kind of demand response providers and are an outcome of the stakeholder involvement. They differ in, for example, the maximum length of activation and minimum time between activation. They are specified as either 4 hours or 12 hours. Moreover, the specifications vary in the amount of activation per winter period, namely 40 or 20 activations per winter period.

In case of a large share of demand response in the strategic reserve, the capacity from demand response is de-rated. This happens roughly speaking in blocks of 300 MW. The first 300 MW are not de-rated, i.e. have an equivalence factor of 1, the next 300 MW are de-rated at a factor lower than 1 and so on. The differences in equivalence factor from one group to the next can be maximum 0.196.

The default contract duration for both SGR and SDR are 12 months. Longer contracts (24 months and 36 months) were granted to SGR in the first and second tendering in 2104/15 respectively 2015/16.

The cost for the allocation is considered low as no additional market platform needs to be established. A small tendering process is established with limited suppliers.

Operational phase

The operational phase is coined by the rules for activation, i.e. the economic and technical trigger of the strategic reserve.

The *economic trigger* is linked to the market outcome of the Belgian day-ahead market Belpex DAM. In case there is not sufficient supply to satisfy all demand, and the price reaches the cap of 3000 €/MWh, the volumes of the strategic generation reserve are bid ex-post in a separate Belpex Strategic Reserve Market Segment Belpex SRM.

The *technical trigger* is activated by the system operator Elia if it detects a sufficient risk for a structural shortage in the Belgian control zone. This follow up is done using forecasts on estimated consumption and generation and is conducted intra-day, after clearing of the day-ahead market (18h00). The structural shortage is detected if the forecast demand for the Belgian control zone is higher than the forecast generation plus the available incremental bids or there is an insufficient margin to cover an unplanned outage of a nuclear unit.

One of the main costs related to the strategic reserve is the integration of the product in the operational infrastructure of the system operator. A large cost is the integration of the strategic reserve in the business processes (IT support) of the system operator (dispatch, measurements, settlement, publication).

Administrative costs

The initial design costs are higher than the actual administrative costs of operation, both allocation process and operational phase. The main cost for design until allocation are the personnel costs. And indeed, this cost could be complemented with external services. During operational phase the largest costs are related to the integration into the business processes of the Belgian system operator.

An integration of cross-border participation is at this point not foreseen as all capacity needs to be located within the Belgian control zone. A redesign and assessment study to what extent cross-border capacity could be activated on behalf of the Belgian TSO would be required.

An opening of the strategic reserve for non-domestic capacity would require to integrate capacities from control zones of neighbouring TSOs in the business process of the Belgian TSO. As this is already by now the largest share of cost during the operation, further cost increases can be expected.

For the periods 2014 and 2015 the Belgian regulator CREG has approved a budget of 5.94 million € for covering cost of the TSO. The total cost can be split in € 3.99 million for the development of the strategic reserve and € 1.66 million for recurrent business processes. Additionally, € 11002 are expected per activation of the strategic reserve. In comparison, the cost for contracting for winter 2014/15 and November and December 2015 summed up to € 36.86 million. Additional costs for the activation are not reported.

Table 13: Summary of case study – Belgium

Country of case study	Administrative costs / barriers	Interviewees
Belgium	• Design phase: High cost (personnel cost) for constitution procedure and functional cost • Additional eligibility and allocation costs are low • Large share of cost for integration in TSO's business process	TSO

5.5. FINDINGS FROM THE CASE STUDIES

Given the lack of available data and experience with cross-border capacity mechanism, it is difficult to give precise quantitative estimates of the overall administrative costs. However, the case studies indicate that the costs of setting up and operating a national capacity mechanisms are fairly small compared to the overall cost of the capacity mechanism (remuneration for procurement and activation). While the scope in the design phase matters, and the type of model is also a factor, we estimate that the administrative cost can be as low as 0.5 FTEs annually for a strategic reserve mechanism and not much higher than a handful of FTEs for a market-wide mechanism. Similarly, the design phase may require no more than 3-5 FTEs annually, although possibly over a longer time period depending on the consultation process, stakeholder involvement and decision-making structures.

The administrative costs of cross-border participation also depend on the model, and are not necessarily very large. The evidence from the GB mechanism indicates that an external stakeholder such as a participating interconnector owner may require up to 1.5 FTE in total during the design phase. The administrative costs are not expected to be high in the operational phase, less than 1 FTE for a participating interconnector owner.

It should be emphasised that the cost level is closely related to the fact that GB has chosen an interconnector model rather than a generator model.

With a generator model, the administrative costs of cross-border participation may be substantial. Eligibility and compliance (monitoring of delivery or availability) are particular issues. The main reason for the extra costs is the number of potential participants and the need to monitor delivery or availability per participant. If an interconnector model comes with obligations related to the actual generation on the other side of the interconnector at plant level, however, the costs would increase correspondingly.

A cross-border strategic reserve mechanism may be complicated in practice, and will be discussed further in the design chapter.

In general, the IT costs are considered to be negligible, even within a market-wide mechanism, provided that the design of the required IT systems can be integrated with existing systems for day-ahead and balancing market operations, settlements etc. This applies also to possible cross-border participation.

It should be noted that there is a trade-off between costs in the design phase and the operational phase. The French capacity mechanism is considered to be easy to operate in practice due to the time and effort spent in the design phase to create a mechanism that is fully integrated with other market processes. The German grid reserve, on the other hand, is complicated in practice due to the need for renegotiations and adjustment in the operational phase.

All in all, the evidence suggests that the impact of EU harmonisation of the framework for cross-border participation on administrative costs is likely to be small. The capacity mechanism and corresponding cross-border participation rules must be tailored to the national or regional markets, but can to some extent depend on the type of model. Several TSOs expect that harmonisation of other aspects of the European market design through Network Codes and the Market Design Initiative will make it easier to harmonise capacity mechanisms as well, thus making a special initiative for capacity mechanism harmonisation less necessary.

In this regard, standardisation of capacity adequacy and de-rating methodologies through ENTSO-E will also reduce the administrative costs.

5.6. Costs Associated with Cross-Border Participation

Determination of the exact costs that are dedicated to cross-border participation is challenging. This is mainly due to the lack of available data and experiences (only two capacity mechanisms allow for cross-border participation) and the difficulty in differentiating between costs for national participation and cross-border participation. However, it is possible to make a qualified judgment on a reasonable cost interval and the main factors that drive the costs.

In this section, we first discuss the costs accruing in different phases of designing and operating a capacity mechanism, as a basis for estimates of the necessary input of full-time employees (FTEs) for all stakeholders. We then estimate the costs of cross-border participation, and the cost savings that can be expected if EU capacity mechanisms are harmonized.

5.6.1. Costs in Different Phases

Costs accruing in different phases and for different stake-holders are assessed as follows:

- Costs for cross-border participation in the **design phase** cover one-time costs for e.g. cross-border participation in the consultation, design negotiations with neighbouring stakeholders (TSOs or NRAs) and/or costs for external advice. The costs are mainly born by National ministries, NRAs and TSOs. We estimate that the costs in the design phase dedicated to cross-border participation do not exceed 10% of the overall costs for design of the capacity mechanism. The overall costs depend on the scope of the process and the overall effort spent (depending on factors such as the bureaucratic traditions and requirements for documentation, etc.). However, from our discussions with different NRAs, TSOs and Ministries, a benchmark figure of 10% of total administrative cost seems reasonable.

  Over time, one would also expect learning effects between countries even with a national approach (i.e. the baseline with no EU framework available), so the overall costs on a European scale will not be linear in the number of countries developing a capacity mechanism. Nevertheless, harmonized rules that support international cooperation, or provide a framework for different types of capacity mechanisms, could yield a potential additional gain. However, a substantial amount of the resources spent in this phase will be related to the consultation process and the tailoring of the EU framework or framework elements to meet the national requirements, which limits the impact of harmonization with regard to design.

  In relation to the two types of cross-border participation (IC and Generator), we do not find any evidence that the design cost, shared by TSOs, authorities and market participants, will differ significantly between the different models.

- Costs dedicated to cross-border participation for setting a **capacity requirement**, cover e.g. defining a reliability standard and calculating the need for capacity that will be required under the mechanism (i.e. the demand for capacity). These costs will typically be borne by the TSO in its role as system operator. We estimate that the additional costs for inclusion of cross-border participation here are negligible to none. This is mainly due to the fact that the TSO has to take cross-border contributions into account in the calculation of the capacity requirement in any case. Hence, we foresee very low additional costs for the TSO and none for market participants and the NRA. We also expect the cost to be zero for foreign market participants and authorities as well.

