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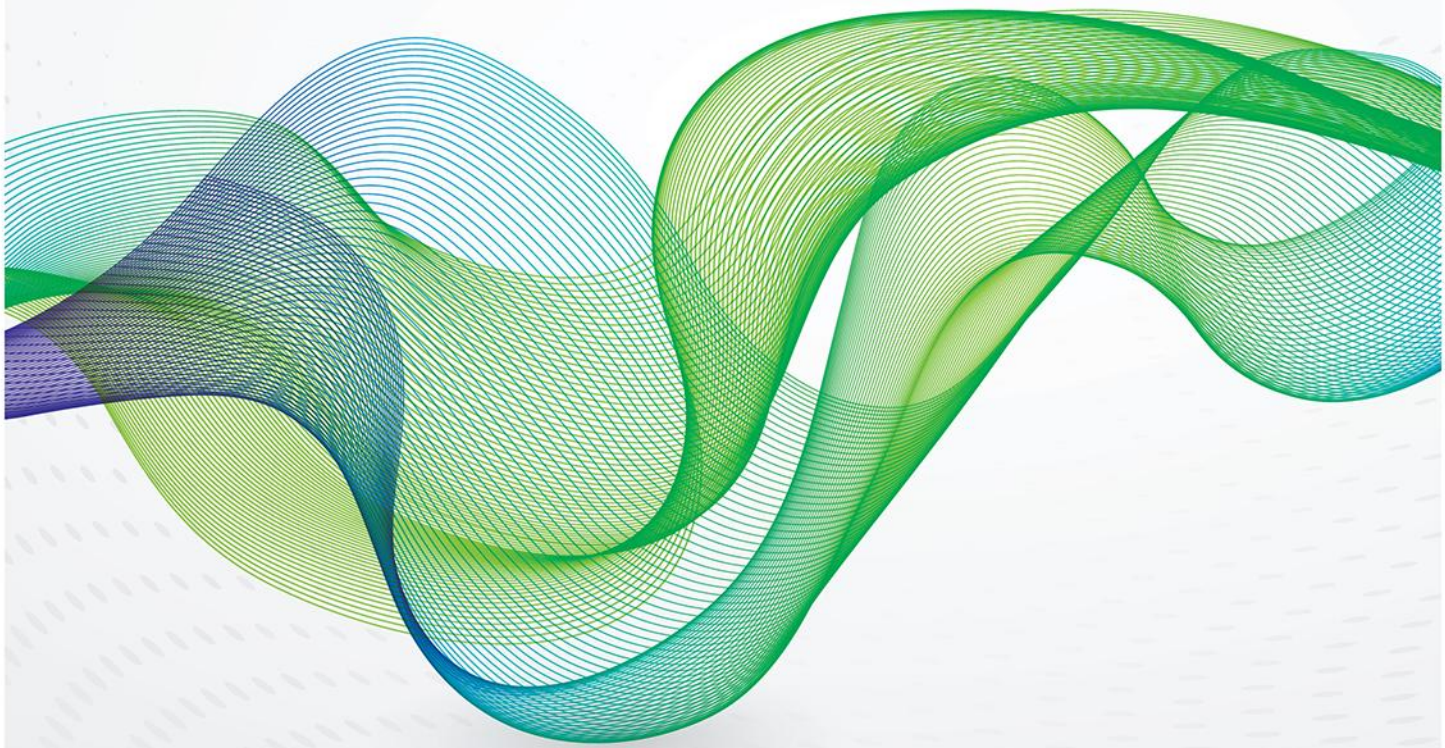
The Limits of Direct Cross-Border Participation in Capacity Markets of Weakly Interconnected Systems



OIES ENERGY COMMENT

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1. Executive summary

Capacity Remuneration Mechanisms ("CRMs") have become an increasingly important feature of European electricity markets as Member States seek to address growing adequacy concerns associated with the energy transition. While CRM designs differ across jurisdictions, there is a clear trend, particularly among larger electricity systems, towards market-wide mechanisms in which capacity is procured competitively through centralized auctions.[1]

At the same time, the European regulatory framework has progressively strengthened the requirement that national CRMs allow the participation of foreign capacity providers. In particular, Regulation (EU) 2019/943 requires Member States operating CRMs to enable direct cross-border ("XB") participation, while recent European Commission guidance establishes such participation as a prerequisite for fast-track State aid approval of market-wide mechanisms.

The case for direct cross-border participation appears simple: if foreign resources can compete in domestic capacity auctions, countries may be able to rely on a wider pool of adequacy resources and reduce the cost of securing supply.

However, this logic only holds where foreign resources can actually increase their contribution during domestic scarcity events. Whether this condition holds can be assessed through a simple test: are imports constrained by the availability of foreign capacity, or by the interconnector itself? If imports are limited by the availability of foreign generation, direct XB participation may create value by improving incentives for investment, availability or delayed retirement abroad. In those circumstances, direct XB participation can be an efficient way of procuring adequacy across borders. But if imports are limited by the interconnector itself, paying foreign generators is unlikely to increase the effective contribution of foreign resources.

This test is particularly important for weakly interconnected systems. When interconnection capacity between two countries is limited relative to the size of the neighbouring system, scarcity events in the importing country are likely to coincide with full utilisation of the interconnection. In such circumstances, the scarce resource is not generation capacity in the neighbouring market, but the interconnection itself. Under these conditions, direct XB participation may primarily result in transfers from domestic consumers to foreign generators, while adding substantial implementation complexity and administrative burden.

Our analysis also highlights an often-overlooked consequence of cross-border interactions: their effect on Member States' incentives to introduce CRMs. Because CRMs generate adequacy benefits that spill across borders, smaller countries connected to larger neighbouring systems may have an incentive to free-ride on the capacity procured by those neighbours rather than implement their own mechanisms. Direct XB participation can reinforce these incentives. For smaller systems, allowing foreign participation may significantly increase the volume of capacity contracts that must be procured and financed, while delivering limited additional adequacy benefits when interconnection capacity is small relative to the neighbouring market. As a result, mandatory direct XB participation may in some cases increase the relative cost of introducing a CRM for smaller countries, further reinforcing their incentive to free-ride on their neighbours.

