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CAPACITY MECHANISMS AND CROSS-BORDER PARTICIPATION:
THE EU WIDE APPROACH IN QUESTION[1]

Dominique FINON

July, 2014

SUMMARY

A capacity remuneration mechanism (CRM) which excludes cross border participants is considered to have serious distortive effects on long term competition, compared to explicit cross border participation (CBP), on the grounds that it doesn't capture the advantages of multi-system competition. This paper examines the reality of these advantages by distinguishing situations with and without congestion between systems during critical periods because congestion separates markets and their collective goods of reliability and adequacy for each system, and suppresses any economic and physical relevance of a capacity commitment from a new external participant to a CRM. From the limited perspective of any single system, there are two potential advantages of explicit CBP: the first is the supplement of the set of committed capacities to a CRM; the second is the lower cost of the adequacy policy of the system, thanks to enlarged competition, but it is illusory because the clearing price of capacity is the same with and without explicit CBP. Moreover concretization of such benefits for the system is not possible when there is congestion.

From the EU wide perspective, we identify some potential gains of social efficiency from explicit CBP at the multi-system level, when we have systems with a long standing situation of overcapacity beside systems with tight situations during their critical periods; or when there exists projects of hydro equipment (pumping storage, etc... But again, congestion removes any sense to any additional revenue to them. In any case erratic revenues certainly do not steer new investment towards either system. Furthermore exchanges of capacity rights between systems equipped with different CRMs introduce a supplement of distortions compared to the same situation with implicit CPB and no trade of capacity rights. It is problematic in the case of congestion; this delays the price signal of capacity scarcity in the system with the least attractive CRM in terms of revenue and risk management.

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1. INTRODUCTION

The promotion of generation adequacy by the introduction of a capacity mechanism in the different member-states' electricity markets is under narrow scrutiny by the European Commission. Beyond the discussion of the compliance of each capacity remuneration mechanism (CRM) with the requirements of the Electricity directive in terms of Public Service Obligation and the compliance with the State Aid art 107 of the Treaty on the public intervention (EC, Guidelines on state aid,

[1] We are grateful to Charles Verhaeghe (from Compass-Lexecon and former Cross border exchange expert in an energy regulatory authority), for his comments and advices on a first version of this paper.

2014)[2], an important part of the debate is focused on cross-border participation with bilateral exchanges of capacity rights between systems.

This is often considered as the solution that is the most consistent with the improvement of integration of the successive energy markets (forward, day ahead, transmission rights, intraday, balancing) up through real time. The document on Guidelines states that: *« [Capacity] mechanisms should be open to any capacity, including capacity located in other member states, which can effectively contribute to meeting the required adequacy standard and security of supply » (EC, 2014).* The E.C. document accompanying the communication of the Commission on "Generation Adequacy in the Internal Market" (E.C., 2013) considers in this way that "*a mechanism which excludes cross border participants could result in new generation capacity displacing imports. This would undermine the financial viability of generation in other member states and could have a negative impact on regional security of supply"* (p.28). This position on cross-border trade of capacity rights is backed by an interpretation of Article 4.3 in the 2006 SoS Directive: *"Member States shall not discriminate between cross-border contracts and national contracts"*, which refers itself to the provision of free trade of the European Treaty. The economic rationale of this position is that, in the internal electricity markets, both domestic and non-domestic capacities contribute to delivering "reliability" (the short term security of supply) and " capacity adequacy" (the long term guarantee of supply reliability), while the high degree of interdependency will be improved by further integration.

In economic terms, the collective goods "reliability" and "adequacy", which are specific to each system, are in fact so interdependent with those of the other systems that they compose collective goods which are common to these systems. Accordingly these multi-systems common goods should ideally be managed by integrated energy markets and by a shared capacity mechanism with eventual bidding zones. If it is not possible to implement a single CRM, then harmonized CRMs with exchanges of capacity rights are the next best alternative, which means that each mechanism should be open to capacity located in other member-states. If it is not possible to get similar CRMs, cross-border exchange of capacity rights is assumed to still be socially efficient despite the heterogeneity of the different capacity rights, provided that external generators which contract in another system CRM are able to offer exactly the same capacity products, and opt out from their home CRM when it exists.

This EU-wide perspective can be interpreted in the following way: A true EU- wide approach to reliability and adequacy requires reliance of any system A on any generation capacity located in another system B that has been forward committed to provide guarantee of supply in system A during critical periods of the later. This reliance on bilateral capacity contracts is defeated if the TSO of B may call back the reliability rights forward committed by generators of B in capacity contracts with A during system B's critical periods, eventually synchronous with critical periods of A. Obviously a problem with cross border trade of energy and reliability rights emanating from cross border trade of capacity rights arises when both systems have the same critical period, since only then the contracted capacities in system B cannot be replaced by anything else for the supply reliability of B. In another words, whatever the effort made in his system to reach a precautionary adequacy target, each TSO gives up any control over the long term security of his system (the capacity adequacy),

[2] Following principles of the guidelines to be applied to the CRMs**:** Contribution to a well-defined objective of common interest. Need for State intervention to be demonstrated. Appropriateness of the aid measure. Incentive effect (The aid should not change the behaviour of the market players).Proportionality of the aid (aid to the minimum). Avoidance of major undue negative effects on competition and trade between Member States. (Operators from other member states should be allowed to participate where it is physically possible; no interference on the integrated energy market, etc.).

because in the infra-day and real time frames, he should mutualize all the reliability rights of its system with the ones of the other systems, even if the adequacy target of the latter is much less precautionary. Nevertheless national laws establishes the principle of joint responsibility of the TSOs and regulators in matter of security of supply, principle which is completely in line with the principle of subsidiarity, which remains underlined in the 2006 Directive SoS, whatever the art. 4.3 of the directive, which invites to a second thought on this issue.[3]

Moreover this position does not dissociate situations where there is no transmission constraint between systems during scarcity periods from situations where there is a high probability of congestion during these periods. The collective good of adequacy is proper to each system in this situation, which makes it really problematic to treat cross-border participation in a bilateral and commercial way. During moments of congestion during critical periods, as we argue below, no specific generator from B having bilaterally contracted his capacity with the other system A, and not in the CRM of B, can be considered as having contributed more to the supply reliability of A rather than the other generators in B. It is the system B which globally contributes to the reliability of the system A in a statistical way; it is not the sum of energy flows coming from the generators of B which have committed on the CRM of A to be reliable at the delivery date.