International cooperation can result in synergies and inclusion of other markets (and variables) in calculating and setting the capacity requirement. As such, harmonizing rules for TSOs responsibilities is already included in e.g. Network Codes, and further provisions for cooperation are expected. However, since the costs are estimated to be negligible to none, we do not foresee a major welfare gain from a common framework for cross-border participation.

In relation to the two types of cross-border models (IC and Generator), we do not find any evidence that the total cost for setting the capacity requirement will differ between the different models.

- Costs dedicated to **eligibility** refer to costs involved in pre-qualification of participants in the capacity mechanism, e.g. documentation of available capacity, fulfilment of technical and geographical requirements and de-rating of participating actors/units. The eligibility criteria can be subject to interpretation, language barriers, jurisdictional differences and certification of the participants. Depending on the design, these costs can be recurring and could result in a heavy burden on NRAs and ministries to cooperate and negotiate with counterparts to ensure practical inclusion of cross-border participation. There is a trade-off between the time (i.e. cost) used in the design and eligibility step/phase on one side and the time used in the operation and compliance steps on the other side. Due to differences in technical standards, interpretation, language, jurisdiction, certification and the need to negotiate on them, the costs can be relatively high. Based on our interviews and the type of model, we estimate the costs in terms of FTEs to vary between 0 and 9 per annum. The costs are mainly borne by National ministries, NRAs and TSOs. The costs for cross-border market participants are not expected to be substantial.

  Especially in the eligibility phase, we foresee a difference in costs related to the type of model applied. The costs depend partly on the number of eligible participants, but also on the number of countries included in the “eligibility area”. Thus, the costs can be high in a generator model, with a higher number of potential participants and a need to interact with market participants and stakeholders in several countries (although depending on the market structure and number of actual foreign bidders). In an IC model, the costs would be limited to the amount of interconnectors, that also fall within the national jurisdiction.

  In the eligibility phase, there is clearly a potential for welfare gains from increased cooperation and setting of harmonized standards. Although rules for TSOs responsibilities are to some extent already harmonized via e.g. Network Codes, further cooperation can be beneficial.

- Costs in the **allocation process** cover costs for e.g. an open auction in a market-based mechanism or an administrative procedure in a strategic reserve. Based on our interviews, we estimate the additional costs associated with cross-border participation to be low, considering that it would have to be done in a national capacity mechanism too. As the number of market participants increase, the total cost of participation is likely to increase. Participation costs are related to analysis of the capacity mechanism and determining bidding strategies. To some extent, however, this would be a one-off cost involving up to 1 FTE. As we expect a cost factor increase per market participant, we estimate higher costs in a generator model than in an interconnector model.

The interviews did not indicate that any form of harmonized rules would affect the cost for the allocation process in relation to cross-border participation.

- In the operation phase, we make a distinction between the ordinary operation phase, meaning the day-to-day operation costs in case there is no stress situation, and the phase of control/compliance in case there is a stress situation.

  Costs needed for (**ordinary**) day-to-day business **operation** are often borne by the responsible authority, typically the TSO, to monitor the need for capacity and act in accordance with the capacity mechanism. The costs depend greatly on the design of the capacity mechanism and there can also be overlap with the eligibility phase. There is a trade-off between the time used in earlier steps/phases that can result in lower costs in the operation phase and/or vice versa. We therefore estimate the costs between 0.5 to 2 FTE per annum for the TSO and the NRA. Market participants' costs will be negligible in this phase if there are no stress situations. We do not find any difference in costs between the type of model (generator or IC) or any benefits in European harmonization (neither option 1 or option 2). We expect the additional costs related to IT systems etc. to be negligible.

- Costs needed for operation, in terms of **control/compliance**, especially in stress situations, are the costs that are dedicated to monitoring of compliance (delivery or availability), including imposing penalties in case of non-compliance and other enforcement related issues, activation of reserves and renegotiation of contracts with foreign capacity providers. Depending on the obligation, there could be a heavy burden on NRAs and ministries to follow-up and negotiate with counterparties in another jurisdiction to overcome jurisdictional and practical barriers related to compliance and penalties. The TSO, as operator of the capacity mechanism, will also bear costs for the compliance stage in cases of stress to e.g. control that participants actually have delivered.

  We estimate that more eligible participants would result in higher costs, due to e.g. increased cooperation, enforcement and negotiation with neighbouring countries' stakeholders (TSOs or NRAs) and participants. Therefore, the generator model is estimated to be costlier (estimated at 4 to 12 FTE per annum for TSO and NRA and 0 to 1 FTE per annum per market participant) than an interconnector model (2 to 4 FTE per annum for TSO and NRA and 0 to 1 FTE per annum per market participant). In both cases we assume that there is a trade-off between the resources spent by the regulator and the TSO, i.e. it is a matter of national choice whether the main work is carried out by the parties.

  In the control/compliance phase, there is clear potential for welfare gains due to increased cooperation and setting of harmonized standards. However, full harmonization will be very challenging considering the limit of Member States' jurisdiction (and that they are willing to allow) and the requirement for uniform application of enforcement rules. A framework for increased cooperation can be beneficial. It is, however, impossible to estimate the scope of such a gain/benefit.

5.6.2. COSTS IN TERMS OF FTES

Based on the interviews and the discussion in the previous paragraph, Table 14 shows a best-guess estimate of the additional costs associated with cross-border participation in a capacity mechanism, i.e. the additional costs if cross-border participation is facilitated. In this cost estimate we generally do not distinguish between the different types of capacity mechanisms, unless specifically described; the estimates are based on experiences from strategic reserves as well as marked-based mechanisms. We briefly touch upon the differences in costs in relation to the different models (i.e. generator or interconnector model) and options for a common framework in EU-wide regulations for capacity mechanisms (option 1 or 2).

Table 14: Estimated FTEs dedicated to cross-border participation in capacity mechanisms

	Regulatory Authority (NRA) and Ministry	Transmission system operator (TSO)	Market participant*
Design**	Approx. 10% total costs (1-2 FTE + external advice)	Approx. 10% total costs (1-2 FTE + external advice)	0-1 FTE per participant (TSO/Generator/DSR provider)
Setting capacity requirement	N/A	Negligible (part of TSO responsibilities)	N/A
Eligibility GM	2-4 FTE	2-4 FTE	0-1 FTE
Eligibility ICM	0-1 FTE	0-1 FTE	0-1 FTE
Allocation process	Negligible	Negligible	0-1 FTE
Operation (ordinary)	0.5-2 FTE	0.5-2 FTE	Negligible
Control / Compliance GM	2-10 FTE***	2-8 FTE***	0-1 FTE
Control / Compliance ICM	0.5-2 FTE	0.5-2 FTE	0-1 FTE

Legend:
GM: Generator model
ICM: Interconnector model
N/A: Not applicable
FTE: Full time employee per annum
** Indicates the costs per participant. The total depends on the number of participants.*
*** Costs in the design phase are one-time costs. FTEs in other phases refer to (annually) recurring costs.*

****Trade-offs mean that the sum of FTEs across NRA/Ministry and TSO is in the interval 4-12. For other cost elements the number of FTEs is additive.*

The cost estimates presented in Table 14 are expressed in FTEs for the different design/administrative elements (Rows, see also Table 4 and Table 5 above) for the three main stakeholder groups (Columns); i.e. National Regulatory Authorities (NRAs) and Ministries, TSOs and Market Participants. Differences between the costs for a generator model and an interconnector model are expressed by separate rows (GM and ICM). In addition, we also indicate where there may be a need for external assistance, which is primarily in the design phase. Note that there is also a trade-off between external and internal resources. Less external advice would imply more FTEs, and the sum of costs would be expected to be little dependent on the mix between internal and external resources.

The estimates on FTEs are based on the interviews we have conducted. The estimates provide a range of the amount of FTEs - in absolute numbers – based on current experience with capacity mechanisms, i.e., the FTE estimates are not averages, unless explicitly stated. The capacity mechanisms that we use for our estimates have a different distribution between the phases due to trade-offs, meaning that a capacity mechanism that uses a lot of FTE in the design phase, often uses fewer FTEs in the control / compliance phase. For example, in the German capacity mechanism, the amount of FTEs in the 'Control / Compliance' phase in a Generator Model (GM) ranges between 2-8 since there is a strong need to renegotiate with participants their technical standards and delivery after the initial awarding of the contracts, whilst there also are four TSOs that each is responsible for its own area. Another example is France, that used relatively a lot of time / money for the design phase to avoid high compliance costs later. This cost trade-off between different phases is not included in the estimates above.