We illustrate these issues through the case of the Spanish capacity market, recently approved by the European Commission.[2] Spain provides a useful empirical illustration with broader relevance for European CRM design because it has two borders with similar absolute import capacity, but very different neighbouring systems.

[1] Italy, the United Kingdom, Poland, and Belgium already operate market wide mechanisms. France is considering replacing its current decentralised market-wide capacity mechanism with a centralised model, while the Czech Republic is actively debating the introduction of a similar system. In Spain, the CRM has recently been approved by the European Commission and takes the form of a market-wide capacity market.

[2] The European Commission approved the Spanish capacity mechanism in May 2026, which at the moment had not included direct XB participation.

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Using Compass Lexecon's European resource adequacy model, we assess whether direct XB participation with France and Portugal is likely to generate efficiency gains or consumer savings. Our results show a sharp contrast between the two borders. In the case of France, the interconnection is already expected to be saturated during almost all scarcity events in Spain, implying that direct XB participation is unlikely to increase the effective contribution of French resources to Spanish adequacy. In contrast, the interconnection with Portugal is not systematically saturated during Spanish scarcity events, suggesting that direct XB participation may increase the contribution of Portuguese resources and generate efficiency gains.

The results have broader implications for the design of European CRMs. They indicate that EU regulation should adopt a more effects-based and proportionate approach to XB participation in CRMs. Rather than treating direct XB participation as a general requirement, the regulatory framework should recognise that its benefits depend on the specific characteristics of interconnected systems, including the relative size of interconnection capacity and neighbouring electricity markets. A more flexible framework would allow Member States to justify, based on system-specific evidence, whether implicit participation alone is sufficient to capture the benefits of cross-border participation. Such an approach would be more consistent with the underlying economic rationale of the Internal Electricity Market and with the objective of ensuring cost-effective security of supply across interconnected systems.

2. How Europe pays for cross-border adequacy

It is widely accepted that the design of CRMs should account for the contribution of cross-border resources to security of supply. Since electricity systems are physically interconnected, scarcity events in one country may be alleviated through imports from neighbouring systems. Failing to recognise this contribution may lead to the over-procurement of domestic capacity and unnecessarily increase the cost of ensuring adequacy.

Cross-border participation in CRMs can take several forms, which differ importantly in both their economic rationale and their implications for incentives and market design. In practice, three broad approaches can be distinguished: (i) implicit cross-border participation, (ii) participation of the interconnector itself, and (iii) direct participation of foreign capacity providers.

2.1 The implicit approach

Under implicit cross-border participation, the contribution of neighbouring systems is recognised through the adequacy assessment underlying the CRM. In particular, the volume of domestic firm capacity required to satisfy the reliability standard is reduced to reflect the expected contribution of imports during scarcity events. Within the European framework, this contribution is captured through the Maximum Entry Capacity ("MEC"), which represents the estimated contribution that a neighbouring system can provide during periods of system stress.

Under this approach, foreign resources do not participate directly in the capacity mechanism and do not receive capacity payments from the importing country. Instead, cross-border adequacy contributions are recognised implicitly through lower domestic procurement requirements. Implicit participation therefore affects the demand for domestic adequacy resources, but does not directly alter investment or availability incentives for foreign resources.

2.2 Participation of the interconnector

A second approach consists in allowing the interconnector itself to participate directly in the CRM. Under this model, the interconnector competes in the capacity auction with a capacity volume equal to its MEC. This is conceptually similar to applying a de-rating factor to other capacity resources: the interconnector is not remunerated for its full technical capacity, but for its expected contribution during scarcity events. If successful, the interconnector receives the capacity payment associated with the auction clearing price.

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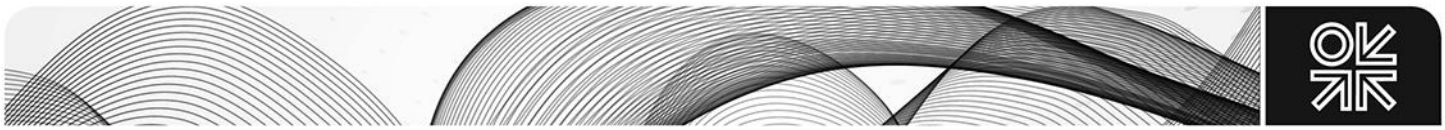

This approach recognises the adequacy value of cross-border transfer capability. As under implicit participation, the contribution of neighbouring systems is still limited by the expected import capability of the interconnection during scarcity events. However, unlike implicit participation, the interconnector itself is explicitly remunerated for providing adequacy value.

2.3 Participation of foreign resources

Under direct XB participation, foreign capacity providers participate directly in the domestic capacity auction alongside domestic resources. Foreign generators, storage facilities, or demand-side response providers may therefore compete to obtain capacity contracts in the importing country. The total volume of foreign participation remains limited by the MEC associated with the relevant interconnection.

Direct XB participation differs fundamentally from the previous two approaches because it may alter incentives for foreign resources. By allowing foreign capacity providers to receive capacity payments directly, the mechanism may incentivise additional investment, delay retirements, or encourage existing resources to ensure availability during scarcity events in the importing country. In principle, these incentive effects may increase the effective contribution of foreign resources to adequacy and reduce the overall cost of achieving the reliability standard.

The potential efficiency gains from direct XB participation therefore arise not simply from recognising imports, which implicit participation already achieves, but from changing the behaviour and availability of foreign resources during scarcity periods.

2.4 Europe's push towards direct XB participation

Until recently, cross-border participation in European CRMs was generally limited to implicit participation or participation of the interconnector itself. Direct participation by foreign capacity providers remained rare in practice, largely because it is considerably more complex to implement.