The approach of calculating probabilistic contributions of imports to the generation adequacy standards -- which means implicit cross-border participation with no trade of capacity rights --, makes sense in physical and economic terms when there is congestion while explicit cross border participation doesn't make physical or economic sense. However the EU-wide adequacy approach to this explicit cross-border participation issue, which doesn't make sense in the case of congestion between systems, is frequently opposed by the majority of electricity market experts, transmission system operators (TSO) and regulators (ENTSO-E, 2013; ACER, 2013; ERGEG, 2013). This implicit cross-border participation approach is wrongly viewed as conservative and uneconomic, while it is the approach of worshipping market trade for any product related to electricity in any situation (among which situation of congestion) which has no economic sense. Efficient market coupling combined with implicit CBP should bring the supposed advantages of explicit CPB when proponents forget congestion.

In the following pages, we choose to focus on the physical and economic fundamentals of bilateral trading of capacity rights to discuss arguments for and against explicit cross-border participation (CBP) by comparing it to implicit cross-border participation, in three steps.[4] In section 2 we discuss the physical and economic relevance of economic cross border participation and point out the difficulties in trading capacity rights between systems that are inherent to the nature of this product, in particular when there are chances of congestion on interconnections between systems.

In sections 3 and 4 we analyze in two steps the social benefits that trade on capacity rights would bring. First we analyze the efficiency of cross border participation from the perspective of an individual system, provided that the external generators are able to supply the same capacity product as the internal one in the local CRM. Second the analysis is developed at the EU level where

[3] Art 3.1. "Member States shall ensure a high level of security of electricity supply by taking the necessary measures to facilitate a stable investment climate and by defining the roles and responsibilities of competent authorities (…)". By the way, the article 4.3 does not define at all what is concerned by the term 'trade', and in particular if it includes the very abstract "capacity product" which is only a promise to be present in the system and to be reliable at the delivery date.

[4] We present the concepts of capacity rights and reliability rights in Box 1, and we describe in the appendix the main traits of the five CRMs which are currently developed.

some social welfare improvements are identifiable. When the energy markets are fully integrated, exchanges of capacity rights bring economic gains in temporary situations of overcapacities in some systems, and in random situations of time-lag between respective critical periods of two systems when the systems are physically integrated.

For the simplification of the argument, we present the concept of capacity rights (named also capacity products) and reliability rights in appendix 1, and the different CRMs in the appendix 2. In the following pages, we also make two important hypotheses to simplify discussion. First we refer to the CRM which creates the clearer capacity rights to be exchanged between CRMs, namely the forward capacity contracts auctioning (known as the forward capacity market or FCM) and the bilateral obligation (BO) as the one currently implemented in France, when we do not consider the problem raised by the adoption of a variety of CRMs. We also consider that capacity product to be exchanged presents credible guarantee for the external capacity to be reliable during critical periods of the imported system, which is not always the case for windpower capacity crediting, and demand side response products. Second we suppose that TSOs and regulators have adopted common criteria of adequacy, for instance for this later the Loss of Load Expectations (LOLE), with the same target of LOLE, in order to avoid the issue of free riding.[5] We suppose also that, if they do not adopt explicit CBP, every TSO will take into account the statistical contribution of their neighboring systems to their own capacity adequacy[6].

2. RELEVANCE OF EXPLICIT CROSS-BORDER PARTICIPATION

Promoters of cross-border capacity rights trading defend the principle of free exchanges whatever the situation. They suppose that the contributions of these systems to adequacy of the other one would be individualized by external candidates. The trading of capacity rights supposes as relevant the extension of the supply of the collective good “adequacy” to every external generator in other systems, whatever the constraints on the interconnection capacities between them. We shall show first that the problem of relevance is different when there is no congestion on the interconnections between systems during their critical periods, than when there is congestion, and second that the market coupling insures the optimization of energy flows from system with a less critical scarcity situation to system with a more critical situation, guaranteeing that the interconnector was consistently congested.

2.1 Relevance of capacity rights trade in explicit cross-border participation

Let us consider two systems between which there could be explicit cross-border participation. To individualize the contributions of generators of system A to the adequacy of system B has a physical equivalence: these generators isolate themselves from their system A and use a dedicated interconnection line to transport their energy to the neighboring one during its scarcity periods. Of course the technical reality is different. But electricity market designs are familiar with de-connection of physical flows and commercial transactions.

[5] The subjacent assumption is that each system works similarly to its security of supply and doesn’t seek to benefit from the efforts of others. So, in the same line we have to suppose also that there is a similar price cap in the different wholesale markets to make the CRMs having a similar role of compensation of missing money resulting from the respective price caps.

[6] We pose this hypothesis because presently a number of TS0s do not take into account import contribution when they estimate the need of reserve margin for their system and establish their adequacy target. It is the case in Belgium, Italy, and Spain in particular.

Trade of capacity rights between them requires narrow cooperation between TSOs to make certifiable ex ante the external generators for the count of the concerned TSO, as well as to control ex post their availability during the critical period of this system. In the auctioning of forward capacity contracts (the FCM), the whole relation relies on a set of special contracts, the first between external generators with their TSO, the second with the interconnectors' owner, and the third between the two TSOs which organize their narrow cooperation. This cooperation of TSOs should organize the management of the collective good "adequacy" common to the two fully integrated systems, when there is no congestion from one system to the other during the critical period of the latter.

But the relevance of such arrangements is questionable when there is congestion on the interconnections from A to B during the critical period of the system B while these arrangements are relevant when there is no congestion during critical periods. In the case of congestion, the collective goods of adequacy and reliability are unique to each system. As pointed out by Cramton et al. (2013), if energy markets are not fully integrated, such that transmission constraints bind imports during periods of scarcity in one of the two systems, reliability in the stressed system becomes a private good specific to this system. Likewise, in this case, capacity adequacy is not a common good at the multi-system level as soon as there is a risk of congestion on the interconnections going to this system. With forward capacity rights, this holds in particular at the horizon of the delivery date.

In such situations of congestion on interconnections, generators of system A who are candidates in the CRM of system B would benefit from undue payments because it is not demonstrable that their energy injected in their home system has been exported to system B among the exported power flows restricted by the congested interconnection capacity. On the other hand, when there is no congestion, this problem does not arise, because all external generators which receive a capacity payment from the auctioning in system B and which produce and clear on the coupled power markets (during critical periods of B, they commit to do it by selling forward capacity rights) can be considered as effectively exporting their energy related to the capacity rights.

