THE UNFOLDING OF REGIONAL ELECTRICITY MARKETS:
MEASURES TO IMPROVE THE FIRMNESS OF CROSS-BORDER TRADING

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Fully integrated regional electricity markets would result in large efficiency gains and potentially huge economic savings for all the countries involved. This is true in the short term (lower system operation costs), but also, and more relevantly, in the medium and especially long term (optimal resources exploitation and coordinated capacity expansion). Nevertheless, for regional markets to be successful, new institutional arrangements are necessary to improve trust in the firmness of cross-border contracts and trades, especially during scarcity conditions. This article identifies the main barriers that have hampered cross-border trading in regional markets so far, and discusses alternatives to mitigate their negative impact.

Keywords

Firm electricity contracts; regional markets; cross-border trades; market integration.

1 INTRODUCTION

Cross-border trades are the cornerstone of the development of regional electricity markets. Interconnections among different countries, initially installed with the objective of increasing the short-term reliability of power supply through shared frequency control, are expected to be (or are already being) enhanced to permit the trade of electricity services regardless of political frontiers. Cross-border trades permit the optimal exploitation of energy resources, with large economic efficiency gains for all the countries involved, first in the short-term operation, and, ultimately, ideally and more importantly, in the long-term capacity expansion.
The higher the degree of market integration, the larger the need of coordination among different countries on several levels, not just technical and economic, but also institutional (see Cepeda et al., 2009, for a discussion on adequacy issues in regional markets). For cross-border trades to properly develop, common rules applying on the entire region must be established and respected by all the countries involved. Only a strong commitment to the compliance of these international agreements can generate trust among different countries and confidence of power sector agents in the regional market itself. Nevertheless, as later illustrated with actual examples, in the current state of development of market integration, either the conflict between the new common rules and the scattered national regulations still in force, or directly the lack of such common rules on regional trades has not allowed the unfolding of long-termed cross-border contracts so far.

This article identifies two main barriers to the development of cross-border agreements in regional markets\(^1\) and discusses alternatives to minimise their impact. The first barrier (analysed in section 3.1) is the lack of coordination and stability in the definition of regional transmission tariffs. The so-called “pancaking” of transmission tariffs or an arbitrary determination of the national transmission charges lead the regional planning towards a suboptimal solution. Additionally, the regulatory risk related to the unexpected changes in the values of these tariffs adds a further barrier for regional generation investors.

The second barrier to cross-border contracts, even more detrimental than the first, is the intervention of national governments (making pressure on their system operators) in case the coverage of their domestic demand is endangered. This sort of interventions may result in the

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\(^1\) These barriers have been highlighted, in one way or another and among others, by Sauma et al. (2011) for the Latin American context and by Saguan et al. (2011) for the European one (focusing on grid issues), and by Baritaud and Volk (2014) for regional markets in IEA countries (centred in institutional barriers).
interruption of exports to neighbouring countries, with the consequent impossibility of fulfilling cross-border contracts. This situation exposes one of the parties in the agreement, commonly the generation, to a risk that is completely unmanageable, hampering the development of cross-border contracts and, therefore, the unfolding of regional markets. As regards this second barrier (broadly studied in section 3.2.2), the article claims that, in case cross-border contracts are not fulfilled due to an export interruption decided by the system operator, a compensation should be paid by the agent actually responsible for the interruption, i.e., the system operator itself or the regulator/government behind it. In order to support the discussion on the ways to quantify the value of such compensation, the paper provides an introductory discussion on the difference among physical and financial contracts in real markets, both in terms of energy and transmission rights (section 3.2.1). Before the detailed analysis, section 1.1 widens on the definition of regional markets and presents some international experiences, while section 2 clarifies the methodology followed in the discussion.

1.1 Regional markets: definitions and relevant examples

Terminology

Before entering into the details of the discussion, it is important to clarify what in our view should be understood as a regional market. Beyond the few discussions that can be found in the literature, see e.g. Olmos and Pérez-Arriaga (2013), in this article regional markets are identified according to the institutional arrangements on which they are based, focusing on the presence of “frontiers” in terms of both political organisation and grid operation.

A first prerequisite for having a regional market is the existence of different system operators. A market covering a geographic area in which different countries, states, or other political entities co-exist, but in which the power system is managed by a single system operator (as it could be the case of PJM or other ISO markets in the United States) should not be considered a regional market. When different system operators exist, a second prerequisite is that they are
subject to different jurisdictions (i.e. their activity is monitored by different governments, based on different regulations). For example, Germany has different system operators active on its territory. However, they are subject to the same jurisdiction; therefore the German market is a national market and not a regional one. According to this definition, the European Internal Energy Market (and, within this and previous to this, the Scandinavian Nord Pool or the Iberian MIBEL), the Central American Electricity Market, the Andean Electricity Interconnection System, and the South African Power Pool are clear examples of regional markets, at different stages of market integration.

This distinction is very relevant for the discussion presented hereunder. In fact, the barriers mentioned in this article are only relevant in a regional market in which different national interests coexist, in which different system operators are active, and in which these operators are in one way or another subject to distinct authorities and jurisdictions that may, at some moment, prioritise the national interests with respect to the regional interests.