Implementing direct XB participation faces a number of challenges:

- **Eligibility criteria:** Defining which foreign resources qualify requires careful assessment of reliability, certification, and performance standards across jurisdictions.
- **Availability and penalties:** Contracts must include clear obligations and penalties to ensure foreign resources deliver capacity during stress events. Enforcement across borders adds legal and operational complexity.
- **TSO agreements and coordination:** Transmission System Operators ("TSOs") in different countries must coordinate dispatch, data exchange, settlement, and certification processes, which is time-consuming and resource-intensive.
- **Market and regulatory alignment**: Differences in market design, capacity valuation, and regulatory frameworks can create additional barriers to seamless participation.

Despite these challenges, the European regulatory framework has increasingly moved towards requiring direct XB participation. Regulation (EU) 2019/943 requires Member States operating CRMs to allow direct cross-border participation of foreign resources. More recently, the European Commission has also established direct XB participation as a prerequisite for fast-track State aid approval of market-wide capacity mechanisms.[3]

[3] European Commission, *Communication from the Commission — Framework for State aid measures to support the Clean Industrial Deal*, C/2025/3602, Section 4.3 and Annex I. Section 4.3 introduces a fast-track approval process for capacity mechanisms, while Annex I sets out the relevant compatibility criteria for strategic reserves and market-wide central buyer mechanisms.

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3. How direct cross-border participation creates value

The economic rationale for imposing direct XB participation in capacity markets is that it may improve the incentives of foreign capacity providers to be available during scarcity events in the importing country. By enabling foreign resources to compete directly in domestic capacity auctions, direct XB participation may reduce the overall cost of maintaining security of supply, particularly when neighbouring systems can make available additional firm capacity that contributes to security of supply during domestic scarcity events.

However, the potential efficiency gains from direct XB participation depend critically on whether it merely recognises an existing contribution to security of supply, or creates an additional one. The relevant question is therefore whether direct XB participation can increase the contribution of foreign resources to security of supply. In this regard, it is useful to distinguish between two separate effects of cross-border participation: a recognition effect and an incentive effect.

The recognition effect arises when the adequacy assessment underlying the CRM accounts for the expected contribution of imports during scarcity periods. This effect is already achieved under implicit cross-border participation, where expected imports reduce the amount of domestic capacity that must be procured to satisfy the reliability standard.

By contrast, the incentive effect arises only if allowing foreign resources to participate directly in the CRM changes their availability during scarcity events. For example, direct XB participation may incentivise additional investment in neighbouring systems, delay the retirement of existing resources, or encourage storage and demand-side response providers to ensure availability during scarcity periods in the importing country. Direct XB participation can therefore only generate additional adequacy value relative to implicit participation if it materially increases the effective contribution of foreign resources during scarcity events.

3.1 A stylised example of direct XB participation benefits

Consider Country A, which is introducing a capacity market to ensure adequacy during periods of system stress. Country A has a peak demand of 50 MW and is connected to Country B through an interconnector with an import capacity of 10 MW.

Suppose first that, under implicit participation, the adequacy assessment for Country A estimates that imports from Country B will contribute 5 MW during scarcity events (i.e. MEC=5 MW). In this case, the domestic CRM procures only 45 MW of domestic firm capacity, with the remaining 5 MW implicitly provided through expected imports from Country B.

Under direct XB participation, foreign resources in Country B are allowed to participate directly in the capacity auction in Country A. If these additional incentives increase the availability of resources in Country B during scarcity events in Country A, then expected imports may increase from 5 MW to 10 MW. Under these conditions, additional foreign resources may displace more expensive domestic capacity, thereby reducing the overall cost of achieving the reliability standard.

Figure 1 illustrates this mechanism. Under implicit participation, the domestic adequacy requirement is reduced only by the expected 5 MW contribution from imports, requiring higher-cost domestic resources (i.e. units A and B) to clear the auction. Under direct XB participation, additional foreign resources (i.e. units 1 and 2) become available during scarcity periods and compete with domestic resources for capacity contracts. This increases the effective adequacy contribution of Country B, lowers total cost of procurement, and consumers benefit from these savings, as the capacity market clears at a lower price (i.e. $P^2<P^1$).

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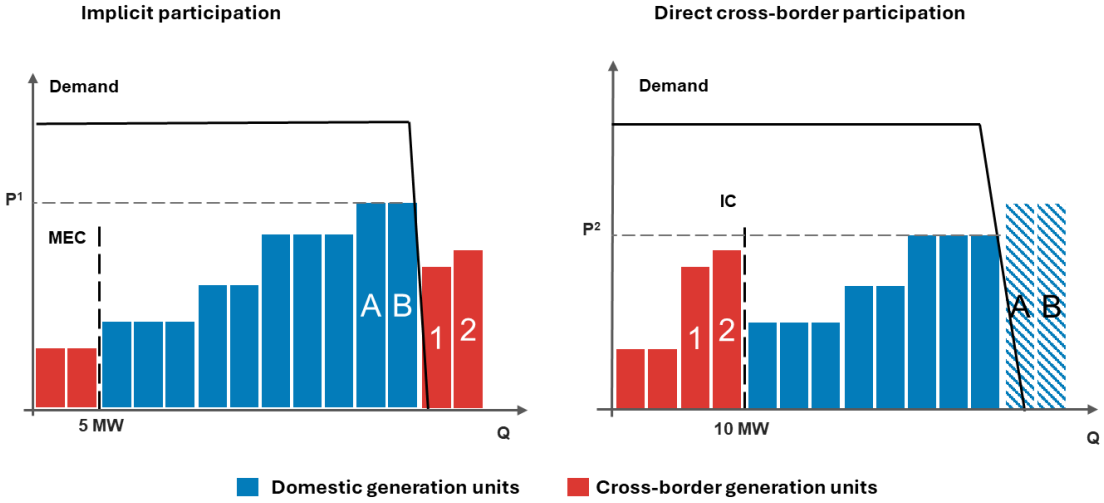
Figure 1: Potential efficiencies provided by direct cross-border participation



Source: Own elaboration

Whether direct XB participation delivers meaningful efficiency gains depends fundamentally on the nature of the constraint limiting cross-border support during scarcity events. If the limiting factor is the availability of foreign capacity resources, then allowing foreign resources to participate directly in the CRM may improve adequacy by incentivising additional capacity availability abroad. By contrast, if the limiting factor is the interconnection itself, then additional foreign incentives are unlikely to increase effective imports during scarcity events, since the interconnector is already fully utilised. In that case, direct XB participation is unlikely to materially increase the adequacy contribution already recognised under implicit participation.