In another words, any external participant to the CRM of B cannot be considered to participate to the offer of the collective goods of B by improving the security of supply of system B at the delivery date when there is congestion on the interconnection from A to B. To be clear, when there is congestion, the two energy markets of course still interact de facto. There is energy and reliability rights trade from the less stressed system A to the more stressed system B which has the highest clearing price. If there is an effective contribution of the first one to the reliability of the second one in statistical term. But in marginalist term, no new external contributor could be considered as contributing to the system B's reliability. The marginal contributions could only come from contributors in the system B. This explains the separation of reliability in two goods own to each system, as well as adequacy.

The principle of explicit cross-border participation in case of congestion is then advocated by putting an obligation on exporters of firm reservation of access rights on the interconnector capacity. This implicitly refers to the fiction of the traceability of the import energy flows from external generators committed in capacity contracts with the CRM of B. With traceability, the reservation should logically be needed because interconnection capacity is restricted and has to be shared in critical periods of system B between "normal" imported energy transactions not linked to a cross-border capacity contracts, and sales of external generators committed by capacity contracts to send energy and reliability rights to the system B during its critical period. The commitment of the capacity rights exports from system A should only be valid with this firm reservation. The TSO of system B should be sure that the reliability rights of the external generators committed in its CRM can be mobilized for its system during critical periods.[7]

[7] Another way to organize the credibility of commitment of external generators could be reservation of part of interconnections capacity for external generators' energy commitment. the units of system A committed in

2.2 *Market coupling against the fiction of traceability*

But, market coupling, which groups the energy markets of A and B and covers day-ahead markets and infra-day markets, calls into question the firm booking of access rights, and doesn't guarantee at all that the energy bid price of the units of A committed in the neighboring CRM of B will be sufficiently competitive to be selected. In fact it implicitly denies the fiction of traceability of electricity when systems are separated by congestion.
To comfort the transferability of capacity rights from a generator of system A to the CRM of B, the logic would impose firm reservation of the corresponding interconnection capacity for the delivery periods. But the day-ahead implicit auction of access rights in the market coupling, which shares these rights in the most efficient way when there is congestion, appears *a priori* to oppose this logic. The recent rules of the Target Model related to market coupling include a "use-it-or-lose-it" requirement that interconnector capacity reserved in the forward markets be offered into the implicit auction, unless a flow is nominated. As bids into a capacity would normally be backed by firm interconnector capacity, the need to offer up this capacity at the day-ahead stage appears to invalidate such bids.

But Baker and Gottstein (2011) argue that « *under certain conditions, it could have certain usefulness. External generators selected in a neighboring capacity auction would typically be required to offer that capacity at the day-ahead scheduling stage and to maintain availability until some nominated point in time before delivery. If the generation in receipt of capacity payments does not clear the day-ahead auction, it would be available into the intra-day stage to provide capacity or balancing services, despite having given up its reserved interconnector capacity. Moreover when the external generation in receipt of capacity payments is displaced at the day-ahead stage, then the replacement generation will provide the equivalent capacity across the interconnector. Effectively, the capacity payments would be an "insurance policy" to ensure that the interconnector capability is backed by adequate external generation capacity ».* But do we need it, even in the crucial case of congestion on the interconnections between the two systems?

Indeed market coupling of the day ahead markets and infra-day markets guarantees that the interconnector capacity was fully and consistently utilized due to market price differentials, i.e. the interconnector was consistently congested. So insurance by contracting capacity contracts with external generators becomes unnecessary and capacity payments to external generation are unjustified. The flows of energy and reliability rights from A to B during the critical period of the latter will be guaranteed by the market game, when a price differential reflects higher scarcity in B. Moreover the logic of market coupling could exclude partly or completely an external generator which receives a capacity payment, from the selection of commercial flows from one system to the other one. This takes place when this generator is not called by the market coupling, or is only partly called. So the conclusion is quite clear: when market coupling organizes in an anonymous way the commercial exchanges of energy and reliability rights inside each system and between systems, any forward commitment of an external generator in the neighboring CRM is superfluous to the reliability in the neighboring system.

In market architectures without market coupling between systems as it is between regional markets with CRMs in the USA (for instance between the MIS0 and the PJM ISO), there is not such an optimization of interconnectors capacity. Transmission rights are allocated by auctioning and the fact

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CRM contracts with the other system B have a priority of access considered by the market coupling software, as if they implicitly have a share in the interconnections, provided that have bought forward transmission rights. But it reduces the potential of competition of energy vendors of the system B to the system A in the market coupling. Moreover it challenges the principles of the market coupling software by giving priority to energy sales of external generators committed in capacity contracts over the other sales of external generators.

is that energy exchanges between systems with different situations of capacity and reserve margin should be more developed during respective critical periods with market coupling. Capacity rights sales combined with firm capacity reservation which allocated by auctioning up to total interconnection capacity could be a way to use efficiently the interconnections at the delivery date during respective critical periods.

To compare, implicit cross-border participation is relevant in any situation of the interconnections during critical periods, with or without market coupling. The contribution of the other systems to the supply reliability of each one, including congested capacities between systems, is taken into account statistically, no matter that we can't identify from whom the reliability rights would come from other neighboring systems. This contribution is taken into account in the calculation of outage probability and the reserve margin target for the whole system. Evaluation of mutual contributions will be done, following the common methods and rules chosen by the transmission systems operators (TSO) and their European association, ENTSO-E, to assess the contribution of the foreign systems ENTSO-E, 2012; Staschus, 2013).

3. SOCIAL EFFICIENCY OF CROSS-BORDER PARTICIPATION FROM THE INDIVIDUAL SYSTEM PERSPECTIVE

Whatever it may be, let us allow in this section the transferability of capacity rights in situations with congestion, in the same way as when they are transferable without congestion. What could be the benefits of explicit cross-border participation for an individual system?

A priori institutional conditions to have explicit cross-border participation on an equal footing are simple: the external generator should offer a capacity product which contains the same services as the capacity product coming from an internal generator (guarantee of reliability and energy sale during critical periods, penalties, rules of certification and ex post checking, etc.). The only condition would be that the external generator should opt out from any commitment in its local CRM in order to avoid double capacity remuneration.[8] That means also that, in situations of congestion, capacity rights are transferable thanks to firm reservation on the interconnection.