**International experiences**

In order to illustrate the relevance of the discussion that follows, several examples on the limitations affecting cross-border trades are presented in this subsection.

In the European Union, only a small part of the huge efficiency potential stemming from market integration has already started to be exploited (Böckers et al., 2013). The EU regulation recognizes the importance of guaranteeing the possibility to trade at a regional level, which is reflected in the article 4.3 in the Security of Supply Directive (2005/89/EC), when it states that “Member States shall not discriminate between cross-border contracts and national contracts”. However, despite the adoption of this Directive by all Member States, there is significant mistrust on its actual application due to the existence of clauses in most national network codes in force that maintain that exports to other countries will be interrupted in case of a domestic emergency of supply (Mastropietro et al., 2015). This mistrust is having a huge impact on the
design of Capacity Remuneration Mechanisms (CRMs) that are being introduced in the
continent, which are the regulatory tools that will drive the development of the EU power sector
in the future and define its efficiency in exploiting the regional resources. In fact, CRMs being
proposed and implemented seem to rely almost exclusively on the domestic generation and
clearly aim at increasing the self-sufficiency of the national power systems. Foreign agents are
almost always excluded from the participation to national capacity mechanisms and to the
consequent remuneration, the main reason for this decision being exactly the impossibility of
guaranteeing the firmness of cross-border contracts during scarcity conditions.

In Central America, the entire discussion that resulted in the creation of the Regional Electricity
Market (Mercado Eléctrico Regional, or MER) was hinged upon the development of so-called
Regional Generation Projects (or PGRs, in their Spanish acronym). The latter are supposed to
be large-scale generation facilities which are supposed to supply loads located in different
countries within the MER, through the ad-hoc-installed regional cross-border interconnection
(SIEPAC line). Obviously, the unfolding of PGRs to exploit economies of scale requires the
possibility of signing firm long-term supply contracts that ensure cross-border trades under
every condition. Article 9 of the Framework Treaty for the Central American Electricity Market
(or TMMEAC, in its Spanish acronym) urges signatory Governments to create favourable
conditions for the development of these cross-border trades. However, national regulations and
legislations are still totally oriented at the prioritised satisfaction of the domestic demand
(CEPAL, 2013). This delay in the modification of legislations to fit the new requirements of the

\[^{2}\text{ACER (2013) well resums the situation when it states that “the experience with cross-border participation (in}
\text{national CRMs) is virtually non-existing”}. This is raising concerns, especially from the generation sectors, see
\text{EURELECTRIC (2013).}\]
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regional market hampers the installation of regional generation projects and it is also impeding the fulfilment of cross-border contracts already signed.

Finally, in another emerging market integration project, the Andean Electricity Interconnection System (or SINEA, in its Spanish acronym), the discussion is still focused on charges for the usage of the regional transmission network and on the distribution of congestion rents, and the firmness of cross-border contracts is not even on the table³.

2 METHOD

The article is based on the identification of the regulatory and institutional barriers that hamper cross-border trades and on the elaboration of proposals for their mitigation. For products other than electricity, apart from customs duties that may be imposed, there is no peculiar feature differentiating internal trade from cross-border deals. However, the specificities of the electrical product introduce several complexities that separate these two environments in power markets.

In modern societies, electricity is considered as an essential good for the fulfilment of basic needs. This status implies that most of regulators perceive the obligation of capping somehow its price and to guarantee its supply to their national demand. The presence of an administratively-set maximum price results in an indeterminacy during scarcity conditions which does not permit the optimal allocation of the resource according to economic principles. Apart from creating a difference between a physical and a financial contract in these situations (the so-called convenience yield), this is important at the moment of quantifying the compensation for the unfulfilment of a cross-border contract, as it will be explained in the discussion.

³ For a general view on market integration in Latin America, the reader may refer to Raineri et al. (2013). For more details on opportunities, challenges, and threats of regional markets in different Latin American context, see Sauma et al. (2011) and Ochoa el al. (2013). For further reading on the EU integration process, see Pellini (2014) and WEC (2013). For an overview with a global perspective, see Baritaud and Volk (2014).
Another element affecting such compensation is represented by price differentials among different countries. Cross-border capacities, due to their historical development, are most of the times not sufficient to exploit the entire trading potential among different countries, as interconnections are often congested. This congestion creates price differentials across the transmission line, which result in a risk against which cross-border traders are not naturally hedged. As discussed in this paper, the objective of transmission rights, either physical or financial, is exactly to provide cross-border traders with this kind of hedging instruments.

The saturation of the interconnection capacity is not the only source of price differentials. The latter may also be originated by a direct regulatory intervention. In fact, in case of concurrent scarcity conditions in two neighbouring systems, the system operator (also prompted by the regulator) of the system that, considering cross-border contracts, results to be net exporter of electricity is very likely to block the potential exports through the interconnection, in order to prioritise the supply to its domestic demand. By doing this, the regulator artificially creates a price differential against which no hedge is possible, and it also impedes the execution of physical cross-border contracts. The potential interruption of exports by the system operator during scarcity conditions is probably the major threat and barrier to the development of cross-border trades. In order to discourage these behaviours that prioritise national interests with respect to regional interests, a compensation must be introduced in case of unfulfilment of cross-border contracts, whose calculation is based on the introductory discussion mentioned above. When the unfulfilment is due to a regulatory decision of interrupting exports, the compensation must be paid by the system operator.