3.2 Measuring the contribution of direct XB participation

Under the European regulatory framework, the contribution of foreign systems to domestic adequacy is reflected through the MEC. The MEC represents the estimated contribution that a neighbouring system can provide during scarcity events in the importing country, taking into account the availability of foreign resources, the correlation of scarcity conditions across systems, and interconnection constraints.

The MEC is determined through adequacy modelling conducted within the framework of the European Resource Adequacy Assessment ("ERAA"). Regional Coordination Centres ("RCCs") calculate MEC values following methodologies approved by ACER, while TSOs are ultimately responsible for their implementation.

Importantly, the current regulatory framework does not explicitly distinguish between the adequacy contribution of neighbouring systems under implicit participation and under direct XB participation. In practice, MEC calculations are generally based on adequacy assessments that already estimate the expected contribution of imports during scarcity periods, regardless of whether foreign resources participate directly in the CRM.

This point is economically important, as direct XB participation can only create incremental value if it materially increases the effective contribution of foreign resources beyond the level already reflected in the MEC.

In principle, this could occur if direct participation in the CRM changes the behaviour of foreign resources. For example, capacity payments from the importing country could incentivise additional investment abroad, delay the retirement of existing capacity, or encourage storage and demand-side resources to ensure availability during scarcity events in the importing country.

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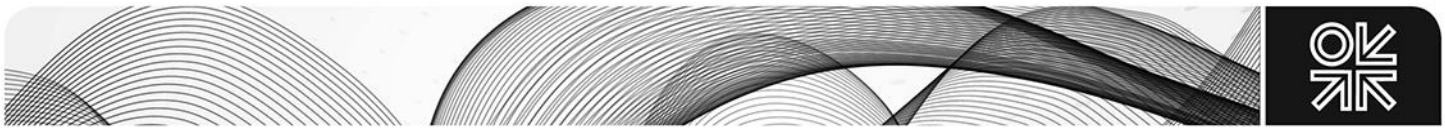

However, capturing these effects within adequacy modelling is inherently complex. Estimating the incremental contribution of direct XB participation would require modelling how foreign resources respond to CRM incentives, including changes in investment decisions, retirement incentives, operational behaviour, and bidding strategies. It would also require modelling the interaction between these behavioural responses and cross-border electricity flows during scarcity conditions. Current European adequacy methodologies do not explicitly incorporate these dynamic equilibrium effects into MEC calculations.

As a result, much of the contribution of neighbouring systems may already be recognised under existing adequacy assessments before direct XB participation is introduced. Under these conditions, the incremental adequacy contribution associated with direct XB participation may be limited, particularly when interconnection constraints already restrict the volume of imports that can be delivered during scarcity periods.

This does not imply that direct XB participation can never generate additional value. If CRM payments materially alter investment or availability incentives in neighbouring systems, the effective contribution of foreign resources may increase relative to the level reflected in existing MEC calculations.

4. When the interconnector becomes the constraint

The previous sections argued that direct XB participation can only generate incremental adequacy value if it materially increases the effective contribution of foreign resources during scarcity events relative to the level already recognised under the implicit participation mechanism (or the interconnector participation mechanism).

This can be assessed through a simple scarce-resource test: if imports are constrained by the availability of foreign resources, direct XB participation can create incremental adequacy value by changing investment, retirement, availability or operational incentives abroad; if imports are constrained by the interconnection itself, additional payments to foreign generators are unlikely to increase security of supply.

When interconnection capacity is small relative to the size of neighbouring electricity market, scarcity events in the importing country are likely to coincide with full utilisation of the interconnection, implying that transfer capacity, rather than foreign generation availability, becomes the relevant constraint.

4.1 When the interconnector is saturated

Consider again the stylised example introduced in the previous section. Country A has a peak demand of 50 MW and is connected to Country B through an interconnector with an import capacity of 10 MW.

Assume that, during scarcity events in Country A, demand in Country B is 100 MW and available firm capacity in Country B is 115 MW. In this case, Country B has 15 MW of spare firm capacity potentially available to support Country A during stress periods. Since the available margin in Country B exceeds the interconnection capacity between the two countries, imports into Country A are constrained by the interconnector itself. The MEC therefore equals the physical import capacity of the interconnection. This situation is illustrated in Figure 2.

Under these conditions, allowing additional foreign resources to participate directly in the CRM of Country A is unlikely to materially increase security of supply. The limiting factor is not the availability of generation or demand-side resources in Country B, but the inability of the interconnection to deliver additional electricity during scarcity periods. Even if further foreign resources were incentivised through direct XB participation, they would remain unable to contribute once the interconnector is fully utilised.

In this situation, implicit participation or participation of the interconnector itself already captures most of the adequacy value provided by the neighbouring system. Direct XB participation may therefore provide limited incremental adequacy benefits, while increasing implementation complexity and resulting in additional payments from domestic consumers to foreign resources that would already have been available during scarcity events. In simpler words, if the wire is full, paying more generators changes little.