From this simple perspective, we identify "on paper" some possible advantages to opening a CRM to imported capacity rights: the first one is the supplement of forward committed capacities to this CRM coming from external generators; the second one is the lower cost of adequacy policy by the contribution of lower pricing . But these benefits appear difficult to materialize, or illusory.

3.1 The supplement of committed capacities to an adequacy

The first advantage is the supplement of committed capacities to a CRM coming from external generators. Indeed the TSO of the importing system (we call it again system B) opens the auctioning to every generator of system A, as well as the internal generators to reach its target of capacity adequacy: total load + reserve margin. So the number of generators of A which are selected by the CRM of B guarantee offers of energy and reliability rights to system B during its critical period. The advantage for the TSO of B comes from the fact that it adds some guarantee during critical hours of its system.

However this advantage disappears in situation of congestion on the interconnection from A to B. The reason is the same as already mentioned: the impossibility to dissociate an external generator

[8] By the way it could be possible to avoid an explicit opting out, if the respective critical periods of its system and the neighboring one on which he applies for a forward capacity contract are completely offset from each other.

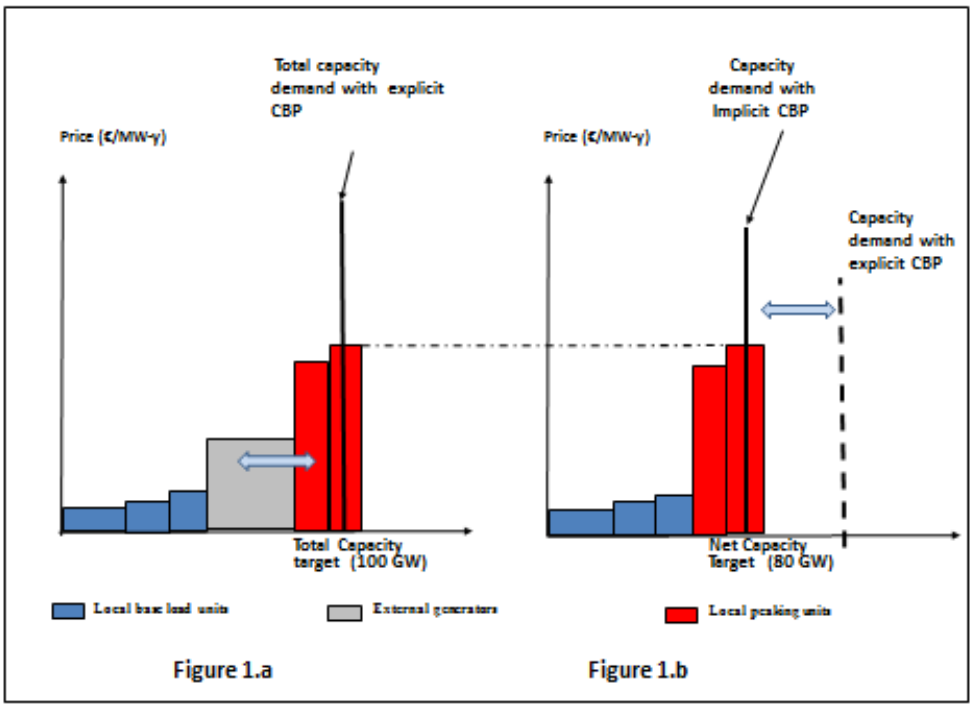
receiving capacity payment from the CRM of B and to certify that his injections of energy are the ones that moved to B during critical periods or else to be sure that this generator would not be displaced by market coupling. Even if an external generator is supposed to offer the same capacity product as an internal generator does, and this product to respect the same standard of supply reliability inside system B, congestion on interconnections during critical period of B makes impossible the equivalence of capacity products between external and internal generators. Even if we use the fictitious guarantee of transfer by firm reservation of access, and make external generator pay for it, this does not increase at all the guarantee of system B's supply reliability.

So this first advantage only holds when systems and energy markets are fully integrated without congestion between them. But the least to say is that this advantage is captured by the implicit cross-border participation when the market coupling software organizes the full integration of energy markets.

3.2 Lowering the cost of adequacy policy

A priori, if there exist efficient generators in system A, one can easily imagine that, whatever their incentives to apply to their local CRM, those who prefer to apply to the CRM of B would decrease its clearing price, if we compare to a situation with implicit cross border participation and without trade of capacity rights. Moreover the internal generators would reduce their bid price, under the pressure of these external competitors. One should incline to consider that, by this way the cost of adequacy policy of system B will be reduced for its consumers.

Figure 1. Comparison of capacity market equilibrium with explicit and implicit cross-border participation



But the fact that other generators can add their bids to those of internal generators does not change the clearing price of the CRM of B. It will not be lower than the price in the situation without trade and with implicit cross border participation in B. The simple reason is that the supply and demand

curves in situations with explicit CPB and those with implicit CPB are not the same. To show that, we take the example summed up in the figure 1. We suppose:

- That system B has an adequacy target of 100 GW (for an extreme peak load of 90 GW with a reserve margin of 11%),
- That the interconnection capacity is such that we estimate statistically the contribution of system A to the adequacy of system B to 20 GW.

The different steps of the merit order supply curve of capacity rights, described in the figures 1.a and 1.b, which represent respectively:

- The situation with implicit CPB with a demand of 100 GW and a supply curve including import of low-cost capacity rights of 20 GW;
- The situation with implicit CPB with a demand of 80 GW of capacity rights only, and an offer not including import of capacity rights.

We observe that at the market equilibrium, the demand curves which are vertical intersect the respective merit order supply curves on the same price step. In the second situation the vertical demand has been displaced by 20 GW on the right while the higher part of the merit orders curve has also been displaced by 20 GW. So for the producers in system B, the clearing price will be the same. But the cost of the adequacy policy for the consumers will be higher because the external generators have to be paid while they do not displace internal generators.

To conclude capacity price is identical and there is no advantage to enlarge market paying field to external generators in this respect. As a consequence, given that consumers of the system of CRM have not to pay external contributors, the cost of the adequacy policy in their system is lower than the same policy with explicit cross border participation.

However practitioners are incline to anticipate some difference between the TSO's estimation of the statistical contribution of other systems in the implicit CBP and the total of capacity rights which will come from external contributors in the explicit CBP. Indeed any TSO tends to be conservative in his approach of external contributions and at the end of the day, with an explicit CBP, the total capacity of selected external generators could be higher than the statistical contribution estimated by the TSO.