However, not all the obstacles to this kind of trades come from market-related risks. Another factor that has a negative impact on cross-border power exchanges, especially in the early stages of the implementation of a regional market, is the inadequate definition of transmission tariffs to be paid by those agents willing to make use of the regional network facilities.
These elements, only outlined in this section, are analysed in detail in Section 3, starting with concerns related to regional transmission tariffs (section 3.1) and then facing the threat of exports interruption during scarcity conditions (section 3.2). Based on this analysis, section 4 presents regulatory proposals for enhancing the firmness of cross-border trades.

3 RESULTS AND DISCUSSION

3.1 Regional transmission tariffs

In a regional market context, countries are required to provide access to their electricity networks to foreign agents. The resulting cross-border flows may have different impacts on the national grid. All of these impacts are subject to charges that are due to the national system operator. Two different kinds of these charges can be identified:

- charges for the usage of the national grid;

- charges to compensate the changes in the operation of the grid and the dispatch of the system that are necessary in order to provide that usage (e.g., compensation for increased network losses).

The assessment and quantification of these charges is usually expressed as compensations among system operators of different countries. For this reason, in the European context, they are known under the name of “inter-TSO payments”.

The definition of these regional transmission tariffs represents a very complex and controversial task. An improper design of these charges can negatively affect cross-border trades in different ways. First of all, some calculation methodologies may indirectly penalise international transactions, by piling up different tariffs for the usage of each national grid involved in the exchange, a problem known in transmission regulation as “pancaking”. This approach may eventually hamper transactions which would otherwise allow to improve the efficiency in the operation of the regional system.
A second, but not less important concern comes from the lack of a transparent and stable methodology for the definition of these tariffs. In fact, if the agents willing to operate on the regional market are not able to predict how these transmission charges will change in the future (especially, if such charges are modified periodically and may suffer significant variations), they will be exposed to a non-manageable risk, which may reduce their interest in cross-border trades.

A dissertation on the correct methodology to determine regional transmission tariffs exceeds the scope of this paper (for a detailed analysis, the reader may refer to Olmos and Pérez-Arriaga, 2007; or Stoilov and Stoilov, 2013). Nevertheless, it is important to underline how these charges should be calculated in a way that favours the efficient operation of the regional system (avoiding pancaking and fostering cross-border trades). Moreover, in order to reduce the associated risk, these tariffs should be defined for each cross-border contract on a long-term basis (e.g., ten years).

### 3.2 Regulatory intervention during system stress

#### 3.2.1 Introductory discussion

**Inefficient pricing during scarcity conditions and contract firmness**

As mentioned above, the presence of an administratively-set price cap that limits the short-term price results in an indeterminacy during scarcity conditions and in a sub-optimal allocation of the scarce resource, i.e., electricity. This subsection deepens this aspect and analyses its

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* Apart from charges due for the usage of the cross-border interconnection, also national transmission tariffs should be designed to be compatible with the regional market. In order to have a level playing field for agents in the regional market, transmission tariffs should have a similar structure and should be charged to the same agents in the entire region.
relationship with the firmness of contracts, focusing on the difference between physical and financial agreements.

A physical contract is based on an electricity delivery commitment by a generator (and on a symmetric withdrawal commitment by a demand) for a specific quantity of energy and at a specific price. This bilateral agreement may be nominated within or outside the short-term organised market. It should also be open to renegotiation, meaning that each part should be allowed to transfer its physical commitment to a third party.

On the other hand, a financial contract does not involve any physical delivery of the product. The generation and the demand signing the contract basically agree on a set of monetary flows which depend on the difference between the short-term market price and the contract price.

From an economic perspective, in an ideal electricity market, a physical and a financial contract are completely equivalent. An ideal market is characterised by offer and demand taking part to the market through bids which adequately reflect their costs and utilities. Furthermore, the price in an ideal market should be determined by the equilibrium between offer and demand, without any intervention by the regulator trying to impose restrictions.

Unfortunately, real electricity markets are far from being ideal, and this is especially true during scarcity conditions. In real markets, the short-term price is not always the result of the equilibrium between offer and demand. When the generation is not sufficient to cover the load (or even when this equilibrium takes place at a price that the regulator considers unsuitable), the price is commonly set administratively, through the application of a price cap (also known as scarcity price or non-served energy price). In this case, it is not possible to assign efficiently the scarce resource.

If the price cap is lower than the value that a certain agent assigns to its electricity consumption, then this agent would prefer a physical contract over a financial one, because the delivery of the physical asset has a higher value than the corresponding financial compensation. In other
contexts, this is what is usually known as convenience yield. The higher the difference between the price cap and the utility value of a certain demand, the higher the preference for a physical contract guaranteeing the delivery.