Another large range is that of "control and compliance" costs in a capacity mechanism, where the maximum refers to the German capacity mechanism, and reflects the need to renegotiate a lot of contracts and the involvement of several TSOs.

Any further experience with capacity mechanisms can surely decrease costs, in which TSO, NRA and participants become more used in using the mechanisms. Any synergy in having certain elements of even one harmonized capacity mechanism can also lower costs.

5.6.3. Estimates of Total Costs

The estimates in Table 13 are used as a basis for the illustrative examples of total costs that follow below. The FTE estimates are translated into costs using an average Full-time Employee (FTE) cost of € 42.000.[24]

Table 15 displays the total costs for National authorities and TSOs, per model (GM or ICM).

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[24] Based on Irish and UK statistics; All staff costs are based on an average salary of € 35.000 plus an estimate of additional costs, faced by the employer (superannuation, insurance etc.) of 20%, so a total FTE cost of € 42.000. Sources: SEM Committee Integrated Single Electricity Market (I-SEM) SEM Committee Decision on High Level Design Impact Assessment SEM-14-085b 17 September 2014; The Earnings and Labour Cost Statistics published by the Central Statistics Office of Ireland; This is based on UK statistics (http://www.ons.gov.uk/ons/rel/fi/occupational-pension-schemes-survey/2012/stb-opss-2012.html).

Table 15: Estimated costs associated with cross-border participation for TSOs/Authorities, initial costs and recurring (annual) costs

	Generator model	Interconnector model
Design – FTE – External advice[25]	 € 84.000 – 168.000 € 50.000 – 100.000	 € 84.000 – 168.000 € 50.000 – 100.000
Total initial costs	**€134.000 – 268.000**	**€134.000 – 268.000**
Setting capacity requirement	€ 0	€ 0
Eligibility	€ 168.000 – 336.000	€ 0 – 84.000
Allocation process	€ 0	€ 0
Operation (ordinary)	€ 42.000 – 168.000	€ 42.000 – 168.000
Control / Compliance (stress)	€ 168.000 – 504.000	€ 42.000 – 168.000
Total annual recurring costs	**€ 378.000 – 1.008.000**	**€ 84.000 – 420.000**

The total costs for market participants are illustrated for the two different models (GM and ICM). Although several examples are imaginable, in this case we have used the following (simple) assumptions:

- 15 national capacity mechanisms implemented in EU Member States
- Generator models: 10 cross-border participants per capacity mechanism
- Interconnector models: 3 cross-border participants per capacity mechanism

The number of 15 national capacity mechanisms is based on an average across years and scenarios of the number of countries with foreign participation observed in the modelling, cf. Chapter 6 and E3MLab (2016).

Table 16 displays the estimates per market participant translated into the total costs for market participants. Particularly the latter costs can vary significantly depending on the number of market participants per Capacity Mechanism.

[25] The costs for external advice are estimated between € 50.000 to 100.000, based on an average fee for one or two (cost-benefit) analysis by the regulatory authority and/or responsible ministry.

Table 16: Estimated total recurring (annual) costs for cross-border participation for market participants (15 national capacity mechanisms)

	Generator model	Interconnector model
Setting capacity requirement	€ 0	€ 0
Eligibility	€ 0 – 6.300.000	€ 0 – 1.890.000
Allocation process	€ 0	€ 0
Operation (ordinary)	€ 0 – 6.300.000	€ € 0 – 1.890.000
Control / Compliance (stress)	€ 0 – 6.300.000	€ € 0 – 1.890.000
Total for market participants	**€ 0 – 18.900.000**	**€ 0 – 5.760.000**

The cost estimates are of course uncertain, and the estimated ranges correspondingly wide. The total cost associated with participation in generator models are particularly uncertain, as total costs depend on the number of participants as well. It should be noted that the high estimate does not take into account any synergies that may occur if generators (or interconnectors) participate in more than one capacity mechanism, or the trade-off between eligibility costs and control and compliance costs.

5.6.4. COST SAVINGS FROM HARMONIZATION

Development of a common framework for cross-border participation is likely to provide the largest cost reductions in the eligibility phase and in the compliance phase. In option 1 (harmonized common framework), the difference between the models may still be substantial, while in option 2 (harmonized elements), the number of varieties will be limited. However, resources still have to be dedicated to pre-qualification and registration (the eligibility phase) and to monitoring, control, penalties, etc. (compliance phase), even with a common framework. A rough guestimate is a reduction of the costs related to the eligibility phase and the control/compliance phase of 30 % in option 1 and 50 % in option 2. We do not expect the cost for participants to be significantly reduced. We do not expect the cost per participant to be significantly reduced.

Although there are some gains from harmonization in the design phase, we expect these to be of a small magnitude and do not take them into account in the estimates below. The costs for design are generally low as described earlier, and they are of a one-off character. The design phase hence only constitutes a small share of the total administrative costs (see the net present value estimates below). Also, the activities related to consultations and changes to legislation and regulations will still have to be carried out formally, even though the production of content will gain from harmonization.

Using the cost estimates above, we show the estimated cost savings associated with the options in Table 17 (Option 1) and Table 18 (option 2).

Table 17: Example: Total reduction in recurring (annual) costs for cross-border participation for TSO/Authorities in Option 1 – Harmonized capacity mechanism framework

	Generator model	Interconnector model
Setting capacity requirement	€ 0	€ 0
Eligibility (30% cost reduction)	€ 50.400 – 100.800	€ 0 – 25.200
Allocation process	€ 0	€ 0
Operation (ordinary)	€ 0	€ 0
Control / Compliance (stress) (30% cost reduction)	€ 50.400 – 151.200	€ 12.600 – 50.400
Total cost saving	**€ 100.800 – 252.000**	**€ 12.600 - 75.600**

Table 18: Example: Total reduction in recurring (annual) costs for cross-border participation for TSO/Authorities in Option 2 – Harmonized basic capacity mechanism elements

	Generator model	Interconnector model
Setting capacity requirement	€ 0	€ 0
Eligibility (50% cost reduction)	€ 84.000 – 168.000	€ 0 – 42.000
Allocation process	€ 0	€ 0
Operation (ordinary)	€ 0	€ 0
Control / Compliance (stress) (50% cost reduction)	€ 84.000 – 252.000	€ 21.000 – 84.000
Total cost saving	**€ 168.000 – 420.000**	**€ 21.000 – 126.000**

Although different levels of EU harmonization of capacity mechanisms mainly affect eligibility and compliance costs, and accrue to TSOs and authorities, the estimated cost savings for national authorities with harmonized basic elements are potentially significant: Up to 44 % for generator models and between 25 and 30 % for interconnector models measured as a percentage of annual recurring costs. The extra cost savings with option 2 compared to option 1 are mainly due to the fact that the rules and procedures for eligibility and control/compliance are defined in more detail (see also the discussion in chapter 4). For example, with option 2 the eligibility criteria and procedures are exactly the same for each type of capacity mechanism. Also, testing of availability and penalty procedures are streamlined and determined in detail with option 2, leaving both regulators, TSOs and capacity providers with lower costs. In option 1, there are still some degrees of freedom with regard to the details, implying higher costs.

5.6.5. Aggregated Cost Estimates

For comparison of the costs for cross-border participation with the estimates of benefits of Chapter 6 below, we present the total cost estimate range of the results of the above Tables for the period of 2021 to 2030, based on the following assumptions:[26]

- A real discount rate of 4%
- The reference for the NPV calculation is January 1st, 2017
- Initial costs accrue in 2018 (the same for all options and occur once, as a proxy for a design phase that spans a period of time before 2021)
- We use the following Options:
  - National capacity mechanisms without harmonization (Table 19)
  - Option 1: Common Framework, reducing the costs related to the eligibility phase and the compliance phase by 30 % (Table 20)
  - Option 2: Harmonization of Basic Elements, reducing the costs related to the eligibility phase and the compliance phase of 50 % (Table 21)

Table 19: Total cost range capacity mechanisms without harmonization, authorities and participants, million €'16

National capacity mechanisms	Generator model	Interconnector model
Initial costs	0,1 – 0,2	0,1 – 0,2
Annual costs TSO/authorities	2,6 – 7,0	0,6 – 2,9
Annual costs market participants	0 – 131,0	0 – 39,3
Sum	**2,7 – 138,3**	**0,7 – 42,5**

Table 20: Total cost range Common Framework (Option 1), authorities and participants, million €'16

Option 1 – 30%	Generator model	Interconnector model
Initial costs	0,1 – 0,2	0,1 – 0,2
Annual costs TSO/authorities	1,9 – 5,2	0,5 – 2,4
Annual costs market participants	0 – 131,0	0 – 39,3
Sum	**2,0 – 136,5**	**0,6 – 41,9**

[26] Rounding errors may occur.