4. SOCIAL EFFICIENCY OF CROSS-BORDER PARTICIPATIONS AT THE EU LEVEL

An approach by individual system only considers the interest of one system. We have only to suppose that an external generator to a system B is able to offer a capacity product which is similar to the product requested from the internal generators of the system A. So, if we jump to the EU-wide level we observe that the individual system approach ignores two issues of EU-wide social efficiency: first the eventual social cost of no trading of capacity rights and the social benefit of exchanges of capacity rights for the whole set of systems; second in case of adoption of different CRMs, the distortive effects that the external trading of different types of capacity rights causes. Concerning these two different issues, the case is again different if the systems are fully integrated, or if they are separate by congestion during their critical periods because exchanges have an economic sense in the first case. So we should analyze the issue of social efficiency in the two situations of the interconnection to the more stressed system -- non congested and congested.

4.1. The defence of implicit CBP

The European Commission assumed negative effects of implicit CBP and no capacity trading in its Document on "Generation Adequacy in the Internal Market" (E.C., 2013). It considers that "*a*

mechanism which excludes cross border participants could result in new generation capacity displacing imports. This would undermine the financial viability of generation in other member states and could have a negative impact on regional security of supply" (p.28).

The first criticism of the statistical contribution approach do not take into account the difference between a capacity market without import of capacity rights (implicit CBP) and a capacity market with imports (explicit CBP). We have seen in section 3 that if there is explicit CBP, the demand of capacity rights in the CRM covers the whole adequacy target. If there is only implicit CBP, the demand of capacity rights only consists in the net demand after subtraction of the external statistical contribution. So with implicit CBP, there is no displacement of imports by new internal generation capacity because the adequacy target is calculated by taking into account the external contribution by energy imports during scarcity periods. The difference is that no external generator gets revenue from the CRM of a neighboring system.

To answer to the second critics that the financial viability of newly built plants in systems A neighboring systems B with implicit CPB is impacted because they are excluded from the opportunity of revenues if CRMs would have existed, we can put forward three reasons.

- First eventual investors could gather capacity revenues from their local CRMs, when they exist.
- Second, capacity revenues from other CRMs with explicit CBP will be uncertain (as are those that can be expected from their local CRM) and certainly not sufficient to trigger investment decisions from external generators. In other words given that a CRM has as a first aim to incite investment in new capacities, it is not these occasional revenue differentials which will trigger investment decision in the neighboring systems.
- Third, the regional security of supply would not be altered by the preference of some systems to take into account the statistical contribution of the other systems rather than allowing bilateral cross-border transactions, because there is no lowered disincentive to invest in the external systems. Investment will be made in each system under the incentives of the revenues of the price spikes of the energy market and those of the forward annual capacity price of the local CRM, when the capacity becomes tight. Moreover the implicit CBP allows a more programmatic approach with much more chance to reach the standard of adequacy at the level of a national system than the EU-wide adequacy approach which is wrongly supposed to be more efficient because more market based.

In case of congestion on the interconnections from A to B, these three considerations on implicit CBP versus explicit CBP should be completed by the observation that any new capacities invested in A with the incentives of complementary revenues from the CRM of B do not contribute at all to the security of supply of B. The problem of capacity adequacy of B has to be solved with incentives which are internal to B.

4.2. Limited social benefits of explicit CBP when no congestion

Assuming first the most favorable situation where there is no congestion in times of scarcity between the two systems –this means that, as said, adequacy as well as reliability are the same collective goods for the two systems-- and where countries have the same criteria of adequacy, what could be the economic gains from trade of capacity rights compared to the case of implicit cross-border participation? Eventual social benefits of explicit CPB by comparison to implicit CPB could be envisaged: the postponement of closures in the systems in overcapacity and the competitive advantages of a system in developing peaking units (gas turbines, etc.), hydro plants (pumping storage, reservoirs "uprating") or Demand-Response programs.

We distinguish short term and long term benefits.

- **Short term gains**

Economic gains from trade of capacity rights will emerge in two short term situations. First we find advantages in situations of transitory overcapacity in one system A by comparison to the case of implicit CPB. Then, an exchange of forward capacity rights from A in overcapacity to B with a CRM which is in scarcity allows to postpone the construction of new reserve units in A, while it may provide some revenues to the equipment about to be closed in the system A in overcapacity, because their annual revenues are too small to cover their fixed operating costs (as we observe since 2012 in number of countries). They would not have such revenues with implicit CPB and no trade of capacity rights[9]. But we should not forget that these situations are temporary and could be shortened by private decisions to close some equipment, by intermittent RES-E capacity increases in A which create a new need for reserves, or by higher unanticipated economic growth.

Second, we could find advantages to trade in capacity rights if there is a "structural"de-correlation between two systems' randoms concerning their respective total loads and their intermittent renewables productions. At the multi-system level, such structural de-correlation leads to differences in the respective critical periods and this makes overcapacity regularly appear in one system A which makes it able to export energy with a significant degree of probability in the other de-correlated systems B during their critical periods up to the interconnection capacity, and vice versa if the latter ones has variable productions. There is a mutual exchange of services which could help to lower the need for reserves in each system. This benefit also exists with implicit CPB. So what will be the supplementary social gain of the explicit CBP, with variable generators of A to be remunerated up to their capacity credit by the CRM of B for their stochastic contribution to the security of supply (SoS) of B, as well as some other external generators of A?

This could play also indirectly by postpone closure of equipment in system A if this one has also a CRM because RES-E generators which are selected by the CRM of B have opted out from the CRM of A, which accordingly allow to select more capacities from local equipment. But there is a *de facto* limitation because renewables electricity production is variable. So the advantage of trading forward capacity rights among systems related to their respective scarcity periods is fleeting, which explains the limitation of capacity credits attributed to variable RES-E production from external generators located in A. Moreover the TSO of B will probably be very conservative in the attribution of capacity credit to the variable RES-E generators of A, because system B could be confront to the risk of very low RES-E production in the system A during its critical period.

- **Long term economic gains**

Economic gains will emerge also in the perspective of long run market equilibrium, the only one that in fact really matters for a capacity mechanism when new capacity development is at stake in some systems.