**Compensations in case of noncompliance of the physical delivery**

However, the generator signing a physical contract may not always be able to fulfil its delivery commitment. This may be due, for example, to the unavailability of its plant during scarcity conditions. Furthermore, when generation and demand are located on opposite sides of a cross-border interconnection, the unfulfilment of the contract may also be the result of the intervention of the operator or regulator of the system where the generation is located, who interrupts electricity exports in order to protect domestic demand. The latter case will be analysed in a following subsection.

In any case, for the physical contract to totally fulfil its objective (i.e., to ensure the demand that it will either have the physical delivery of the product or receive the equivalent of the utility value that it attributes to the supply), an additional compensation for noncompliance should be considered. Figure 1 presents a market clearing during scarcity conditions, through which it is possible to identify which the value of such compensation should be.

![Figure 1. Market clearing during scarcity conditions](image-url)
Therefore, a physical contract, in case of noncompliance of the physical delivery concurrent with scarcity conditions in the system where the demand is located resulting in the demand not being supplied, should consider i) an economic settlement corresponding to the difference between the short-term price, capped at the scarcity price, and the contract price, and ii) an additional compensation equal (or at least proportional) to the difference between the utility value of the demand, also known as its opportunity cost, and the price cap active in the market. However, it must be underlined that the compensation must be paid by the generation only if the demand is not supplied.

Actually, the presence of a compensation in case the demand is not supplied is the only feature which would allow distinguishing a physical from a financial contract. Without this compensation, the two kinds of contract are, once again, equivalent.

**Cross-border congestions and transmission rights**

In a regional market in which market prices are calculated in coordinated way and cross-border interconnections are often congested, significant price differentials arise and different price zones are created. For this reason, provisions of bilateral contracts in a regional environment have to specify (besides standard provisions as quantity, price, duration, physical/financial character, warranties, etc.) a delivery point.

A generation and a demand located in the same node of the network can sign a bilateral contract at a fixed price because they are natural counterparties, this meaning that when the price of electricity increases/decreases, it does it in the same way for the two agents and the contract could be easily settled. However, if the same generation and demand are located on two different sides of a usually congested interconnection, this natural hedge disappears, because the price may vary in a different way for the two agents. In this case, the grid itself becomes the natural counterparty to the generation-demand pair with respect to grid constraint-induced risk. This kind of risk can be hedged through the procurement of transmission rights. The latter entitle
the buyer (in this case, theoretically, the parties signing the bilateral contract) to exploit the congestion rent generated by the interconnection. Since the congestion rent is equal to the price differential between the two zones where the counterparties are located, a transmission right ensures the balance in the economic settlements of the contract and allows the agents to be completely hedged against price risk. Two different kinds of transmission rights are possible:

• Physical Transmission Rights (or PTRs), which entitles the buyer to reserve part of the interconnection capacity for its cross-border trades, thus providing access to a different zone than the one in which it is located, without being exposed to the price differential. In order to guarantee the maximum exploitation of the interconnection capacity (and to avoid gaming from agents willing to block cross-border trades by withholding capacity), PTRs usually include a Use-It-Or-Sell-It (or UIOSI) clause, which requires the buyer to nominate its capacity before the actual usage. Non-nominated capacity is then re-auctioned to a different agent.

• Financial Transmission Rights (or FTRs), which are financial contracts over the price differential between two zones. Different kinds of FTRs are usually auctioned, allowing partial or complete hedge against the risk associated to trading electricity across an interconnection.

The line of reasoning used in the previous subsection to analyse physical and financial energy contracts applies also to physical and financial transmission contracts. Therefore, PTRs and FTRs are totally equivalent, unless scarcity conditions take place. In this case, a demand which

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For a detailed dissertation about the differences between PTRs and FTRs, as well as for a summary of the nomenclature used in different context to refer to these instruments, the reader can refer to Batlle et al. (2014).
attributes a utility to its consumption higher that the administratively-set price cap active in the market will have a preference for Physical Transmission Rights.

Regardless of the physical or financial nature of the transmission right, it must be underlined how these instruments represent an essential hedge for agents willing to trade electricity cross-border. In the absence of such hedge, the base risk related to price differentials significantly reduces the attractiveness of regional trades, when not directly making them impossible. Therefore, the entity (or the entities) holding the congestion rents, commonly the system operators of the grids connected by the cross-border line, should be required to make transmission rights available to market agents. Furthermore, transmission rights should be sold at a fixed price for a term long enough to be a proper hedge for a cross-border contract, i.e. with durations similar to those of the energy contracts. Finally, in the case of regional markets involving several countries, an agent who wants a complete hedge for its energy contract may need to procure transmission rights on more than one interconnection, until “reaching” the price zone in which the demand is located. Therefore, these hedging instruments, when the complexity of the process allows it, should be also assigned simultaneously and in a coordinated manner for all the cross-border interconnections encompassed in the regional market, for the agents to be able to bid for and procure different transmission rights at the same time.