Table 21: Total cost range Harmonization of Basic Elements (Option 2), authorities and participants, million €'16

Option 2 – 50%	Generator model	Interconnector model
Initial costs	0,1 – 0,2	0,1 – 0,2
Annual costs TSO/authorities	1,5 – 4,1	0,4 – 2,0
Annual costs market participants	0 – 131,0	0 – 39,3
Sum	**1,6 – 135,4**	**0,6 – 41,6**

The estimates in the tables above show a huge range between minimum estimates and maximum estimates. The difference is mainly caused by the annual costs for market participants, which is the accumulation of the costs over the period 2021-2030 with the above assumptions. These maximum estimates should clearly be taken with a grain of salt, for several reasons:

- Estimates in terms of whole FTEs are very crude. Costs are likely to vary between participants.
- If the costs appear unreasonably high for market participants, the number of participants is likely to be reduced.
- The cost of participation could be reduced over time as participants get experience. With more national capacity mechanisms, it is also more likely that participants can realize economies of scope/scale by participating in more than one capacity mechanism.
- With more national capacity mechanisms, some of the cross-border participants will already be eligible participants in their national capacity mechanism. Thus cross-border participation does not necessarily imply significantly increased efforts, particularly if the national capacity mechanisms are harmonized.

In the analysis above, we have taken into account the entire range of possible outcomes. For the purpose of providing a more specific estimate we have used the midpoint of the different intervals. This yields the following baseline estimate for the administrative costs:

Table 22: Midpoint estimate of administrative costs without harmonization, million €'16

National capacity mechanisms	Generator model	Interconnector model
Initial costs	0,2	0,2
Annual costs TSO/authorities	4,8	1,7
Annual costs market participants	65,5	19,7
Sum	70,5	21,6

The corresponding costs with option 1 and 2 are as follows:

Table 23: Midpoint estimate of administrative costs with option 1, million €'16

National capacity mechanisms	Generator model	Interconnector model
Initial costs	0,2	0,2
Annual costs TSO/authorities	3,6	1,4
Annual costs market participants	65,5	19,7
Sum	69,3	21,3

Table 24: Midpoint estimate of administrative costs with option 2, million €'16

National capacity mechanisms	Generator model	Interconnector model
Initial costs	0,2	0,2
Annual costs TSO/authorities	2,8	1,2
Annual costs market participants	65,5	19,7
Sum	68,5	21,1

The tables above indicate that the administrative costs of setting up and operating capacity mechanisms are fairly small from the EU perspective. The main cost driver is the number of participants, which is likely to be significantly larger with a generator model. The estimates also indicate that while option 1 and 2 yield administrative cost savings, these savings are small compared to the total administrative costs. Rather, the value of option 1 and 2 is found in the removal of non-monetary barriers to cross-border participation.

5.7. CONCLUDING REMARKS

Based on the above analysis, we consider that the main benefit of a harmonised EU framework for cross-border participation in capacity mechanisms is not to reduce the costs of cross-border participation, but to remove administrative and judicial barriers related to the underlying complexities of such provisions.

In general, the *additional* costs of facilitation of cross-border participation are relatively low for national authorities and TSOs. The main additional costs related to cross-border participation are found in the eligibility phase and the operation phase, in particular related to control and compliance, and the application of penalties. These costs may be reduced by creating a common framework for cross-border participation. We estimate the cost saving for option 1 to be 30 % and for option 2 of 50 % of eligibility costs and compliance costs for TSOs and authorities.

As discussed above, the elements which may potentially require a substantial effort in terms of FTEs are the eligibility costs and the control and compliance costs, in particular for national authorities. The following should be noted:

- There is a trade-off between the FTE effort at these two stages. Thus, the range of total FTEs is likely to be smaller than the sum of the minimum estimates and the maximum estimates.
- The most important cost savings from harmonization of rules are likely to accrue in exactly these elements.

Another difference is the type of model. Whereas the generator model has an estimated cost of € 70,5 million without harmonization in our example, due to its potentially large amount of market participants, the interconnector model has clearly fewer participants and thus a lower cost estimate of € 21,4 million. If interconnector models imply that the interconnector owners choose, or are obliged, to make contractual arrangements with cross-border generators, the costs will be higher. Harmonization has only a limited impact on the direct administrative costs of the two models.

The allocation of costs between the different stages in the development and operation of capacity mechanisms are likely to differ between capacity mechanisms and among Member States. For example, there is a trade-off between the costs in the eligibility and design phase, and the costs in the operation phase.

There is a difference between a generator model and an IC model in relation to the costs. This difference can be explained by the number of participants and jurisdictions. The more participants and countries participate, the greater the potential for increased costs, as the examples show.

The value of EU harmonisation may also be related to the general drive for a more harmonised market design and implementation of the Target Model, which in turn should make it easier to harmonise capacity mechanism frameworks and facilitate cross-border participation. There may also be opportunities related to guidelines for regional solutions and "best practice" guidelines for different types of capacity mechanisms. Additionally, there may be benefits from establishing standard mechanisms for ensuring cross-border compliance and standard agreements in different languages.

6. BENEFITS OF CROSS-BORDER PARTICIPATION

In order to estimate the benefits of cross-border participation in capacity mechanism we have used quantitative models that simulate investment behaviour under different assumptions about the market framework.

The main benefits of cross-border participation accrue from the enhancement of competition in the capacity markets as well as in the wholesale and reserve markets, which result in lower clearing prices in the capacity auction and lower energy market clearing prices; this effect has been quantified in the modelling and is presented in the results section (6.4) of this chapter.

The analysis concludes that capacity mechanisms with cross-border participation are less costly than those without. Moreover, due to the better allocation of resources in capacity auctions, less capacity is maintained in total.

Cross-border participation appears to increase efficiency of capacity mechanisms, both in the long-term (as total investment costs appear to be lower) and the short-term (as payments for load on an annual basis are lower).

Finally, simulation results indicate that energy trade is not modified significantly when capacity mechanisms allow foreign participation (compared to when they do not allow it).

Modelling the effect of capacity mechanisms on the market outcome, and the impact of implicit versus explicit participation, is very complex, as the analysis presented in this chapter will demonstrate. A number of simplifications and assumptions have to be made. Compared to the theoretical analysis of different framework designs, presented in Chapter 4, the following should be noted:

- Capacity mechanisms in the modelling are defined in a stylised manner, as centralised auctions at national level, with common rules for all Member States that implement them.
- The modelling takes into account a part of imports/exports in determining capacity adequacy. De-rating of import capacity to reflect simultaneous stress events is not relevant for the modelling.
- The modelling assumes that the same capacity cannot be offered more than once in capacity auctions. The logic followed in the modelling is that even in the case that participation in more than one capacity auction is allowed, high penalties for non-delivery and the high frequency of stress times occurring close in the EU would ultimately discourage generators in offering the same capacity in different capacity auctions.
- Offering of cross-border capacity in capacity auctions is determined in order to maximise (if not to ensure) the probability of *delivery* of capacity in stress situations.
- The modelling does not limit participation geographically. In the simulations, participation of a foreign capacity provider in a capacity mechanism depends on the ability to deliver power in stress times, considering the limitations of the network.

A detailed overview of the methodology followed as well as of the results can be found in E3MLab (2016).[27]

6.1. OVERVIEW OF THE MODELLING METHODOLOGY

Before going into the description of the benefits of cross-border participation, we present a short summary of the modelling methodology. A detailed overview of the methodology as well as of the results can be found in Appendix A.

The applied approach follows two distinct steps:

1) estimation of how capacities are allocated in capacity mechanism auctions in case cross-border participation is allowed and of the resulting capacity mechanism auction clearing prices (see section 6.1.1).

2) running of a variant of the PRIMES model to estimate how the implementation of capacity mechanisms (with and without cross-border participation) influence investments, taking as given the results of step 1 (see section 6.1.3).

6.1.1. ALLOCATION OF CAPACITIES IN CROSS-BORDER PARTICIPATION

It is assumed that foreign capacity that is allowed to participate in capacity mechanism auctions must be available to produce in excess of normal market driven flows under stress situations, and that its effective delivery is ensured. Moreover, it is assumed that capacities cannot be offered in more than one capacity auction in the simulation, as we consider that the possibility of stress times occurring simultaneously in different systems would discourage generators to offer their capacity more than once, especially in the face of high penalties for non-delivery[28]. Moreover, we assume that national capacity auctions occur simultaneously, otherwise some countries would get more favourable conditions than others.