There could be long standing gains from trade in situations where one country A is endowed of hydro resources or could be much more efficient in building new peaking units (among which endowed hydro resources not yet developed) or in developing larger demand response programs than in the neighboring countries. So in this country A, whatever anticipated situations of system adequacy and eventual establishment of a home CRM, generators can decide to build such units to sell capacity

9 Notice that the capacity revenues for this older and less efficient equipment of A could come from the CRM of B as well the CRM of A. Indeed, if they do not manage to bid efficiently on the CRM of B than more recent generation units of A, they will replace these latter ones on the local CRM of A, given that those units of A which have been selected on the CRM of B should have opted out from the CRM of A.

rights to external CRMs with the possibility to compare anticipation of capacity revenues from home CRM and external CRMs.

But this hypothesis of competitive advantages on peaking unit construction costs is not realistic because these techniques (e.g. combustion turbine) are standardized technologies with the same cost from one country to another.[10] And there could even be cases where investors would do better to build peaking units in the neighboring country to avoid transmission cost.

Another case of long standing advantage is the possibility to increase incentives to invest in "peaking" hydro plants in neighboring countries. It concerns neighboring ones endowed with sites allowing development of new pumping storage equipment or uprating of hydro reservoirs. These technological opportunities are dedicated both to answer to flexibility and forward capacity needs. But the present experience shows that prospects of revenues by flexibility services (based on arbitrage in energy markets) are fleeting. Indeed under the effect of large scale PV generation of the reduction of spreads of day to night prices deters investment in such equipment in the neighboring regions

A final remark to reduce a bit more the scope of this supposed advantage is that a CRM of any system is unable to give long run visibility to capacity revenues in order to limit risks of investing in new capacities, in particular those to be located in other systems with or without CRMs.

To sum up, if we compare explicit CPB to implicit CPB, there is no stable short term or long term competitive advantage in the trading of capacity rights, only casual advantages due to overcapacities here and there. As the main finality of a CRM is to correct the market failure in the matter of investment in new capacities, it is necessary to keep in mind that short term benefits of trading capacity rights should be balanced with the longer term cost of having underinvested in the systems without overcapacity. Indeed there is some chance to make congestion appear on interconnection, because of increased energy flows coming from system A in overcapacity to system B during its critical period.

So the potential advantages of allocating capacity revenues to external generators in situations of no congestion during respective critical periods are not conclusive. It will then be underlined that improvement of market integration has much higher positive effects than capacity rights trading.

4.3. *Explicit CPB vs CPB in case of congestion*

The discussion above holds only if there is no congestion between systems during their critical periods at the delivery date. Consider the case of two systems: if congestion exists or might appear between them during their critical periods, adequacy is no longer a common good, but should be seen as two separate goods. So, trade of capacity rights is problematic if there is a risk of congestion. On one side it could help to postpone closure of equipment in system A in overcapacity from revenues coming from the CRM of B which is in stress. But on the other hand this does not help to increase capacity in B because generators external to B have captured part of the capacity revenues of the CRM of B, because their bids also lower the capacity price on this CRM and consequently

[10] We could consider the particular case with hydro-dominant countries with seasonal or weekly storage capacities (Austria, Switzerland for Germany and now Norway for The Netherlands, Germany and possibly for the UK), but these assets already exist and there is not a stake of new developments. In this case exchange of capacity rights from these systems to other systems would depend on the existence of water inflows over the statistical average in the dam during peak periods. But this does not allow firmness of forward commitments with the neighboring systems.

internal generators have not invested enough. With implicit cross border participation in this case of congestion, internal generators have clearer incentives to invest because capacity price is higher, given that they are not exposed to the competition of existing generators of A.

Another problem already mentioned is that nothing guarantees that energy exports from A to B during critical periods correspond to the units committed in the CRM of B, during the critical period of B when there is congestion. It is an undue surplus for them, which is paid by the consumers of B. It is both an issue of efficiency and an issue of equity for the two systems.

4.4. Distortive effects of cross-border trade with different CRMs[11]

There are many reasons to anticipate a proliferation of disparate capacity mechanisms with differences in their attractiveness for investors in the different electricity systems. For that, all things being equal (in the same situation of capacity scarcity of each system), the most attractive CRM would offer more transparency (for instance the FCM compared to the bilateral obligation), more revenue stability from one year to the next one, or more revenue per MW-month. This will *de facto* install competition between systems to attract investors in peaking units as the fiscal competition plays between member-states to attract foreign firms.

- **Comparison of implicit and explicit CBP without congestion.**

Let us consider the case of implicit CBP between two systems, X with the most profitable CRM and Y with the least profitable one. The differences in adequacy approaches only alter the long term optimum of each individual system considered as if they were separate. Indeed X attracts the peaking unit investment, and consequently will sell more and more energy to Y during its critical period. It is not problematic until congestion emerges on the interconnection from X to Y. After establishment of the congestion, the markets will no longer be fully integrated. System Y will have to suffer higher energy prices and accept some outages during its critical period after the congestion occurs, during the time it takes for investors to install peaking units.[12]
A multi-system with identical CRMs would maintain full integration of markets and would not experience de-optimization of its systems, with the social costs of some loss of load in countries with the least attractive CRMs, after a first period of full market integration. Allowing cross-border trade of capacity products adds a new dimension in the competition between electricity systems to attract investment in new capacity for the objective of adequacy : they need to get sufficient capacity rights to reach their adequacy target at least cost, not only from attracting more investors to install new capacities at home, but also by getting part of them from lower external bidders to their respective CRMs. Explicit cross-border participation amplifies the economic distortions that result from the adoption of different CRMs in neighboring systems versus implicit CBP. As far as capacity adequacy is concerned, and because there is no congestion from one system to another during the critical period of the latter, there is no problem accordingly to adequacy of the integration of systems.

[11] In this sub-section we refer to different capacity remuneration mechanisms which are characterized in the appendix while up to now we only referred to the auctioning of forward capacity contracts, or else the bilateral obligation which both clarify the property rights on capacity in the most relevant way.

[12] There is also a distributional issue between a system X with a CRM which does not substract scarcity rent energy price spikes like the FCM and the BO, and a system Y with a CRM which avoids paying scarcity rents to generators, like the reliability options mechanism. Logically, generators of system Y will be attracted by the CRM of X, and the consumers in system X will pay more for capacities installed in Y than consumers in system Y will pay for other internal capacities.

