



The economic welfare impacts of reserving interconnector capacity for trade in balancing products

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Executive Summary

From the beginning of the process to liberalise Europe's electricity sector, there has been much debate on the treatment of interconnector capacity. Early emphasis focused on ensuring as much capacity as possible was sold on an open market (e.g. day ahead) to optimise its use and reduce the risk of it not being used when market prices in connected electricity markets suggested it should have been (i.e. to reduce the risk of sterilisation).

More recently, debate has turned to the extent to which capacity should be used for the exchange of balancing services. Presumably linked to the desire to avoid sterilisation, there appears to be a consensus emerging in favour of a prohibition on the reservation of capacity from the day ahead market for the purposes of balancing exchange. However, some parties (including the EU) have expressed the view that there might be a case for allowing such reservations if it can be shown that this would increase social welfare.

The report presented here therefore examines the extent to which allowing the reservation of interconnector capacity for the exchange of balancing services might increase social welfare.

Interconnectors between countries enhance social welfare by allowing the transportation of electricity from low priced to high priced areas. The social welfare resulting from any given use is therefore a function of the demand and supply of electricity in the importing and exporting area.

The drivers of supply and demand for day ahead energy and balancing energy are likely to be slightly different. For example, the demand for balancing energy is a function of, among other things, demand forecast error and estimates of generator reliability rather than total electricity demand (as is the case for day ahead energy). The supply of balancing energy is a subset of the supply of bulk energy, as not all generators can change production quickly enough to provide balancing energy.

It follows therefore that there will be a large number of occasions in which there is a different social welfare arising from the use of capacity for day ahead trade and balancing exchange. Indeed, for any given set of day ahead and balancing demand and supply conditions in an hour, there will be a social welfare optimising allocation of capacity between day ahead and balancing trading. *A priori*, it seems highly unlikely that always allocating 100% of capacity to day ahead exchange will be the social welfare maximising outcome.

As well as maximising social welfare in a static sense, there are dynamic benefits to the optimal allocation of capacity between day ahead and balancing exchange. It should encourage more efficient investment in sources of flexible generation, and also in interconnector capacity itself. This is clearly of importance given the likely future rise in intermittent generation in Europe.

The social welfare benefits of optimal interconnector use are likely to be material. Using simplified analysis of a stylised interconnector we show that for 50MW of interconnector capacity, use for exchange of balancing energy might enhance social welfare by up to €640m over an assumed 40 year interconnector lifetime.

Whether a prohibition on the reservation of capacity from the day ahead market would jeopardise the capture of this value depends on a number of factors. Not least among these is the extent to which some value could be captured without a reservation – for example, if some capacity is left unused or if balancing services can be exchanged in the opposite direction to the day ahead flow.

Outside such situations, which will only occur in a proportion of the total hours in a year, a prohibition on reservation of capacity from the day ahead market could reduce social welfare:

- use it or lose it arrangements make it difficult for TSOs or participants to reserve capacity held under long term contracts for balancing exchange, and this may make medium and longer term trading of balancing products (e.g. striking longer term reserve contracts) difficult; and
- in the shorter term, in markets that have explicit auctions of interconnector capacity, TSOs and participants may be able to purchase capacity in the day ahead market itself and use it for balancing exchange (subject to local regulations). However in implicit auction markets (which are becoming more prevalent across Europe) since there is no day ahead market in capacity alone, it is more difficult for either TSOs or participants to do this. It is possible to conceive of arrangements which could facilitate such trade – however their implementation is potentially complex and is untested, and evidence to date shows that it is difficult to secure agreement even to simple market coupling arrangements.

Therefore, before implementing proposals in relation to capacity reservations, policy makers need to think carefully about the risk of an adverse and material impact on social welfare.

Equally, in order to encourage TSOs to procure balancing services internationally, it will also be important to consider wider policy developments. These include TSO incentivisation in relation to balancing procurement and protocols to ensure TSOs can properly rely on international sharing of reserve.

1 Introduction

There has been much debate in Europe on the subject of the treatment of interconnector capacity since the process of market liberalisation began.

Early debates focused on the need to avoid sterilisation of interconnector capacity as part of anti-competitive strategies by market incumbents, and the benefits of ensuring all available capacity is released to the market. There was also extensive debate about so-called “use it or lose it” (UIOLI) arrangements to prevent sterilisation.