With the above consideration in mind, the estimation of foreign capacity offerings in capacity mechanism auctions builds upon two main axes:

a) Deliverability, i.e. how possible is it that capacity can be transferred between two countries, considering technical network limitations and congestion of interconnectors as projected with PRIMES in the EUCO27 scenario.

b) Anticipation of revenues, i.e. suppliers of capacity will allocate their capacity taking into account the capacity requirements of every country with capacity mechanism auction, assuming that the lower the ratio

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[27] E3MLab (2016): *Methodology and results of modelling the EU electricity market using the PRIMES/IEM and PRIMES/OM models,* forthcoming.

[28] There would always be a risk of stress occurring simultaneously in more than one systems and thus of a generator that has offered capacity in the respective CM auctions not being able to deliver and face any applicable penalties. Therefore, assuming that such penalties would be high enough, and given the fact that peak load times in the EU are occurring close, it is assumed for the simulations that generators would not be willing to take that risk.

between supply and demand in a country the higher the auction clearing prices.

The above are represented through functions, namely the deliverability function and the revenue anticipation function, which are illustrated in Figure 6. Detailed explanation of their calibration can be found in E3MLab (2016).

Regarding the revenue anticipation function in particular, it is similar to the capacity auction demand curves, on the specification of which we provide details in the following section (6.1.2). This implies that generators anticipate the shape of the capacity demand curves, albeit they do not know the price cap (which is to be regulated), instead they anticipate how close or far to the price cap the auction clearing price will be.

Overall, generators decide where to allocate capacity maximizing expected remuneration in parallel to the probability that this amount of capacity will be delivered.

The solution of the allocation method results in specific capacity offerings in capacity mechanism markets, and therefore to specific auction clearing prices (given a price cap). These are then fed into the PRIMES model to calculate revenues of plants in capacity auctions (where applicable) and evaluate investment decisions.

It should be noted that the estimation of cross-border allocation of capacities assumes that barriers that hinder cross-border participation are removed, including legal barriers relating to the institutional design of capacity mechanisms (e.g. non-uniform eligibility criteria for participation), as well as barriers stemming from political or other considerations.

Two factors are however taken into account:

- The effect of national assessments of capacity adequacy, as the optimization determines cross-border participation simultaneously with addressing every country's national needs.

- Complexities that arise from the need for coordination and negotiation between TSOs, to a certain extent, through reducing the cross-border deliverability of capacity between countries depending on their "proximity" in the network.

A detailed description of the methodology on the allocation of cross-border capacities can be found in E3MLab (2016).

6.1.2. CAPACITY DEMAND CURVES AND AUCTION CLEARING PRICES

The capacity mechanism demand curves are specific to each market (Member State). They are negatively-sloped linear lines that depend upon a price cap and linking two capacity points: the minimum and maximum capacity requirements of a market (Figure 6) [29].

In particular, the minimum requirement is defined for each market as the amount of additional capacity that is needed in order to fulfil certain reliability criteria**.** The reliability criterion for each MS is set as an actual reserve margin ratio and we

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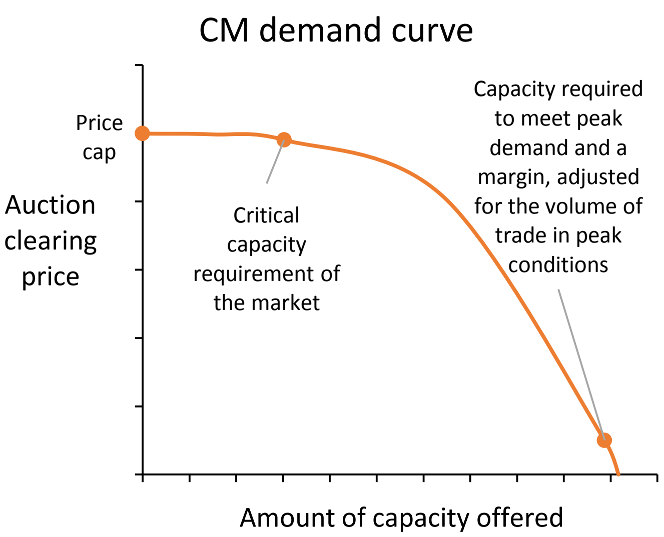
[29] Their design is based on the CM demand curves used by the PJM.

Figure 6: Illustration of capacity auction demand curve



calculate the amount of additional capacity compared to installed capacity levels (as projected in the EUCO27 scenario) that is needed to fulfil this margin. The operating availability of plants[30] is taken into account in order to determine the reserve margin ratio. Moreover, the capacity that is not recovering costs in the energy only markets (as quantified with PRIMES) is added to the amount that is required to meet the reliability criteria. Any capacity up to this amount is considered to be critical and defines the minimum requirement of the capacity mechanism auctions demand curve. The auction clearing price at this point is equal to the price cap.

The maximum requirement (i.e. the size of the capacity market) is set equal to the peak demand, adjusted for the volume of trade in peak conditions, as this is projected with PRIMES for the EUCO27 scenario. For this maximum requirement the auction clearing price is close to zero. Peak load is adjusted to the volume of trade because we consider implicit participation of flows over the interconnectors in generation adequacy. Depending on the country (whether it is mainly an importer or exporter according to the projections of PRIMES for the EUCO27 scenario), we take into account a portion of imports that can be viewed from the side of a regulator as "trusted" and we subtract them from peak load. Similarly, we consider a part of exports as "guaranteed" and we therefore increase peak load accordingly. Obviously, taking into account imports leads to lower auction clearing prices while inclusion of guaranteed exports leads to higher auction clearing prices (Figure 7). The part of imports/exports that is considered is an assumption and can be modified.

Therefore, implicit participation of flows over interconnections is taken into account in the definition of the capacity auctions demand curve, regardless of whether cross-border participation is allowed in the capacity auctions. When cross-border participation is allowed explicitly in a capacity market (explicit participation of flows in the capacity auction), then capacity offering in this market increases. Hence, auction clearing prices tend to decrease in the country receiving the foreign capacity offers. However, as a plant's capacity cannot be offered twice to capacity mechanism auctions, the offer abroad decreases capacity offered domestically,

[30] It should be noted at this point that all capacities (both supplied or demanded), are unforced capacities, which means that they have been de-rated according to the operating availability of plants.

which implies that in case of shortage the auction clearing prices will tend to increase domestically.

A detailed description of the approach followed to derive the capacity demand curves can be found in E3MLab (2016).

6.1.3. Simulations with the PRIMES Oligopoly Model

E3MLab has developed a variant of PRIMES (PRIMES oligopoly model), tailored to the particular needs of this study, that simulates the conditions of an organized wholesale market. The model includes the option to implement a stylized capacity mechanism auction, with or without cross-border participation.

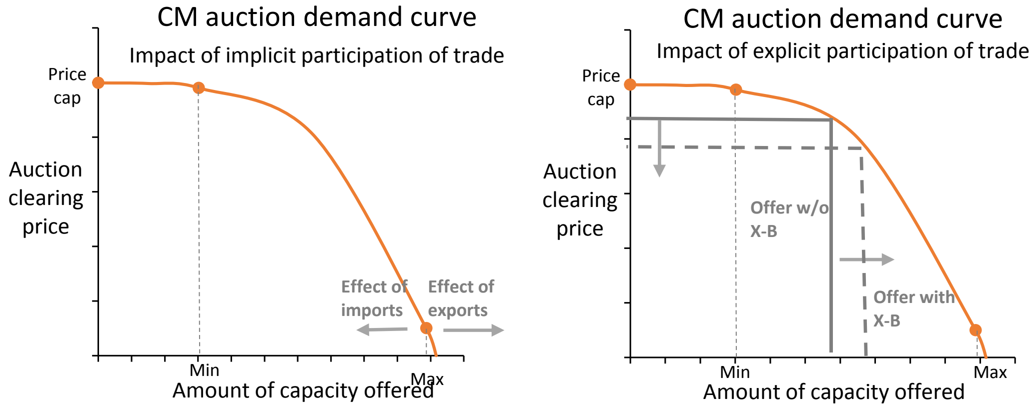
The starting point for the analysis with the oligopoly model is the EUCO27 scenario quantified with the main PRIMES model, from which it takes the first inputs, including the projection of generation capacities of power plants. For each individual plant, the model mimics its strategic bidding behavior in an oligopoly through employing a plant-specific scarcity bidding function (detailed description of the method applied can be found E3MLab, 2016). The model runs for a pan-EU equilibrium and calculates prices, and the revenue streams and costs for each plant.