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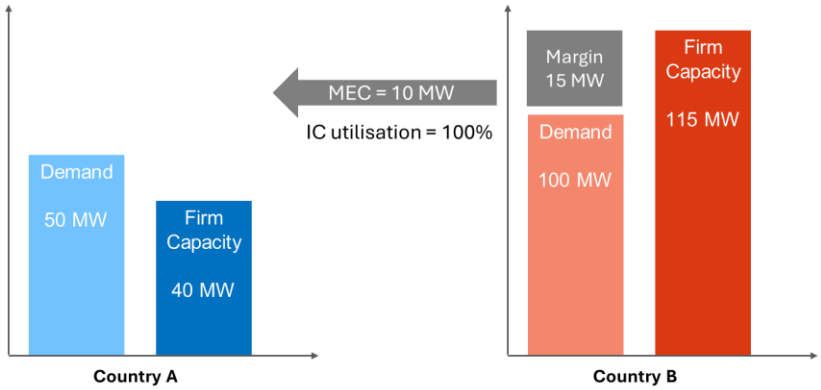
Figure 2: Interconnector saturated



Note: "MEC" refers to the MEC that would be calculated assuming implicit participation
Source: Own elaboration

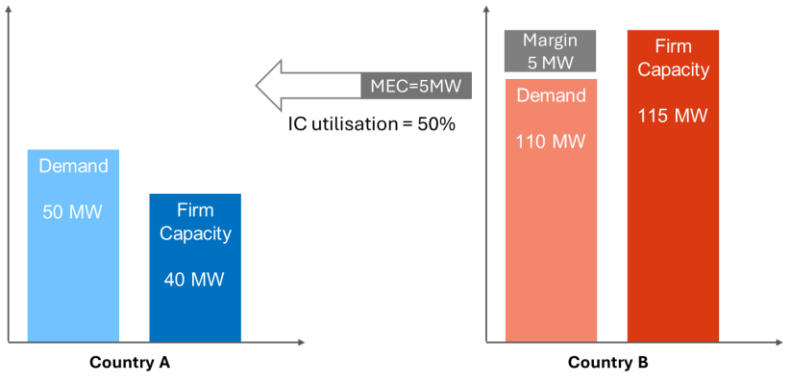
Importantly, the likelihood of this situation increases as interconnection capacity becomes small relative to the size of the neighbouring system. Large electricity systems are likely to retain substantial available capacity margins during scarcity events in smaller neighbouring countries. Where interconnection capacity represents only a small fraction of the neighbouring system's available capacity, scarcity events in the importing country are likely to coincide with saturation of the interconnector.

4.2 When the interconnector is not saturated

The situation differs when interconnection capacity is not fully utilised during scarcity events.

Consider again the previous example, but assume now that demand in Country B during scarcity events in Country A is 110 MW rather than 100 MW. In this case, Country B has only 5 MW of spare firm capacity available to support Country A, despite the existence of 10 MW of interconnection capacity. The interconnector is therefore not saturated, as imports are constrained by the limited availability of foreign resources rather than by transfer capability itself. This situation is illustrated in Figure 3.

Figure 3: Interconnector not saturated



Note: "MEC" refers to the MEC that would be calculated assuming implicit participation
Source: Own elaboration

Under these conditions, direct XB participation may improve adequacy outcomes. By allowing foreign resources to compete directly in the CRM of Country A, capacity payments may incentivise additional availability or investment in Country B, thereby increasing the effective contribution of imports during scarcity periods in Country A.

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5. System size asymmetries and cross-border adequacy incentives

5.1 Why the size of the neighbouring system matters

The scarce-resource test depends not only on the absolute size of the interconnector, but also on the size of the neighbouring electricity system.

This is because the likelihood that interconnection capacity becomes the binding constraint during scarcity events depends on whether the neighbouring system is likely to have enough available capacity to fill the interconnector when the importing country is scarce. If the interconnector is small relative to the neighbouring system, then the neighbouring system may often be able to provide enough exports to fully utilise the interconnection.[4] In that case, the limiting factor is more likely to be transfer capability, rather than the availability of foreign generation resources.

By contrast, if the interconnector is large relative to the neighbouring system, the neighbouring country may not always have sufficient spare capacity to fill the interconnector during scarcity periods in the importing country. In that case, imports are more likely to be limited by the availability of foreign resources. Direct XB participation may then be more effective, because capacity payments can increase the availability of resources that are actually capable of increasing the importing country's adequacy contribution.

This distinction can be illustrated by comparing two otherwise similar interconnections. Suppose Country A has a 5 GW interconnector with Country B. If Country B is a large electricity system with peak demand of 100 GW, the interconnector represents only 5% of Country B's peak demand. In that case, it is relatively plausible that Country B will have enough available capacity to fill the interconnector during scarcity events in Country A. The interconnector is therefore more likely to be saturated, and additional payments to generators in Country B are less likely to increase imports into Country A.

The conclusion is different if the same 5 GW interconnector connects Country A to a smaller system with peak demand of 15 GW. In that case, the interconnector represents one third of the neighbouring system's peak demand. It is less likely that Country B will consistently have sufficient spare capacity to fill the interconnector during scarcity events in Country A. Imports are therefore more likely to be constrained by the availability of foreign resources, creating greater scope for direct XB participation to increase the effective contribution of the neighbouring system.

In addition, even when the interconnector is not fully saturated, the effectiveness of direct XB participation may remain limited if interconnection capacity is small relative to the size of the neighbouring market.

This follows from the fact that the volume of foreign capacity contracts available under direct XB participation is ultimately constrained by the interconnection capacity between the two systems. When this volume represents only a very small fraction of the neighbouring market, the additional incentives created by the CRM are unlikely to materially affect aggregate investment or availability decisions abroad.

In practice, foreign resources competing for direct XB contracts are likely to include a large number of existing infra-marginal units that would already have been available during scarcity events even in the absence of direct XB participation. Under such conditions, the resources with awarded contracts are unlikely to be the marginal resources whose behaviour would change as a result of CRM payments. Instead, direct XB participation may primarily remunerate existing foreign resources that would already have contributed to adequacy under implicit participation.