As market arrangements for the allocation of longer term and day ahead capacity become more common, the debate has moved on to more detailed aspects of interconnector allocation, including the use of interconnector capacity for the trading of intraday and balancing services. In particular, there has been recent debate between the EC, ERGEG, ENTSO, Eurelectric and others as to whether capacity can be reserved from the day ahead market for trade in balancing services.

There appears to be a consensus emerging in favour of a universal prohibition of such reservations – in other words, limiting the use of interconnectors for the exchange of balancing services to situations in which day ahead capacity remains unused commercially.

The Norwegian Electricity Industry Association, EBL, commissioned Frontier Economics to consider the case for or against such a prohibition from an economic welfare perspective. We have structured this report as follows:

- in **chapter 2**, we set out the context of the debate to date on interconnector capacity use and reservations;
- in **chapter 3** we provide a conceptual framework for the analysis of the welfare implications of capacity reservation, and then apply this framework to make a qualitative assessment of the potential costs and benefits of reserving capacity from the day ahead market for the exchange of balancing services;
- in **chapter 4**, we describe a simple model of an interconnection between two countries and present results of stylised quantitative analysis carried out to estimate the potential benefits of reserving day ahead capacity; and
- having concluded that, in some cases, material welfare benefits may exist, in **chapter 5**, we consider the potential impact of a prohibition on the reservation of capacity from the day ahead market on the ability to capture them.

2 The debate to date

In this chapter, we briefly set out the context of the debate on the reservation of interconnector capacity and then summarise our understanding of the current debate on the on reservation of capacity for the exchange of balancing services.

2.1 Context of the reservation debate

Subsequent to market liberalisation, the structure of many electricity markets in Europe was characterised by:

- incumbents with significant retail and wholesale market shares; and
- long term contracts for interconnector capacity held by these incumbents which foreclosed competition from other markets.

In this context the origins of the desire, on the part of regulators and non-incumbent traders alike, to see all non-committed interconnector capacity released to the market is firmly grounded in an attempt to ensure that social welfare is maximised.

In order to maximise the level of competition faced by incumbents, there was strong regulatory pressure to terminate long term interconnector contracts and release the capacity to the market, and to implement “use it or lose it (UIOLI)” such that when capacity was not being used under pre-existing contracts, it was not “sterilised” but was open to use by others.

In many markets, UIOLI arrangements for interconnector capacity have operated at the day ahead stage. Nominations under longer term interconnector contracts are made before the point at which bids are submitted to the day ahead energy or capacity market, and if those nominations indicate that there will be some spare capacity on the interconnector, that spare capacity is released to the open market¹. This process provides the opportunity for any party to secure the spare capacity, and this in turn ensures that the maximum volume of energy from competitors in neighbouring systems is available in the day ahead market.

However, the operation of such UIOLI arrangements may prevent parties from retaining capacity which is not planned to be used at the day ahead stage, but which is being held in order to compete in the provision of balancing services (or, in some situations, intraday energy). For example, even if a generator is not

¹ For details on the operation of such UIOLI arrangements in the context of the overall market timescale leading up to the day ahead market in the CWE area, see for example, “Harmonisation of gate closure times” (Frontier Economics, 2007) at http://www.dte.nl/images/01-08-2007%20Harmonisation%20of%20gate%20closure%20times_tcm7-107510.pdf

an incumbent, under such UIOLI arrangements, they might not be able to reserve capacity as unused beyond the day ahead stage against the possibility of being able to exploit high balancing prices in neighbouring systems. If they did not provide a nomination for use of the capacity, they might lose the entitlement to its use.²

2.2 Reservation of capacity for balancing services

The concept that all but the previously nominated interconnector capacity must be released to the market day ahead and then subsequently intraday could, if not accompanied by explicit arrangements to address the issue, result in it being difficult or impossible to guarantee the availability of interconnector capacity for the exchange of balancing services.

There has been much debate to date on the issue of the use of interconnector capacity for short term trading (i.e. intraday and balancing timescales). The European Commission held a workshop on 15 May 2009 at which a number of parties discussed their views on the subjects. At present, there is no consistent approach to the use of interconnectors near real time in Europe.