3.2.2 Exports interruption during scarcity conditions

After the introductory discussion, this subsection focuses on the second (and most important) barrier and source of risk for cross-border electricity trades, i.e. the possible regulatory intervention impeding the execution of regional contracts during scarcity conditions. In order to properly understand this threat it must be reminded that, from the very beginning, power sector regulation always had a great emphasis on the security of supply and that this issue was mainly addressed on a national basis. Institutional arrangements also reflect this point of view (Baritaud and Volk, 2014). System operators are usually in charge of guaranteeing, whenever
possible, the supply of the demand connected to the grid they manage, taking a wide range of measures. Evidence (and also network codes) has demonstrated that one of these measures consists is reducing to zero the flows through cross-border interconnections, in case the system operator expects this flow to be directed out of the system, in the export direction. This obviously does not permit the execution of cross-border contracts that serve a demand located on the other side of the interconnection, and the objective is to retain the generation committed in the contract in order to cover the largest possible share of domestic demand.

This potential intervention by the system operator (commonly also prompted by the regulator) represents a sword of Damocles hung above cross-border trades. In fact, in theory, the risk associated with the fulfilment of a contractual commitment should be completely manageable by the counterparties entering into the agreement. Nonetheless, if a regulatory intervention by the system operator can impede the execution of the cross-border contract, potentially triggering a compensation for noncompliance to be paid by the generator, then one of the agents is exposed to a risk on which it has no control, and it is subject to a penalisation for an unfulfilment which it is not responsible for. Paradoxically, the compensation for noncompliance, a clause which should aim at increasing the firmness of the contract, becomes, in this situation, a significant disincentive to the stipulation of the contract itself.

Because of this threat, some framework agreements regulating regional markets have tried to avoid this kind of regulatory interventions, as for the case of the already-mentioned article 4.3 in the Security of Supply Directive of the European Commission (“Member States shall not discriminate between cross-border contracts and national contracts”). Unfortunately, even in those cases where these requirements have been made explicit, network codes keep on entitling the system operator (when not directly demanding it) of the possibility of blocking exports during scarcity conditions.
Analysis of a two-system case

In order to see the impact of this regulatory intervention, a case study entailing two systems connected through a cross-border line with limited capacity is considered. A generator is located in system B and it has signed a contract for the physical delivery of electricity with a demand located in system A. Furthermore, the generator is also in possession of a transmission right that hedge its position against price differentials. Three different prices are involved in this case:

- $p_A$, which is the price in the system where the demand is located;
- $p_B$, which is the price in the system where the generation is located;
- $p_C$, which is the price stipulated in the cross-border contract.

Now, it will be assumed that the system operator of system B decides to interrupt exports through the interconnection because of the occurrence of scarcity conditions in its grid. In this situation, prices in the two systems will no longer be coupled and a price differential is likely to appear. However, this differential does not originate any congestion rent, because no electricity is flowing through the interconnection, benefitting from the trading price gap. Since transmission rights are correlated with congestion rents, an indefinite situation takes place, and the most likely scenario is that no financial compensation is provided to the transmission rights holders.

If the physical energy contract between generation and demand was properly designed, the compensation for noncompliance should be due only in case the demand in system A is not supplied. Therefore, the situation outlined above can be divided into two sub-cases (considering that the generator is always available and injecting electricity to the grid of system B):

- Demand in system A, despite the block of exports from system B, is supplied. In this case, the generation should settle only the difference between the price in system A ($p_A$) and the contract price ($p_C$), without being subject to the payment of any compensation. Since the
transmission right held by the generator is not paying any congestion rent, the difference between the prices in place in the two systems \((p_B - p_A)\) should be covered by the generator itself. It must be highlighted how this implies a financial loss for the generator only in case the price in system A is even higher than the price in system B, where scarcity conditions are in place. This situation is analysed in the following sub-case.

- Demand in system A is not supplied. This implies that there are scarcity conditions also in system A (concurrent scarcity conditions in the two systems) and it may be expected that the price in this system is even higher than the one in system B. In this case, the generation receives \(p_B\) from its market, but it has to pay to the demand in system A the difference \(p_A - p_C\) plus the compensation for noncompliance, suffering a significant financial loss.

The risk encompassed in this latter sub-case is absolutely unmanageable by the generator and it represents a huge disincentive to the stipulation of cross-border agreements.

**Proper allocation of the risk of cross-border interruption**

Since this penalisation associated with a situation in which the generation has no responsibility is so detrimental, it may be thought that one possible solution is to include in the cross-border contract clauses that limit the payment of the compensation to a noncompliance only related with the availability of the generation facility. Therefore, a noncompliance due to regulatory intervention would not be subject to a penalisation, eliminating this risk (or part of it, since the risk related with the price differentials would remain). However, such a design would further reduce the firmness of the cross-border commitment, and it would simply result in a transfer of the unmanageable risk from the generation to the demand, making the contract less attractive for the latter.

If the objective is to foster the unfolding of cross-border contracts and to create a regional market in which the demand in one system relies on the generation in a neighbouring system when planning in the long term, only “real” force majeure conditions (e.g., a natural disaster) should
exempt the generation from paying the compensation to the demand when the physical delivery is not guaranteed.