- **Comparison of implicit and explicit CBP when congestion between systems**

Let us put apart the economic rationale of capacity right exchanges between two systems
If there are congestions on interconnections between systems (or if it will happen in the near future), again investment in peaking units goes to systems where the CRM is the most profitable (system X), all things being equal. Let us suppose that system Y is stressed in terms of capacity. Fortunately, congestion will play to encourage investment in the most stressed system by the dis-alignment of prices in the two energy markets during the critical periods of the stressed system Y and by the increase of the capacity price of its CRM. So the scarcity rents will be more important, while the capacity revenue from this CRM is attractive. Both will trigger decisions of investment in new capacities until the sub-capacity of system Y is corrected. But on this point there is a difference between implicit CPB and explicit CPB. The difference comes from the fact that explicit CBP creates a difference of attractiveness of CRMs not only for investors, but also for any generators external to the system with the most attractive CRM, all things being equal.

When system Y with the less attractive CRM is closer to scarcity than X, that means that, at a given moment, because the capacity price will increase in the CRM of Y, the generators of X will begin to be attracted by the CRM of Y rather than by their usually more favorable CRM, as well as the generators of Y usually also attracted by the CRM of X and preferring to opt out from their home CRM. Up to now nothing is anomalous. But the problem comes from the fact that this switch occurs at a capacity price level of Y which is lower than the one that would be seen if the CRMs were identical, and with a delay. Generators of Y stay too long on capacity sales to the CRM of X because the price of the CRM of Y starts to increase from a lower level than it would be if the CRM of Y was identical to the CRM of X. This will also deter investors in Y from ordering new equipment during a time longer that it would have with implicit CPB.

4.5. Efficient combination of market coupling and implicit CPB

In fact efficient market coupling combined with implicit cross border participation should bring the advantages that proponents of explicit CPB seek without taking into account all the benefits of the market coupling. Better integration of day-ahead, intraday and balancing markets mutually reinforces the reliability in each system, and beyond the long term supply reliability insurance. In case of congestion, market coupling guarantees the maximization of benefits of energy and reliability rights trade between the systems, provided that the interconnector capacity is fully and consistently utilized, due to market price differentials.

Pooling the flexibility resources via the extension of balancing zones and the better integration of intraday markets, should indeed moderate the expense of new back up of large scale wind and solar productions. The more the area of reliability rights is important, the less the balancing need of each system will need internal adjustment and operating reserves services and – as an effect on capacity adequacy – the less reserve margins for the long term supply security are needed, provided that interconnection capacities are there. So the issue of increasing liquidity and integration of energy markets is of prime importance and, when addressed, this issue reduces the stake of capacity rights trading and explicit CPB.

5. CONCLUSION

This paper has examined the reality of the advantages of explicit CPB and drawbacks of implicit CBP by distinguishing situations without congestion between systems from situation with congestion during critical periods. The EU-wide approach of explicit CBP does not present the social welfare

benefits from trade in capacity rights and from the deepening of the competition on each respective CRM that the critics of implicit CBP attribute to it. A capacity remuneration mechanism which excludes cross border participants has no distortive effect on long term competition and no significant lowering of efficiency gains, compared to explicit cross border participation, even when electricity markets are technically and economically integrated during their respective critical periods .In any case congestion on the interconnection during these periods suppress any eventual advantage of explicit CBP.

In situations with no congestion, from the perspective of any single system, there would not be a lower price of the adequacy policy of the system, thanks to enlarged competition, but this is illusory because the clearing price of capacity is the same with and without explicit CBP, while the consumers would not have to pay capacity payments to external generators. From the EU wide perspective now, we identify some social efficiency gains from explicit cross border participation at the multi-system level, when there is a system with a long standing situation of overcapacity, or when opportunities of new hydro equipment development (pumping storage, reservoirs) exist in some systems neighboring those with tight situations during their critical periods. It could avoid closure of equipment which could contribute to the reliability of each system, and could help to trigger investment decisions inn theses hydro projects. But, as said, investment decisions are very difficult to establish on quite sound anticipations of revenues by capacity payments on the neighboring CRM, in addition to energy and flexibility service revenues. In any case it certainly doesn't steer new investment in peaking units in the other systems. Furthermore exchanges of capacity rights between systems equipped with different CRMs introduce a supplement of distortions compared to the same situation but with implicit CPB and no trading of capacity rights. In case of congestion, this delays the price signal of capacity scarcity in the system with the least attractive CRM in terms of revenue and risk management.

In situations with congestion, the search of social benefits of explicit CBP compared to implicit CBP is simply unnecessary. To organize trade of capacity rights rather than taking into account statistical contribution of neighboring systems A to the system B's adequacy has no economic sense because any new external generator from systems A would not improve the security of supply of the system B. So it would be with new postponing of closure of equipment or triggering investment in new units in the other systems via capacity revenues from B. Moreover if CRMs are different, explicit CBP in situation with congestion during critical periods would add a problem of investment deferral in the system with the least incentivizing CRM.

To conclude external contribution of other systems to the adequacy of one system cannot be managed by bilateral forward capacity transactions between systems because, beyond the absence of clear advantages, probability of congestion on interconnections in respective critical periods suppresses any economic relevance to the exchanges of capacity rights. Now that we are faced with an increasing physical and technological complexity of the systems with the development of large scaled variable RES-E capacities, de-correlated thermo-sensible loads, and new electricity usages with uncertain load profile as electrical vehicles, anticipation of capacity margin needs and possible contribution of external generators will be increasingly difficult.

The pragmatic approach of implicit cross border participation should be chosen, to manage the interaction of "securities of supply" of respective system. A reasonable approach is to simply use statistical contribution during critical periods, commonly estimated by the ENTSO-E modeling approach. It is the least inefficient method to decompose the extremely entangled adequacy issues of systems in physical interactions, in a series of manageable subsets. By this pragmatic way we should avoid expected and unexpected inefficiencies, as well as costly informational infrastructures and huge transaction costs to manage the exchange of capacity rights.

Appendix 1

Capacity rights and reliability rights

Collective goods can be managed either by voluntary provision "à la Coase" with creation of exchangeable property rights, or by different types of government provision -- taxation to fund the production of collective goods, subsidization of private production of them, etc.,-- which imply the identification and definition of property rights. Attached to the two collective goods of adequacy and reliability, they are exchangeable property rights which are temporally nested.