The majority of participants at this workshop appeared to be opposed to the reservation of capacity on interconnectors from the day ahead market to provide for exchange of balancing products. These views are summarised in Table 1.

² While the regulatory rationale for the implementation of UIOLI arrangements is clear and, in the circumstances of the time, probably sensible, it seems that there have been a number of unintended consequences as a result of implementation, of which this is one example. There are potentially a range of other unintended consequences that we do not address in this report.

Table 1. Summary of views from EC workshop on balancing, 15 May 2009: reservation of capacity

Participant	Comments
Tractebel / University of Leuven (report on behalf of EC)	<p>“It is not recommended to reserve capacity for real-time energy delivering services (e.g. secondary or tertiary control in UCTE)”</p> <p>“No cross-border capacity reservation, no charges”</p>
EREGG (reference to guidelines for good practice on access to interconnectors)	<p>“No reservation for cross-border balancing - exemptions: unexpected flows caused by primary control, and interconnections with no congestions”</p> <p>“Cross-border procurement of reserve capacity: possible only for primary control reserves or interconnections with no congestions”</p>
ENTSO-E	<p>“ENTSO supports a general principle of no capacity reservation for XB balancing services “</p> <p>“Should be considered if demonstrated to be of greater economic advantage or for severe security issues”</p>
Eurelectric	<p>“Secondary/tertiary reserves (real-time energy delivery): no reservation of cross-border capacity for balancing purposes”</p>
EFET	<p>“EFET strongly objects to the idea that TSO might reserve transmission capacity for balancing”</p> <p>“Capacity allocation in the most efficient sequence -> long-term, day-ahead, intra-day, balancing”</p> <p>“Unused capacity of both regulated and merchant lines should be used”</p>

Source: Participant presentations

While we understand there were a small number of presentations and representations from participants at the workshop (e.g. TIWAG, EBL) which expressed an alternative view, these views appeared to be in the minority.

However, we understand that some parties (including representatives of the EC) considered that reserving capacity to allow for balancing trade would be justified if it could be shown that, from a social welfare viewpoint, it would be optimal. In other words, a capacity reservation at, say, the day ahead stage would be justified if it could be shown that putting in place a prohibition on the reservation of capacity would reduce social welfare overall. We also understand that, since this meeting, some parties have expressed the view that the reservation of capacity for the use of the provision of reserve on DC links might be appropriate.

In the remainder of this report, we therefore consider the economic welfare case for reservation.

3 Conceptual analysis of interconnector reservation

From an overall social welfare viewpoint, the key question is whether this absence of an ability to reserve capacity for balancing exchange can create a suboptimal outcome.

If this were shown to be the case, then there would be benefit in exploring arrangements which:

- permitted capacity reservation for balancing purposes; and
- avoided the risk of these reservations being used for anti-competitive purposes by dominant incumbent operators.

In this section we:

- provide a definition of social welfare maximisation;
- set out a framework for the consideration of the welfare implications of incremental interconnector flows;
- use that framework to assess whether the absence of an ability to reserve capacity for balancing exchange is welfare maximising; and
- set out some conclusions on capacity reservation based on this qualitative analysis.

3.1 A definition of welfare maximisation

In considering the optimality or otherwise of allowing capacity reservations for balancing exchange, it is important to distinguish between two economic concepts:

- economic efficiency, or welfare maximisation, which is concerned with whether the welfare of all economic agents in aggregate is maximised irrespective of the distribution of that welfare; and
- equity, which is concerned with the distribution of welfare.

The use of interconnectors to exchange power between countries inevitably has equity considerations. For example, building an interconnector of a material size to export power from country A to country B will almost certainly result in an increase in wholesale price in country A and a reduction in country B. Other

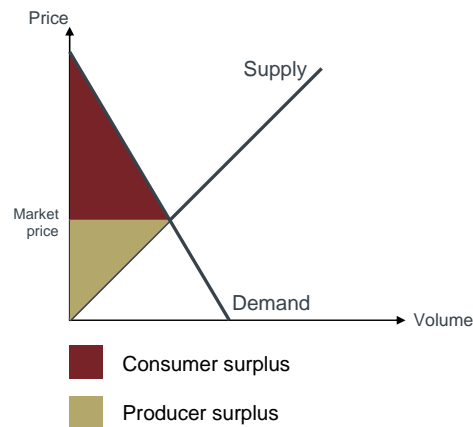
things being equal, consumers will be worse off in country A and better off in country B.