These are subsequently used to evaluate investments and estimate which would be cancelled due to insufficient revenues. This means that the investment evaluation process will yield with a capacity mix that deviates from the capacity mix projected in the EUCO27 scenario (6.1.4).

The evaluation of investments is undertaken with a tool on which we will refer to as the Investment Evaluation model. The method implemented in the Investment Evaluation model takes into account three main uncertainty factors: ETS prices, natural gas prices relative to coal, and net demand for electricity (net of renewables generation). Investment decisions are evaluated by stochastic modelling of about 100 combinations of the uncertainty factors.

The heterogeneity of decision makers is also represented by applying a probability distribution for hurdle rates (required rate of return). The mean and standard variation of this distribution depends on the degree of uncertainty. In the case of markets with capacity mechanisms we therefore assume that

Figure 7: Illustration of the impact of implicit/explicit participation of flows in the CM auction demand curve



- the hurdle rates have lower mean and standard deviation compared to energy-only markets, as revenues are more certain.
- the mean and standard deviation of hurdle rates is lower when foreign participation is allowed than when it is not.

The argument for the latter assumption is that when cross-border participation is allowed in the capacity mechanism, competition increases, implying that investors can accept slightly lower returns in order to maintain investments. This implies that it is "easier" for investors to decide positively on maintaining an investment when cross-border participation is allowed.

A detailed description of of the investment evaluation methodology applied can be found in E3MLab (2016).

Finally, the PRIMES Oligopoly model re-simulates the pan-EU wholesale market with the updated capacity levels (after removal of the capacities that are not receiving sufficient revenues according to the investment evaluation) and provides the final results on system costs.

6.1.4. *EUCO27 CAPACITIES AND REDUCED CAPACITIES IN THE SIMULATIONS*

The basis of the modelling analysis is EUCO27, which represents the perfect capacity expansion, in that it is the capacity expansion that could be delivered in a perfectly designed market, and under no uncertainty and perfect foresight. Then, the whole modelling approach (simulations with the PRIMES Oligopoly model and the investment evaluation process) is basically dedicated to observe how this "perfect basis" (the capacities of EUCO27) would perform in several market contexts, and when evaluated from decision makers that have uncertainty and a level of risk aversion. In other words, the modelling approach will yield with the deviations of capacity expansion from "perfect" under several market contexts and when introducing uncertainty and heterogeneity in decision making. More specifically, the deviations are due to the following aspects of the modelling:

- Capacity expansion of EUCO27 is the product of a simulation that assumes perfect foresight and certainty, while deviated capacities occur from simulations where plant owners are surrounded by uncertainty regarding ETS, gas prices, demand, RES developments, etc.
- Economics of capacity expansion of the EUCO27 are evaluated with a WACC of 8.5%, common for all plants. In the Investment Evaluation model however, plant owners are heterogeneous and use different hurdle rates[31] for evaluating investments. Moreover, the hurdle rates are modified among the different market design cases simulated (EOM, capacity mechanism, capacity mechanism with cross-border participation), to mimic the fact that market conditions and competition affect behaviour of investors and their required rates of return. In particular, the modelling assumes that plant owners consider that revenues from capacity mechanisms are more certain than revenues from the wholesale markets, and hence apply lower hurdle rates in the cases with capacity mechanism compared to the EOM case; moreover (and most important for the analysis of cross-border effects), it assumes that allowing cross-border participation in capacity mechanism

[31] The hurdle rate is the minimum rate of return that a plant owner is willing to accept in order to undertake an investment project.

would also lead to lower hurdle rates due to increased competition compared to the capacity mechanism cases without cross-border participation.

- In the simulation of the EUCO27 consumers' prices are such that ensure full recovery of all costs at portfolio generation basis (i.e. as if all plants where part of a single portfolio). In the simulations with the PRIMES Oligopoly model and the Investment Evaluation model the plant owners evaluate investments considering the revenues and profit/losses separately for each plant. Portfolio evaluation and plant-specific evaluation yield different results, and in particular we observe that recovery of all costs is not possible when looking at the economics of each individual plant, even in the EUCO27 context. This may appear to contradict the theory that in a perfectly designed market recovery of costs at portfolio basis is sufficient to ensure recovery of costs at individual plant basis. However, the EUCO27 context, even though it is designed as closely as possible to a perfect market context, it still cannot exclude some distortions, in particular:
    - The time horizon under study is year 2030. By that time, the power plant fleet cannot be entirely renewed, hence the optimal configuration of the plant mix cannot (yet) be accomplished as it carries along inefficiencies of the past.
    - The capacity expansion of the EUCO27 is subject to policy restrictions (e.g. phase-out of nuclear)
    - At the same time, policy promotions are accounted for, hence some plants receive revenues out-of-the-market (e.g. RES and CHP).

    c. Due to the above distortions, portfolio economics are not the same with individual plant economics.
- In the EUCO27 no specific market design is assumed, but total costs pass on to the consumer prices in order to (as already mentioned) ensure full cost recovery. In the simulations with the PRIMES Oligopoly model market design is treated explicitly and revenues are collected from the wholesale, balancing and reserve markets, as well as from capacity mechanisms if applicable.

It is important to note that the fact that there are reductions from the EUCO27 context in the simulations with the PRIMES Oligopoly model implies neither excess capacity of the EUCO27 nor that in the simulated cases there are less capacity requirements. The reductions, as explained above, occur because the simulations introduce uncertainty which alters the behaviour of investors. Thus, the reduction in capacity from the EUCO27 context potentially implies that generation adequacy is not ensured for all countries (albeit the modelling handles this issue as described below). The EUCO27 capacity expansion is determined considering strict reliability criteria, MS specific. The reduced capacities of the cases simulated potentially violate these criteria if they are not specifically taken into account in the simulations.

The PRIMES Oligopoly model handles this in a way to ensure that equal reliability standards apply thus avoiding load curtailments as in the standard model-base scenario. To do so the reduced capacities compared to the standard scenario are assumed to be replaced by the TSO renting peak devices at high costs. The remuneration of these rented capacities is set at the level of the annuity payment for capital cost of a gas turbine unit using a high unit cost of capital and the costs are passed through to consumer payments for the system services. With this approach, the level of reliability across all scenarios is similar. If not, any comparison among the scenarios would be infertile.

However, the above methodology does not fully cover the replacement reserve requirements which by definition are providing by non-spinning capacities. The standard model run has included replacement reserve which in the model can be met by plant capacities which are not operating for energy purposes at all (if found not economically appropriate according to optimisation of dispatching). Old plants which are not economic to operate may remain idle and not decommission in order to meet the replacement reserve requirement. However, some of these non-operating old plants are decommissioned according to the oligopoly model simulations and they are not replaced by the rented peak devices. So, if one would like to maintain full comparability between the oligopoly model runs and the standard model it would have been necessary to add a remuneration to old plants remaining idle. This remuneration would essentially cover maintenance costs and a small fraction of capital costs. These costs should be lower than the costs of the rented peak devices per unit of capacity. The oligopoly model report includes the hypothetical cost of replacement reserve, as needed to reach the same levels as in the standard model scenario. This cost element has not been added to total costs reported hereinafter, but it is shown separately.

6.2. MODELLED CASES

Overall the modelling has been conducted for the following cases:

- *Case B – EOM: Base-case without capacity mechanisms*[32]

We assume that market distortions have been removed from the energy-only market, implying that interconnectors are fully utilized for cross-border trade according to hourly price differences in the day-ahead market, and that left-over interconnector capacity is made available for exchange in intraday markets and of balancing services; there is no priority dispatch; all nominations are market-based; and all resources participate in the market. Prices are set competitively, but not purely according to the marginal cost of generation, i.e. a degree of scarcity bidding is assumed. There are no capacity mechanisms in place in any MS.

- *Case C – Partial CM: Capacity mechanisms implemented in four Member States, without allowing explicit cross-border participation*

We assume that capacity mechanisms are implemented in four Member States: France, Ireland, Italy, and the United Kingdom. These are national in scope, there are no provisions for cross-border participation.

- *Case D – All CM: Capacity mechanisms implemented in all Member States, without allowing explicit cross-border participation*

We assume that harmonized capacity mechanisms are implemented in all Member States. These are all national in scope, i.e., there are no provisions for cross-border participation.