"Reliability rights" are rights that offer every generation unit which produces, which is able to adjust their production, or which is in reserve, ready to produce energy and to offer balancing services and ancillary services sold to the TSO which is in charge of guaranteeing the system reliability to every producer and consumer. As energy can be exchanged up to the gate closure of the infraday, the reliability rights cover not only the different types of reserve and balancing services bought by the TSO but also energy which is forward exchanged for different delivery dates. It is exchanged between producers and loads which are "balancing responsible" for a delivery hour in bilateral transactions, on the day ahead market, intraday markets just before the "real time" during which the TSO takes the complete physical control of the system. So any kWh injected in the system also includes an implicit "reliability right". It should be underlined that, if all the reliability rights in a system are in principle tradable with the other systems, the TSO must keep hold of some domestic reliability rights in order to balance the system in the "real time" period of one hour.

"Capacity right" is a property right on the long-term reliability insurance of the system to which all the dispatchable equipment and to a much lesser extent, variable generators, contribute. This is a collective good under the responsibility of the government, the regulator and the TSO. The capacity rights associated with a generator's unit can be vague as they are with the capacity payment. They can also be attributed in a discriminatory way, as with the strategic reserves mechanism focused either on old units, or some specific new gas turbine equipment.

Nevertheless they are clearly defined with mechanisms which fall under the category of quantity-instrument (as opposed to price instrument) with forward bilateral capacity obligation (BO), forward capacity contracts auctioning (FCM) and reliability options auctioning (RO) when they represent in fact a forward promise of reliability during their critical period of the delivery year. Generators selected in a capacity auction would typically be required to offer that capacity at the day-ahead scheduling stage and to maintain availability until some nominated point in time before delivery. If the generation in receipt of capacity payments does not clear the day-ahead auction, it would be available into the intra-day stage to provide capacity or balancing services. In other words, it commits to be available to sell reliability rights in the form of energy or reserves on day ahead, intraday, and balancing markets. In this case these rights correspond to forward commitments to be able to commit on the reserve markets or to deliver energy on the energy markets at the delivery date any time during the critical period. In these CRMs the capacity right is a complex product with a number of components.

- The *physical component* includes, on the side of contracting generators, a physical obligation of the contracting generator which is a provision of energy during some periods, the definition of these critical periods, an ex-ante certification, an information requirement on outage, an ex-post control that contracting generators have been available. The same physical component includes in the case of the bilateral obligation on retailers, an obligation of capacity rights adjusted on the forward peak load plus a reserve margin, the definition of this reserve margin, the ex-ante and ex post verification by the TSOs before and after the delivery date. In the case of a centralized forward capacity market it includes the definition of the demand function by the TSO besides the reserve margin.

- The *contracting component*: in the case of central auctioning of forward capacity contracts (FCM) or reliability options (RO), it includes the means of selection by auctioning, the type of auctioning, the contract duration, the timing of payments, etc. at the general level; on the side of the generator, it includes all the physical characteristics of the capacity product, plus the penalty in case of outages and non-availability; on the side of the TSO, it includes the strike price of the reliability options in the RO mechanism, and in the FCM mechanism the subtraction rules of peak revenues on the energy market (reference price, etc.).

- The *geographic component* (in the case of locational FCM as in the PJM ISO) includes geographic restrictions in case of transmission and delivery constraints.

Appendix 2

The different capacity remuneration mechanisms

These are designed along three different principles: a coordination by price, a coordination by quantity, and a command and control approach (Oren, 2004; Cramton et Stoft, 2006; Finon et Pignon, 2008).

1. Price instrument

Capacity Payments: All generators, incumbents and entrants are paid for being "available" during every period. Bid prices should be aligned with marginal cost even in scarcity periods with a bid cap. In the most socially efficient design, the level is set administratively, by aligning the sum of energy and capacity revenues with long-run marginal prices of peaking units.[13] Under this efficient outcome, the capacity payment is calculated as the expected value of lost load (VoLL) per MWh during the curtailment hours multiplied by the loss of load probability (LoLP) targeted by the regulator. This is added to the short-run marginal price. One drawback of this mechanism is that there is no guarantee that the capacity target will be reached.

2. Quantity instrument

- **Capacity Obligation (CO):** An obligation is established 3-4 years in advance for suppliers to sign contracts with new and existing generators. At the delivery date, the suppliers must submit the required number of capacity certificates equal to the peak load of their customers' portfolios, plus a surplus corresponding to the reserve margin needed for system reliability. It is defined a number of years in advance by the system operator in order to give time for investors to install new peaking units. As a result, suppliers may comply by developing vertical arrangements, either by building their own capacity units or by long-term contracts with independent producers or entrants. A secondary market is implemented for marginal adjustments by the obliged suppliers and the committed producers to ensure reliability.

- **Capacity forward auction (FCM)** is a capacity payment where the price is set by a centrally conducted auction in which generators bid for capacity contracts. The auctions are conducted a number of years in advance (four to five years before delivery). Both existing and new capacity providers may participate. Forward contracts might be differentiated between new units (for which capacity revenues could be guaranteed in some way or another for several years), and existing units (for which revenue is only guaranteed for the year of delivery).

- **Reliability option auction (RO)** is a forward auction like the Capacity Auction, but the generators who effectively offer a "call option" receive the option premium in exchange for a guarantee that their generation capacity will be available during peak periods. It balances this guarantee against a capping of the revenue by the option strike price. When wholesale price exceeds the level of the latter, the generators reimburse the loads (in fact the TSO) for the difference. It is a financial instrument with forward coverage rather than a physical instrument. It aims to guarantee stable revenue streams with energy revenues capped by the strike price and a fixed premium per MW. This is also a way to protect consumers against price variability and price spikes.

[13] This was one of the main rationales for the adoption of the pool market architecture in Ireland. See IEA (2012) and Lawlor J. (2012).

3. Command and control

Targeted mechanism for strategic reserves requires some new reserve units (or demand-side response) to make up for any shortfalls foreseen by the TSO. Payments which are contractually guaranteed for a long period are made only to specific generators and technologies. They are called on only as a last resort to prevent distortion of the energy market price signal. They are well adapted to systems with hydraulic dominance or small systems with some very large plants (such as the Finnish system). However, while the targeted mechanism may be effective in reaching the adequacy objective in the short-run, it could deter investment in peaking units through the market, given that market players can anticipate the SO decision to call for tenders if reserve margins decrease too much.

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