[4] Note that the likelihood of interconnection saturation also depends on the correlation of scarcity events in neighbouring countries.

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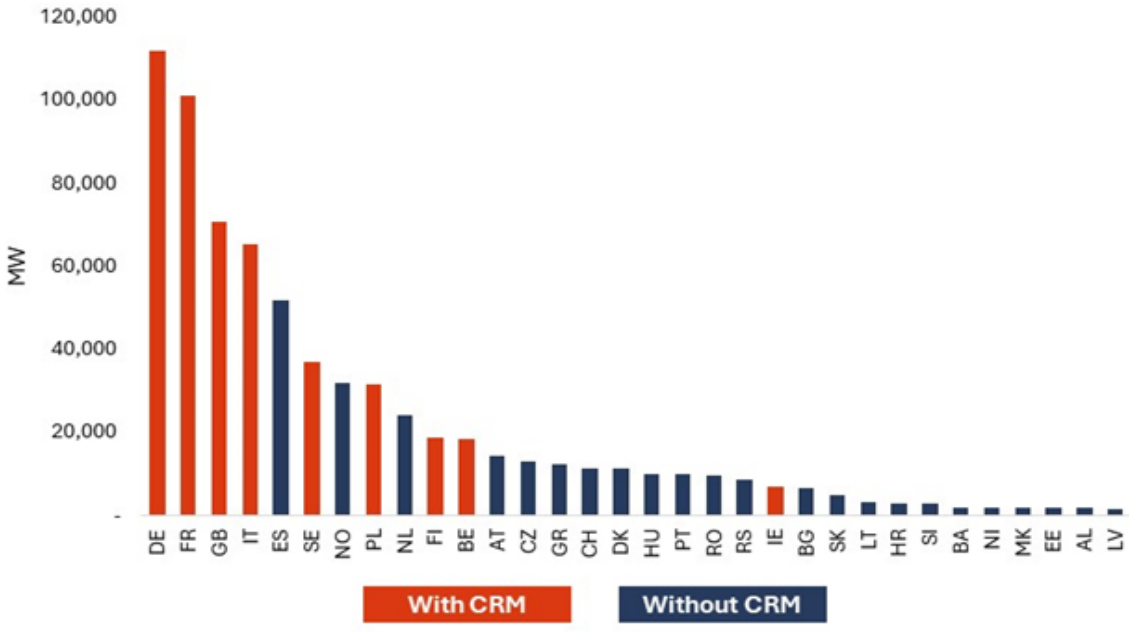
5.2 The effect of direct XB participation on free-riding incentives

The size asymmetry described above can also affect Member States' incentives to introduce CRMs. This is because CRMs generate cross-border externalities. When a country introduces a CRM, the additional capacity procured through the mechanism may improve not only its own security of supply, but also the one from its neighbouring countries.

These incentives are likely to be asymmetric. In particular, a small country connected to a much larger neighbouring system may benefit materially from the CRM of the larger country, while the reverse effect is likely to be limited. The larger system may procure or retain significant volumes of firm capacity, some of which can support the smaller country during scarcity events. By contrast, the CRM of the smaller country is less likely to have a material impact on the adequacy of the larger system.

As a result, free-riding incentives may arise even in the absence of direct XB participation. A small country may have weaker incentives to introduce its own CRM if it can partly rely on the adequacy benefits created by the CRM of its larger neighbour, without contributing to the costs of that mechanism. Figure 4 provides suggestive evidence consistent with this intuition. It ranks UK and EU countries by peak demand and distinguishes between those that have a CRM (red columns) and those that do not (blue columns). A clear pattern emerges: larger electricity systems are more likely to have implemented CRMs, while smaller systems are more likely not to have done so. This pattern is consistent with the idea that smaller countries may have weaker incentives to introduce national CRMs when they are closely connected to larger neighboring systems.

Figure 4: Peak demand by country and CRM status



Note: The European Commission has recently approved the Spanish CRM, and hence it is likely that Spain will soon implement its own CRM

Source: Own elaboration based on ENTSO-E's Pan-European Climate Database and ACER, Security of EU electricity supply – 2025 Monitoring Report

Direct XB participation may further reinforce these free-riding incentives. From the perspective of the smaller system, interconnection capacity is likely to represent a large share of domestic resources. As a result, allowing direct XB participation may substantially increase the volume of capacity contracts that the country must procure and finance.

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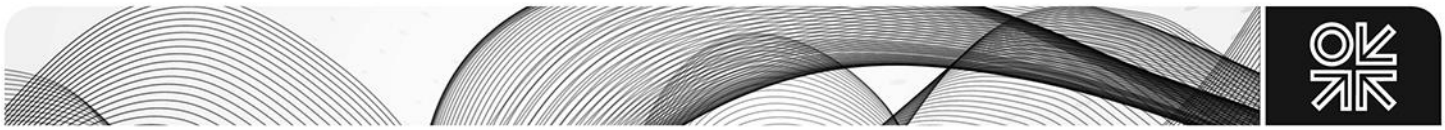

At the same time, because the neighbouring system is larger, the interconnection is likely to represent only a small share of the neighbouring market. Consequently, the additional payments associated with direct XB participation are unlikely to have an effect on investment or availability decisions abroad, and therefore may not deliver adequacy benefits to the smaller country. As a result, direct XB participation increase the relative cost of introducing a CRM for smaller systems, further reinforcing their incentive to free-ride on their neighbours.

6. Spain: A tale of two borders

The case of Spain, which has recently obtained European Commission approval for a market-wide CRM, provides empirical illustration of how low import capacity can affect the value of direct XB participation.

Spain has not yet implemented direct XB participation, but it has committed to doing so in the future. We assess whether this is likely to increase effective imports during scarcity events.

The Spanish system is a useful test case because it exhibits two fundamentally different cross-border configurations:

- a weakly interconnected border with a very large neighbouring system (France); and
- a more balanced interconnection with a smaller neighbouring system (Portugal).