- *Case E – All CM & XB: Capacity mechanisms implemented in all Member States, allowing explicit cross-border participation*

We assume that harmonized capacity mechanisms are implemented in all Member States, as in Case D. However, all are open to cross-border participation.

- *Case F – Partial CM & XB: Capacity mechanisms implemented in four Member States, allowing explicit cross-border participation*

[32] Case B basically reflects Policy Option 2 analysed for the Problem Area I of the MDI Impact Assessment, E3MLab (2016).

We assume that capacity mechanisms are implemented in four Member States: United Kingdom, Ireland, France, and Italy, as in Case C. However, all are open to cross-border participation.

The main differences among the options are related to the scope of capacity mechanisms and the provisions for cross-border participation. Table 25 provides an overview of the options, as well as of the abbreviation which will be used in the reporting of the results of the simulations hereof.

Table 25: Overview of modelled capacity mechanism options

	Capacity mechanisms in four Member States	Capacity mechanisms in all Member States
Without cross-border participation	Case C: Partial CM (C)	Case D: All CM (D)
With cross-border participation	Case F: Partial CM & XB (F)	Case E: All CM & XB (E)

The focus of the exercise is what benefits accrue when going from the upper options without cross-border participation, to the bottom options with cross-border participation. Hence, in this section, we concentrate on the benefits of including cross-border participation. Option 1 is merely used as a common starting point for the analysis.

6.3. Assumed Capacity Mechanism

The modelling does not consider a specific capacity mechanisms design, instead it assumes a stylized capacity mechanism auction which is general in scope and covers all generators, with or without cross-border participation.

In all cases that include capacity mechanisms (cases C to F), it is assumed that the countries with capacity mechanisms apply capacity auctions at a national scale, but with similar rules, i.e. there is a common framework for the capacity mechanisms.

It is assumed that a given plant cannot offer its capacity to several capacity markets, i.e. capacity can only be paid for delivery in one capacity mechanism, implying that foreign capacity that participates in a capacity mechanism, cannot simultaneously be taken into account in its domestic capacity mechanism (in cases E and F).

Moreover, it is assumed that when setting the reliability standard/capacity requirement, imports (and exports) are taken into account. The maximum size of the capacity market is equal to peak demand, adjusted for trade in peak situations. This means that if a country is expected to export power during peak demand, the exports are also taken into account.

The modelled capacity mechanisms have the following features:

Eligibility: All capacities are eligible, if dispatchable, including hydro lakes and storage, provided that they are not remunerated under a different support scheme. For example, CHP, and biomass are excluded from participation. Also, plants in process of decommissioning or operating only a few hours per year due to environmental restrictions, as projected in PRIMES, are excluded.

Remuneration: All eligible capacities are remunerated for the available capacity, excluding outages.

Auction rules and clearing price: The yearly capacity mechanism auctions yield a single clearing price per market, sealed envelope price-quantity offers (with stepwise functions) and single round. The capacity mechanism price is derived from the intersection of demand for capacity and the offers, sorted in ascending price order. Demand for capacity is defined by the regulator as a negative-sloped linear line depending upon a price cap and linking two capacity points: the minimum and maximum requirements (see chapter 6.1.2). If the offered capacity is below the minimum requirement the auction clearing price is equal to the price cap, while above the maximum requirement the price is equal to zero. The definition of the capacity demand curve takes into account a portion of imports/exports as projected with the PRIMES model for the EUCO27 scenario. In particular, it takes into account trusted imports (the majority in our case) at peak load times and the guaranteed proportion of exports. Therefore, implicit participation of flows over interconnections is taken into account. The inclusion of imports results in lower auction clearing prices, while the inclusion of exports results in higher auction clearing prices. In case cross-border participation is allowed in the capacity mechanism auctions, capacity offerings are increased, which results in lower auction clearing prices. Removal of capacities (due to mothballing or cancelling of investments due to insufficient revenues in the wholesale market) decreases capacity offering and thus results in higher auction clearing prices.

Award: The capacity mechanism winners sign a reliability option (one-way option) which has a strike price. If the market price in the day-ahead market is above the strike price, the capacity mechanism winners are obliged to return the revenues above the strike price.

6.4. RESULTS

The results of the simulations with the PRIMES oligopoly model could be summarized in one sentence as follows: Allowing foreign participation in the capacity mechanism results in increased competition, which ultimately leads to lower prices in the markets and overall saves on costs for the consumers. Benefits in terms of cost are presented in Table 28 and Table 29 as savings in total payments for load[33] induced by allowing cross-border participation.

When cross-border participation is allowed, the pool of plants that are eligible to participate in the capacity auctions is increased. This has a direct effect on the capacity demand curves that yield the capacity auction clearing prices; as the

[33] Total payments for load have two components, the payments to capacity auctions and the payments to the wholesale and reserve markets. Payments to capacity auctions are calculated as the auction clearing price of each market times the capacity eligible to receive remuneration. Payments to the wholesale and reserve markets is calculated as the load-weighted annual average system marginal price of the markets times the annual demand of the markets. Part of the payments to the wholesale and reserve markets is the rent paid by TSOs in case the level of capacity is not sufficient to cover for load. The figures reported are the sum of the load payments of all countries and of years 2021-2030.

capacity demand curves are negatively sloped (see section 6.1.2), increased offering of capacity results in lower auction clearing prices[34].

This in turn implies that revenues of generators from the capacity auctions are lower when foreign participation is allowed. Therefore, the likelihood of not receiving sufficient revenues is higher and some investments will be cancelled (see section 6.1.3 and 6.1.4). Indeed, the simulations with the PRIMES oligopoly model show that the total capacity is somewhat reduced when explicit cross-border participation is allowed. The reduction, however, is not very considerable (see Table 26). Changes are more pronounced for base-load capacity and mainly apply to old coal and lignite capacity, while changes in mid-load CCGT plants are negligible. The level of peak load capacity is also somewhat reduced.

Table 26: Changes in capacities due to cross-border participation, GW in 2025 and 2030

	Options with capacity mechanisms in 4 MS		Options with capacity mechanisms in all MS	
	2025	2030	2025	2030
Baseload	-1,98	-0,13	-1,67	-3,66
Medium load	+0,01	-0,01	0	0
Peak load	-0,16	-0,16	-1,64	-0,09
Total	**-2,13**	**-0,3**	**-3,3**	**-3,74**

Lower capacity implies that the reserve requirements would increase in the scenarios with cross-border participation. It should be remembered that given the reduction of capacities that occurs compared to the EUCO27 scenario (6.1.3), the modelling assumes exceptional reserve procurement by TSOs, who rent the amount of capacity that ensures that equal reliability standards apply thus avoiding load curtailments as in the standard model-base scenario (6.1.4). The cost for renting capacities is passed on to consumers and is part of the payments to wholesale and reserve markets which are shown in Table 28 and Table 29. Thus, with higher capacity reductions, the costs for replacing capacity is increasing.

As was explained in section 6.1.4, the capacity that is being rented by TSOs does not fully cover the replacement reserve requirements which by definition are providing by non-spinning capacities. In case TSOs were to rent the equivalent of the total capacity reduction, the cost would amount to 0.3-0.5% of the total turnover value of the market (Table 27), which compared to for example the cost of capacity mechanisms, is not very high. Comparing the cases with and without cross-border participation, we see that due to lower capacity in the latter, the cost for replacing capacity reductions would be higher.

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[34] Note however that as it is assumed that a plant's capacity cannot be offered twice to capacity mechanism auctions, the offer abroad decreases capacity offered domestically (if capacity mechanism is applied also domestically, as the case of capacity mechanisms in all MS), which implies that in case of shortage the auction clearing prices will tend to increase domestically. Overall though, auction clearing prices will be lower.

Table 27: Replacement cost equivalent to total capacity reduction and comparison to capacity mechanism costs, as % of total turnover value, for the period 2021-2030

	Options with capacity mechanisms in 4 MS		Options with capacity mechanisms in all MS	
	Partial CM (C)	Partial CM & XB (F)	All CM (D)	All CM & XB (E)
Cost equivalent to cover through rent total reduction of capacity (% of total turnover value)	0.46%	0.48%	0.31%	0.37%
CM payments (% of total turnover value)	2.94%	2.52%	8.22%	7.32%

Up to this point, we have seen that capacity auction clearing prices are lower and that the total level of capacity is reduced. These two effects lead finally to lower payments in the capacity markets. The results of the simulation support this finding for the cases of implementation of capacity mechanisms in all MS and in four MS. In particular, in the case of capacity mechanisms in all MS, payments to capacity markets amount to 240 BN€'13 (cumulative amount in the period 2021-2030) in the case without cross-border participation, and to 210 BN€'13 in the case with cross-border participation (Table 28); this means that cross-border participation saves 30 BN€'13 in the period 2021-2030, reducing the payments to capacity markets by 13%. In the case of capacity mechanisms in four MS, total cost of the capacity mechanisms in the case without cross-border participation is 87 BN€'13 while in the case with cross-border participation it is 74 BN€'13 (Table 29), which makes it cheaper by 13 BN€'13, or by 15%.