Since the risk associated to the compensation is not removable, it should be properly assigned. Actually, the most reasonable solution would be to transfer this risk to the party that is responsible for the contract noncompliance, i.e., the system operator deciding to interrupt exports through the cross-border interconnection. This implies that, whenever the physical delivery is not possible because of an intervention from the system operator, the latter should be required to assume the consequences of its actions, by paying both the compensation and the financial settlement related to the price differentials. The system operator (once again, representing the regulator and, eventually, the government) should be also required to deposit warranties for the coverage of such payments.

The main drawback of this approach is represented by the possibly exaggerated warranties that should be deposited to cover potential compensations to be paid by the system cutting the exports, which could make this mechanism practically unfeasible. In order to assess this aspect, the following subsection focuses on the factors that influence the magnitude of these warranties6.

6 The analysis of financial solutions to provide such warranties exceeds the scope of this article. Nonetheless, it is also possible to foresee a role for development banks or other international institutions. When the development of a regional market presents clear and quantifiable benefits for the countries involved, such entities may be willing to provide governments with insurance products that cover the event of export interruption and the consequent compensations. The premium to be paid to purchase such insurance would be proportional to the factors presented in the next subsection, but it would also depend on the trustworthiness of the government and its commitment to the development of the regional market (which is supposed to prevent export interruptions).
Factors affecting the warranties for interruption

Warranties to be deposited in order to cover the consequences of an interruption of electricity exports basically depend on two terms: the value of the penalisation to be paid for each hour of noncompliance of the contract, composed by the compensation itself and the financial settlement covering price differentials between the two zones, and the expected duration of scarcity conditions, which prompt the occurrence of the situation requiring the payment of the penalisation.

As regards the duration, it must be highlighted that, depending on the regional market under study, scarcity conditions may not be sporadic events taking place with a very low frequency. Electricity shortages may sometimes be the result of isolated and temporary unavailabilities of generation plants or transmission facilities in the system. Nevertheless, many times, scarcity conditions are related with planning mistakes in the medium and long term, which generate structural deficiencies that need months, or even years, in order to be solved.

As concerns the penalisation, the analysis of the two-system case outlined above is deepened in this subsection, in order to identify the factors that have an influence on these compensations. Two new prices need to be introduced in order to consider all possible combinations:

- $p_{\text{sc}A}$, which is the price cap (scarcity price) in the system where the demand is located;
- $p_{\text{sc}B}$, which is the price cap (scarcity price) in the system where the generation is located;

All the possible situations in which the penalisation has to be assessed are composed by the combination of two variables: the supply to the demand in system A, which could take place or

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7 This could be the case in hydro-dominated systems, in which a dry year could result in scarcity conditions lasting an entire season. But also other causes are possible. See for example Batlle el al. (2010) for a description of scarcity conditions suffered by many Latin American countries in the decade 1995/2005.
not; and the price difference between system A and system B. Table i presents all these possible combinations.

<table>
<thead>
<tr>
<th>Demand is supplied</th>
<th>Demand is NOT supplied</th>
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<tbody>
<tr>
<td><strong>Scarcity only in system B</strong> ($p_{capB} &gt; p_A$)</td>
<td>No compensation</td>
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<tr>
<td><strong>Concurrent scarcities</strong> ($p_{capB} &gt; p_{capA}$)</td>
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<td><strong>Concurrent scarcities</strong> ($p_{capB} = p_{capA}$)</td>
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<td><strong>Concurrent scarcities</strong> ($p_{capB} &lt; p_{capA}$)</td>
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Several reflections regarding the warranty for export interruption can be withdrawn from the information provided so far. First of all, the warranty should be proportional to the probability of occurrence of scarcity conditions. However, this is not much related to isolated scarcity conditions taking place in one of two systems. In fact, if a shortage occurs only in system A, exports from system B to A are not interrupted and no penalisation is required. On the other hand, if the scarcity only affects system B, the demand in system A is supplied, and no compensation is to be paid (only the price differential should be settled). Therefore, the warranty should increase according to the probability of concurrent scarcity conditions in the two systems. If the complementarity of generation mixes in the two systems results in an extremely low likelihood of concurrent shortages, the warranty could assume very low values.
Another factor affecting the warranty is the price cap active in the system where the demand is located. The higher this scarcity price, the lower the compensation to be paid in case the physical delivery of the electricity is not possible. In fact, as explained in a previous subsection, this compensation should be set as the difference between the utility value that the demand attributes to its supply and the price cap active in the market.

Furthermore, the warranty is influenced also by the price differential between the two systems, since it should be settled also when exports are interrupted and no congestion rent can be exploited. As it has been mentioned, the warranty is related with concurrent scarcity conditions, therefore the price differential is represented by the difference between the two price caps defined for the two systems. The lower this difference, the lower the warranty required.

Focusing on the last two factors, it can be said that if the price caps active in the two systems are harmonised in a single value, and if this regional price cap is set to a reasonably high price, the warranty could once again assume very low values.