Although the French and Portuguese borders have similar absolute import capacity, their economic implications are very different because the neighbouring systems differ significantly in size. The comparison therefore shows that the value of direct XB participation depends not only on the absolute size of the interconnector, but also on the size of the neighbour market.

We assess whether direct XB participation would likely generate material efficiency gains or consumer savings in the Spanish CRM. To do so, we simulate the European electricity system using Compass Lexecon's resource adequacy model, implemented in the PLEXOS® platform. The model performs adequacy simulations across 35 climatic years and evaluates scarcity outcomes under a wide range of system conditions.

The results show a sharp contrast between the French and Portuguese borders, consistent with the analytical framework developed in the previous sections. France illustrates the case where the interconnector is the binding constraint, and hence direct XB participation may mainly result in transfers to foreign generators without material adequacy beneit. Portugal illustrates the case where foreign generation is the scarce resource, and hence direct XB participation may result in efficiency gains.

6.1 France: Plenty of power, not enough wire

The interconnection between Spain and France is structurally limited relative to the size of the French electricity system. Spain's current import capacity from France is around 2.5 GW, equivalent to approximately 3% of French peak demand. Following the commissioning of the Bay of Biscay interconnection project, Spain's import capacity from France is expected to increase to around 5 GW by 2030, representing approximately 5% of French peak demand. Despite this expansion, the Spanish-French border will still remain in the lower tail of European interconnections when measured as import capacity relative to the size of the neighbouring system (see Figure 5 below).

Our simulations indicate that, under these conditions, direct XB participation is unlikely to generate material incremental adequacy benefits for Spain.

In the adequacy simulations, scarcity events in Spain almost systematically coincide with full utilisation of the interconnection with France. Across the 35 climatic years modelled, in 2030 we identify 82 hours of scarcity in Spain, of which only 9 correspond to situations in which the interconnection with France is not fully saturated. Moreover, the simulations show that substantial firm capacity remains available in France

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during many Spanish scarcity events but cannot contribute further to Spanish adequacy because the interconnection is already fully utilised. In particular, we find that, during scarcity events in Spain, around 8 GW of firm capacity remains available in France but is unable to supply the Spanish system due to interconnection constraints.

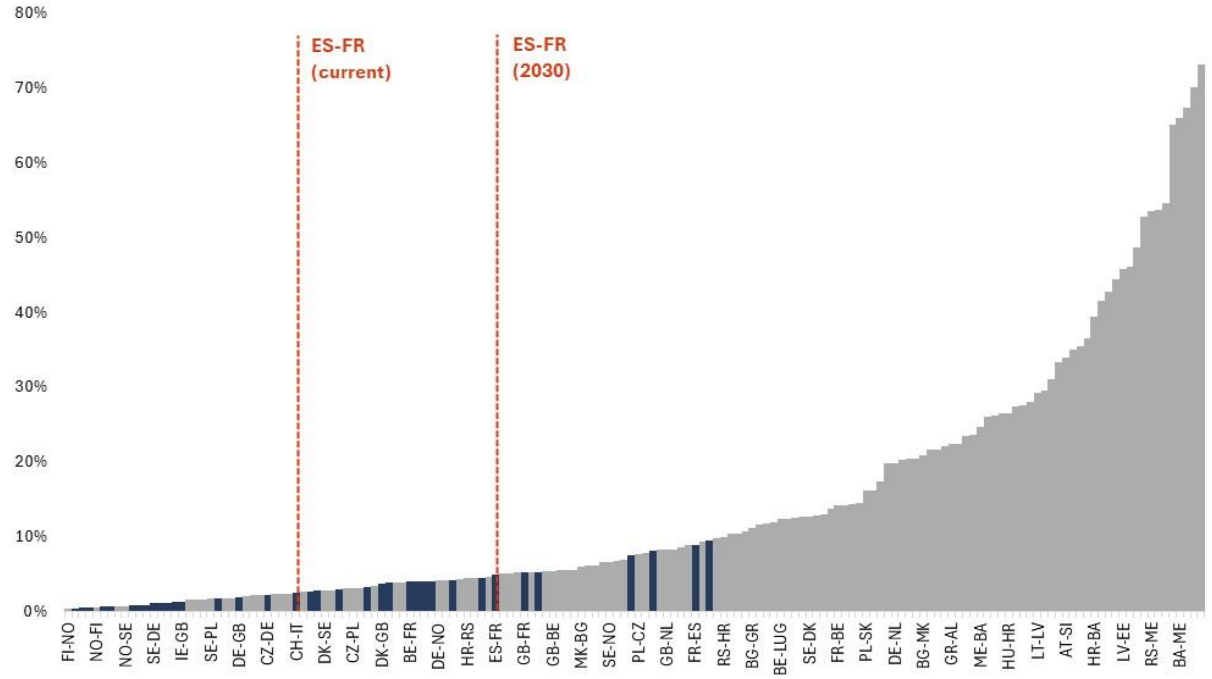
The results also indicate that the low level of interconnection between the two countries is the principal driver of these outcomes. For example, when the interconnection capacity between Spain and France is hypothetically increased to 20 GW in the modelling exercise, the interconnector is no longer saturated in any hour across the 35 climatic years analysed.

Taken together, these results strongly suggest that, under current interconnection levels, the principal constraint limiting French contributions to Spanish adequacy is transfer capability rather than the availability of French generation resources. In other words, during Spanish scarcity periods, the scarce resource is the interconnection itself, not firm capacity in France.

Under these conditions, direct XB participation is unlikely to materially increase the effective contribution of French resources during scarcity periods, as the binding constraint is not the availability of French capacity, but the ability to transport additional electricity into Spain. Instead, it may primarily result in financial transfers from Spanish consumers to French generators, while adding implementation complexity and administrative burden to the CRM.