Enhanced competition is perceived by generators not only in the capacity mechanism but also in the wholesale market. As participants in the market increase, the competitive pressure increases and the expected rates of return (hurdle rates) of generators/investors become lower (discussed in section 6.1.3). Therefore, bids in the wholesale and reserve markets will be at lower levels resulting in lower market clearing prices and ultimately to lower payments in the wholesale markets. This holds for both the cases of capacity mechanisms in all countries and capacity mechanisms in four countries examined. In particular, in the case of capacity mechanisms in all countries (Table 28) load payments to the wholesale and reserve markets amount to 3019 BN€'13 (cumulative amount in the period 2021-2030) in the case without cross-border participation and to 2963 BN€'13 in the case with cross-border participation, saving in the latter 56 BN€'13 in the period 2021-2030 (or 2%). In the case of capacity mechanisms in four countries (Table 29), load payment to wholesale and reserve markets is 3,065 BN€'13 in the case without cross-border participation and 3,043 BN€'13 in the case with cross-border participation, saving in the latter 22 BN€'13 (or 1%).

We may summarize that cross-border participation reduces the cost of capacity mechanisms by 13-15%, as well as the load payments to wholesale and reserve markets by 1-2%. Total payments for load decrease by 1-3%.

Table 28: Benefits of cross-border participation in the cases with capacity mechanisms in all MS, BN€'13, 2021-2030

	All CM (D)	All CM & XB (E)	Benefit of XB participation
Load payment to CM	240	210	30
Load payment to wholesale and reserve markets	3019	2963	56
Total load payments	**3259**	**3172**	**87**

Table 29: Benefits of cross-border participation in the cases with capacity mechanisms in four MS, BN€'13, 2021-2030.

	Partial CM (C)	Partial CM & XB (F)	Benefit of XB participation
Load payment to CM	87	74	13
Load payment to wholesale and reserve markets	3065	3043	22
Total load payments	**3152**	**3117**	**35**

At this point, it is worth mentioning the impact of allowing cross-border participation on trade volumes; the results of the simulation show that it stays at about the same level with or without foreign participation in capacity mechanisms, both in 2025 and 2030 (Table 30). This result indicates that market forces that drive trade decisions are not likely to be significantly influenced by foreign participation in capacity mechanisms. It should be noted that implicit participation of flows is taken into account in all cases, with and without cross-border participation in the capacity mechanisms, in the definition of the capacity demand curves (see section 6.1.2).

Table 30: Sum of Total Imports of all Member States for years 2025-2030 across all options, TWh

	Options with capacity mechanisms in 4 MS		Options with capacity mechanisms in all MS	
	All CM (D)	All CM & XB (E)	Partial CM (C)	Partial CM & XB (F)
2025	265,1	260,6	239,8	239,2
2030	254,9	256,1	244,9	249,1

6.5. Discussion and Concluding Remarks

The model results rest on a number of judgements and assumptions which are nevertheless necessary. Among them, the assumptions that are crucial in the context of assessing the impact of allowing cross-border participation in capacity mechanisms are the following:

- The assumed impact of capacity mechanisms and of cross-border participation on the hurdle rates of investors affects the monetary difference between the options analysed. The lower the hurdle rates, the lower the biddings to the wholesale markets and thus the lower the overall costs. This assumed change in behaviour, which, albeit expected, is highly uncertain and hard to quantify, affects the monetary differences between all the options analysed and the impacts on EUCO27 investments. It becomes very crucial when comparing the cases of capacity mechanisms with and without cross-border participation. Assuming no change in investment behaviour would reduce the benefits of cross-border participation.

- In all capacity mechanism implementations in the model the demand curves for the capacity auctions include part of the flows through interconnectors as projected in the EUCO27 scenario. As a result, importing countries reduce demand for capacities and exporting countries increase demand. The amount of imports/exports that is considered is a judgement, based on the idea that a part of imports can be viewed as "trusted" in terms of generation adequacy, while a part of exports can be viewed as "guaranteed", as if bilateral contracts were in place. This judgement however plays an important role in the definition of the capacity demand curves and the capacity auction clearing prices. The higher the part of imports that is included the lower the capacity auction clearing prices, while the higher the part of exports, the higher the resulting capacity auction prices. These assumptions therefore affect the cost estimations of all capacity mechanism options, including those that assume foreign participation of cross-border trade in the capacity mechanisms.

It should be noted that the modelling exercise cannot decide to what extent capacity mechanisms are needed for capacity adequacy. The exercise is designed to answer what-if questions:

- If a capacity mechanism is implemented, would cross-border participation be more cost-efficient?

- What is the impact of implementing capacity mechanisms in an un-harmonised manner to some MS only compared to applying capacity mechanisms in all MS in a harmonised manner?

- What is the cut-off distance beyond which cross-border capacity is insignificant?

The analysis attempts to quantify how participation from cross-border capacity enhances competition, thus resulting in lower capacity auction clearing prices. The estimation of total system costs under increased participation assumptions is a measurement of the likely economic value to the consumers that participation would provide compared to non-participation.

We conclude that capacity mechanisms with foreign participation enhance competition and lead to better allocation of resources in capacity mechanism auctions, thus less capacity is maintained compared to the cases without cross-border participation. The effect on trade flows is not significant (compared to capacity mechanism cases without cross-border participation), which hints that market forces that drive trade decisions are likely not to be significantly influenced by foreign participation in capacity mechanisms. Finally, cross-border participation leads to lower system costs, as the enhanced competition results in lower capacity mechanism auction clearing prices as well as in lower wholesale market prices.

6.6. Comparison of Costs and Benefits

The modelling analysis concludes that for the period 2021-2030 the benefits of cross-border participation amount to 1-3 % savings in total load payments, stemming from 13-15 % savings in capacity payments and 2-3 % savings in the wholesale and reserve markets. The benefits of cross-border participation are higher in the case where capacity mechanisms are applied in all EU MS than when capacity mechanisms are implemented only in four countries. Nevertheless, the benefits are substantial in the four-country case as well, saving in total 35 BN€ in the period 2021-2030 as compared to 87 BN€ in the case of capacity mechanisms everywhere.

The total benefits in terms of saved load payments to generators (sum of annual savings for the period 2021-2030), both in the capacity markets and the wholesale and reserve markets, are summarized in Table 31.

Table 31: Cost savings of cross-border participation according to the modelling analysis, BN€'13, 2021-2030.

	Options with capacity mechanisms in all MS	Options with capacity mechanisms in 4 MS
Cost savings in load payments to CM	30	13
Cost savings in load payments to wholesale and reserve markets	56	22
Total cost savings	**87**	**35**

In chapter 5, the analysis of the administrative costs involved in implementing cross-border participation concludes that such costs are estimated to be in the range of 1.6-138.3 million €'16 in case a generator model is implemented and 0.6-42.5 million €'16 in case an interconnector model is implemented. These figures are derived as the NPV of the annual costs for TSO's and other authorities, as well as of market participants, using a discount rate of 4 %. One-time costs designing the relevant schemes is also included in the NPV calculation. Results are summarized in Table 32.

Table 32: Ranges of total costs of cross-border participation for authorities and participants, million €'16

	Generator model	Interconnector model
Total cost range without harmonization, authorities and participants	2,7 – 138,3	0,7 – 42,5
Total cost range Option 1 (30% reduction), authorities and participants	2,0 – 136,5	0,6 – 41,9
Total cost range Option 2 (50% reduction), authorities and participants	1,6 – 135,4	0,6 – 41,6

Due to the different approaches in deriving the administrative cost estimates for authorities and participants in chapter 5 and the benefits in terms of payments for load obtained from the modelling and discussed in this chapter, the two cannot be compared directly, they however provide a complete overview of the estimated costs involved. And despite the substantial uncertainty in the cost estimates, the benefits of cross-border participation are found to be well above the minimum cost estimates.

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MJ-02-16-461-EN-N

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Publications Office
doi:10.2833/20431