**Bilateral or trilateral contracts? Transmission right compensations**

Until this point, it has been assumed that the system operator blocking exports, thus impeding the fulfilment of the cross-border contract, should be required to pay, on the top of the financial settlement related to price differentials, a compensation reflecting the loss of utility of the unserved demand. Such compensation is commonly included in the physical contract stipulated between generation and demand. Nonetheless, it is not obvious how to transfer such compensating responsibility to the system operator. Any clause of an agreement reached between two parties cannot be automatically transferred to the system operator, who had no role at all in the elaboration and in the signature of the contract and cannot be required to pay the compensation expressed in the physical contract. A possible solution is to include a clause in the contract governing the physical transmission right (to be procured by the generation who sold the physical cross-border contract), in which the system operator commits to pay the price
differential also in the absence of any congestion rent (due to the block of exports) plus a generic compensation, valid for all the physical contracts, regardless of the value of the specific compensation considered by bilateral agreements. The generic compensation (and the potentially associated warranty) should be calculated according to the reflections expressed in the previous subsection. The gap between the generic compensation of transmission rights and the specific compensation of physical contracts may still expose the generation party to a significant risk. It is, therefore, of paramount importance to set the transmission right compensation high enough, in order not to hamper the signature of cross-border contracts.

Another option would be to let the agents include the compensation they would require in case of noncompliance in the bids they present in the auction for transmission rights. However, this solution has two disadvantages. First, it would result in an auction with two-parameter bids, which could be difficult (when not impossible) to clear. Second, firm contracts are usually pursued by demands with very high utilities, which are also those that would require the highest compensation in case of noncompliance. Therefore, the agents who are more in need of firmness would be disadvantaged in the procurement of the cross-border product.

Finally, it must be remarked that the transmission right contract should be designed in a way that considers the payment of the compensation only in case the demand is not served because of the curtailment of exports. This may be not a simple settlement, since the party procuring the transmission right may be only the generator in the exporting country. However, this

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* In this context, the identification of the subject in charge of fixing the compensation assumes a particular relevance. System operators, especially where they combine this role with the one of market operator, have access to the best information to carry out this calculation, but they clearly have a conflict of interests. A possible solution is that national regulatory authorities contract an independent consultant, who estimates the compensation in a transparent and reproducible way.
complexity may be solved with the obligation to associate the transmission right with a bilateral contract, which specifies the demand involved in the agreement and the methodology to verify its supply.

Avoiding the compensation: demand-response options

Pushing this line of thinking a little further, it is possible to assume that the system operator may be eager to reduce its exposure to the risk of having to pay the transmission right compensation, especially when the conditions in place in the two neighbouring markets result in the calculation of a high compensation. Since the compensation is due only in case the demand in the bilateral contract associated to the transmission right is not served, the system operator may pursue solutions that minimise the probability that such demand is curtailed (this may also be reflected in lower warranties to be deposited). An option would be to procure demand-response products either in its own system or in the system where the demand is located.

Following the nomenclature expressed in previous subsections, if the operator of system B wants to avoid the transmission right compensation for blocking exports and causing the curtailment of the demand in system A, it could procure demand-response capacity in its system until it covers the interconnection capacity. Obviously, the system operator would be willing to contract demand-response only until the remuneration required for this service does not exceed the compensation to be paid in the framework of the transmission right. During scarcity conditions, it can curtail such demand and let the generation committed in the cross-border contract deliver on the other side of the interconnection, without blocking exports. Nonetheless, this solution may raise political problems. In fact, if the system operator curtail flows through the interconnection it is exactly because the population and government deems unacceptable that electricity is being exported while some domestic demand is left unserved. By contracting demand-response, the system operator can claim that the demand not being served had signed
an agreement and is receiving a corresponding remuneration, but this may not entirely solve the problem.

Another option, which involves even more institutional complexities, is that the operator of system B directly procures demand-response products in system A, where the demand in the bilateral contract associated to the transmission rights is located. In this case, during scarcity conditions in both systems, exports towards system A can be blocked, but the compensation can be avoided by curtailing the demand-response resource in system A and by using the available capacity to serve the demand holding cross-border contracts. This simple reasoning, however, entails many complexities. How much demand response must be procured in order to be sure that the compensation can be avoided? Which load can sell this service? In order to answer these questions, the operation procedures in system A must be known and it should be possible to create some sort of priority list, according to which loads are curtailed during shortages. Obviously, it would only make sense to procure demand response from loads which have a priority higher than the one assigned to the demand with cross-border contracts. Furthermore, the amount of demand response also depends on the severity of expected scarcity conditions. It is evident that in the case of an overall blackout affecting system A, no demand-response product can ensure that the demand holding cross-border contracts is served. In spite of these complexities (some of them unsolvable), it is still possible to foresee some kind of agreement among operators of systems A and B and some load in system A that minimises the probability of curtailments that involve the payment of the transmission right compensation.