More broadly, this result may be particularly relevant for weakly interconnected systems with large neighbouring markets. In such systems, the principal obstacle to greater cross-border adequacy support may not be the lack of foreign generation resources, but rather the limited ability to transport electricity across borders during scarcity periods.

Figure 5: Import capacity by border as a share of the exporting country's peak demand



Notes: Blue columns correspond to borders importing from the five largest electricity systems by peak demand. Grey columns correspond to all other borders

Source: Own elaboration based on ENTSO-E's Pan European Climate Database

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Figure 5 illustrates this intuition by ranking European borders according to import capacity as a share of the exporting country's peak demand. Borders connected to very large neighbouring systems tend to exhibit relatively low ratios, implying that interconnection capacity is more likely to become the binding constraint during scarcity events.

6.2 Portugal: Same wire, but smaller neighbour

Spain's import capacity from Portugal is around 2.5 GW, broadly comparable in absolute terms to the French border. However, it represents approximately 25% of Portuguese peak demand. This fundamentally changes the economics of cross-border participation. Because the interconnection represents a much more meaningful share of the neighbouring market, the volume of potential XB contracts is sufficiently large to likely influence investment and operational incentives in Portugal. Moreover, the interconnection is less likely to become systematically saturated during Spanish scarcity events, increasing the likelihood that additional Portuguese resources can effectively contribute to Spanish adequacy when incentivised through the CRM.

The simulations confirm this intuition. The interconnection between Spain and Portugal is not systematically saturated during Spanish scarcity events, as there remain a significant number of scarcity situations in which spare interconnection capacity is still available. In particular from the 82 hours of scarcity identified in Spain across the 35 climatic years modelled in 2030, 62 correspond to situations in which the interconnection with Portugal is not saturated.

Under these conditions, the relevant constraint is not usually the interconnection itself, but rather the availability of resources in Portugal during scarcity periods in Spain. Unlike the French border, the interconnector is not systematically saturated, creating greater scope for direct XB participation to increase the effective contribution of Portuguese resources.

Allowing Portuguese resources to compete directly in the Spanish CRM may increase the effective contribution of imports during scarcity periods by improving incentives for availability, delaying retirements, or supporting additional flexibility resources in Portugal. In this case, direct XB participation may therefore generate genuine incremental adequacy value beyond the contribution already recognised through implicit participation. By enabling Portuguese units to substitute more expensive domestic capacity in Spain, where they are competitive, direct XB participation can reduce the overall cost of procuring sufficient firm capacity. In this setting, payments to Portuguese generators would be associated with genuine efficiency gains and lower adequacy costs for Spanish consumers, rather than merely constituting a financial transfer with no corresponding benefit, in contrast with the French case discussed above.

7. Policy implications

European regulation on cross-border participation in CRMs has largely been framed around the assumption that allowing foreign resources to participate directly in domestic capacity markets will improve efficiency and reduce adequacy costs. Regulation (EU) 2019/943 effectively treats direct XB participation as a general requirement for CRMs, while recent European Commission guidance makes it a prerequisite for fast-track State aid approval of market-wide mechanisms. Such a one-size-fits-all approach appears difficult to justify economically.

Our analysis shows that the relative merits of implicit and direct XB participation depend on the nature of the relevant scarcity constraint during scarcity periods. Direct XB participation can create value in some circumstances, but it is not universally welfare-enhancing. In particular, its effectiveness depends on whether imports are constrained primarily by the availability of foreign resources or by the interconnection itself.

When interconnection capacity is small relative to the size of the neighbouring electricity market, transfer capability is likely to be the binding constraint. In those circumstances, additional remuneration of foreign generators is unlikely to materially increase imports or improve adequacy outcomes. Instead, direct XB

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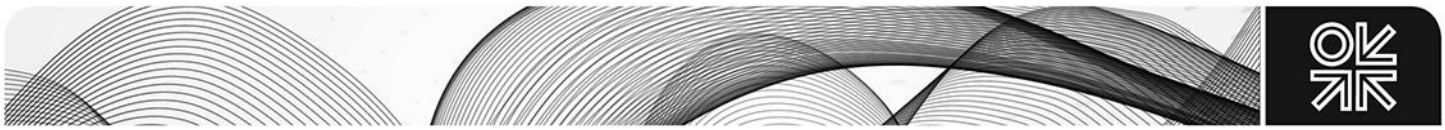

participation may mainly result in transfers to foreign generators while increasing implementation complexity, administrative burden, and consumer costs. Under such conditions, implicit participation is likely to constitute a simpler and more efficient approach.

By contrast, when interconnection capacity is large relative to the neighbouring system, imports may instead be constrained by the availability of foreign resources. In those circumstances, direct XB participation may improve efficiency by strengthening incentives for foreign resources to remain available during scarcity periods and increasing the adequacy contribution of neighbouring systems.

Where interconnection capacity is the binding constraint, a further question arises as to whether participation of the interconnector itself could be a superior alternative to implicit participation. From an economic perspective, this approach may appear desirable. If transfer capability is the scarce resource during scarcity periods, remunerating the interconnector might provide the right incentives for transfer capacity expansions.

However, the case for remunerating interconnectors is also subject to important limitations in the European context. Most European interconnectors are regulated assets whose investment costs are already recovered from consumers through network tariffs. As a result, additional CRM revenues may not materially strengthen incentives to expand interconnection capacity, particularly where investment decisions remain driven by regulatory approval processes and cross-border planning arrangements.

EU regulation should adopt a more effects-based and proportionate approach to XB participation in CRMs. Rather than treating direct XB participation as a general requirement, the regulatory framework should recognise that its benefits depend on the specific characteristics of interconnected systems, including the relative size of interconnection capacity and neighbouring electricity markets. A more flexible framework would allow Member States to justify, based on system-specific evidence, whether implicit participation alone is sufficient to capture the benefits of cross-border participation. Such an approach would be more consistent with the underlying economic rationale of the Internal Electricity Market and with the objective of ensuring cost-effective security of supply across interconnected systems.

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