The arrangements outlined in this subsection raise relevant questions regarding how these interventions fit with the regulated nature of the system operation activity. Is it within the “mandate” of a system operator to procure demand-response products in a neighbouring power system? Who pays for the compensation in case of curtailment or for the remuneration of the demand response? Should these costs be included as additional items of the system operator’s regulated remuneration? However, all these contradictory issues “bloom” from an original
contradiction, hidden in many network codes and operation procedures. In fact, whenever a system operator modifies the outcome of a properly designed electricity market (composed by both short-term and long-term markets) for non-technical reasons, it is already violating its “mandate”. Downstream market activities undertaken by the system operator may be incongruous, but they are only a result of this first undue intervention. This discussion is deepened in the next subsection.

**Binding agreements and enhanced institutional arrangements in the regional framework**

The attention so far has been focused on the compensation to be paid in case cross-border contract cannot be fulfilled due to the interruption of exports. However, the payment of a penalisation is only a second best. The first-best solution entails the actual fulfilment of the contract, with the system operator of the exporting country taking no measure that impedes the physical delivery of electricity to the demand. Even if a regulatory framework capable of achieving this first best is still far from being in place, gradual changes to the institutional arrangements governing the regional market could approach this ambitious goal.

In order to increase the confidence in the fulfilment of cross-border contracts, binding agreements must be signed by all the countries in the regional market, who should commit to permit the execution of cross-border contracts, guaranteeing for them the same treatment as national contracts, regardless of the supply conditions in their system. However, the experience from the European Union demonstrated how the existence of these binding agreements is a necessary but not a sufficient condition for the fulfilment of cross-border contracts. Network codes in force in each country must be modified accordingly. This shift represents a dramatic

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9 It must be remarked that if the frequency in the power grid starts decreasing because a load with no contractual coverage in the electricity market has not been disconnected, this does not represent a technical issue, because the decision of not disconnecting the load is a political one.
change of paradigm in the way national countries manage their security of supply, but it should be introduced pursuing the huge efficiency gain that a regional market entails.

On the same line of reasoning, the unfolding of cross-border contracts, and the consequent development of regional markets, also requires a redefinition of the role of the system operator. Even after power sector liberalisations, the system operator has often kept being considered as responsible for the security of supply, implying somehow the obligation to serve all the electricity demand in the system. However, in a regional market context, the national system operator should be only in charge of maintaining network parameters (frequency and voltage) within predefined limits, managing the grid in a way that allows, whenever possible, the execution of the commercial agreements signed in the wholesale electricity market. If national system operators are not relieved by the institutional obligation of serving the load connected to their network, they will always be forced to take measures that favour their domestic demand, thus jeopardising the effectiveness of the regional market.

4 CONCLUSIONS AND REGULATORY PROPOSALS

The full development of regional markets has been hampered, so far, by the presence of institutional barriers that lead the regional capacity expansion towards suboptimal solutions, either because of an inefficient definition of transmission tariffs or due to a mistrust of the firmness of cross-borders contracts that eliminates the possibility to base the future security of supply on cross-border investments. The lack of commitment in this direction results in each country installing enough local generation capacity to meet the domestic demand, minimising the savings derived from regional integration.

In order to avoid this scenario of national electricity autarkies, encompassed in a regional market just for short-term left-overs, this article has first identified the main barriers to the development of firm cross-border contracts and has presented proposals to mitigate their impact. The main recommendations are summarised in these conclusions.
• Regional transmission tariffs must be calculated in a way that fosters cross-border trades (e.g., avoiding pancaking) and should be defined on a long-term basis, in order to reduce the risk when signing a long-term cross-border agreement.

• Transmission rights (either physical or financial) represent an essential hedge against price differentials for agents willing to trade electricity cross-border and they must be made available in the market. Congestion rents should be assigned competitively, on a long-term basis, and in a coordinated way for the different frontiers encompassed by the regional market.

• If cross-border contracts cannot be fulfilled because a system operator, in a context of regional scarcity conditions, decides to block exports in order to prioritise its domestic demand, the demand covered by the contract must receive compensation. This compensation, whose payment represents a risk completely unmanageable for both parties involved in the agreement, must be paid by the agent actually responsible for the interruption, i.e., the system operator (or the regulator/government behind it), and should be associated to the transmission right.

• One alternative to enforce the compensation scheme would be to design specific warranties to be deposited by each country (through the system operator). Such warranties, as explained in the article, must be proportional to the probability of occurrence of concurrent scarcity conditions in the neighbouring countries and to their expected duration, and inversely proportional to the price caps active in the market or markets (the higher the price cap, the lower the warranty). The problem linked to this alternative is that in contexts characterised by scarcity conditions that, once occurred, may last for months (as it could be the case of hydro-dominated systems), such warranties could be so high that the entire mechanism may become in fact infeasible. In these contexts, alternative measures (although not fully efficient), discussed in this paper, should be explored.
• The presence of such a designed compensation/warranties scheme is supposed to improve the commitment to the fulfilment of cross-border contracts by system operators, reducing the probability of exports interruption, which is the actual first-best solution (indeed the only good one) pursued by this measure. Furthermore, it should also represent an incentive to manage regional scarcity conditions in a more coordinated way.

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6 REFERENCES


The unfolding of regional electricity markets: Measures to improve the firmness of cross-border trading