However, building the interconnector may still be the optimal thing to do from the perspective of the totality of customers in countries A and B³, in that the total cost of serving the combined load of the countries may be lower as a result of the construction of the link.

From an economic perspective, therefore, it should be the welfare of all relevant parties in interconnected markets that is considered in order to assess whether a capacity reservation for balancing exchange is appropriate. If total welfare is maximised, then society as a whole will be better off as a result of more efficient use of resources to meet demand. Once this is the case, equity issues can then be addressed separately. If decisions are made which increase total economic welfare (i.e. which increase the economic welfare to be allocated between parties), then conceptually it will always be possible to ensure that everyone in society is at least as well off as they were previously, with some parties being strictly better off.

This welfare is measured by the aggregate value of consumer and producer surplus in each market.

Figure 1. Consumer and producer surplus



Source: Frontier Economics

Consumer surplus is the utility which customers derive from the fact that they pay the equilibrium market price for all of their consumption of a particular

³ For a discussion of this issue, see “Improving incentives for investment in transmission infrastructure” (Frontier Economics and Consentec, 2008) at http://ec.europa.eu/energy/gas_electricity/studies/doc/electricity/2008_rpt_eu_transmission_incentives.pdf

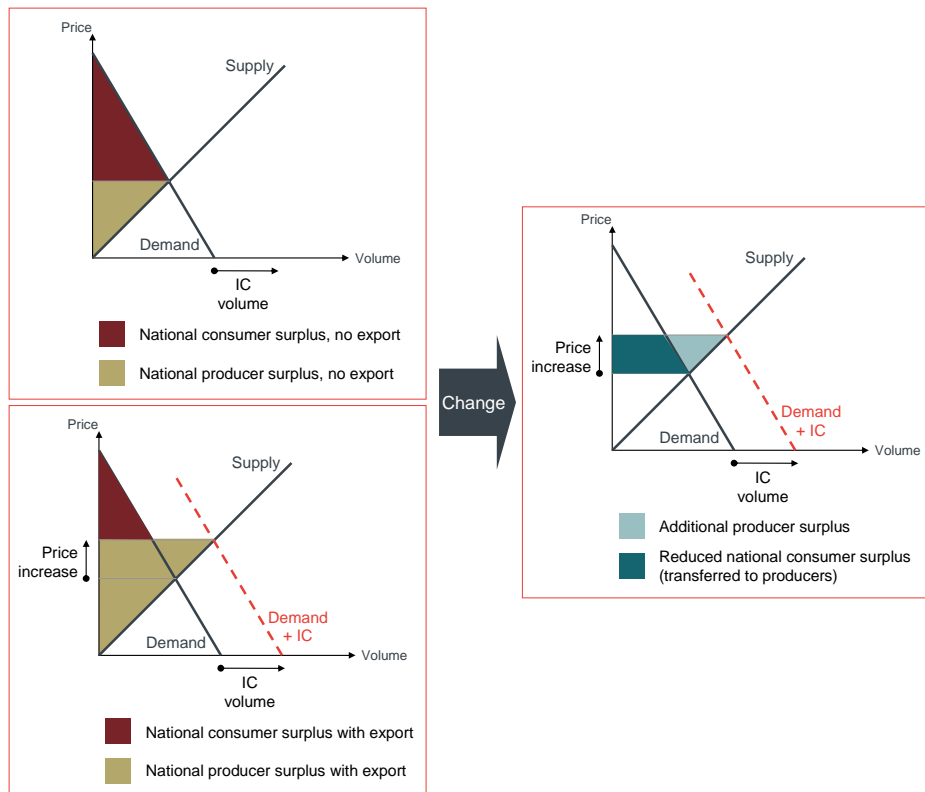
product or service, but would have valued lesser volumes of consumption more highly.

Similarly, producer surplus is the profit which producers derive from the fact that they are paid the equilibrium market price for all of their output, but would have produced some volumes for a lesser amount.

3.2 Framework for the analysis of the welfare impact of interconnection

It is possible to consider the welfare impact of the use of interconnection between two markets using this framework.

Figure 2. Welfare impact of interconnection - exporting region



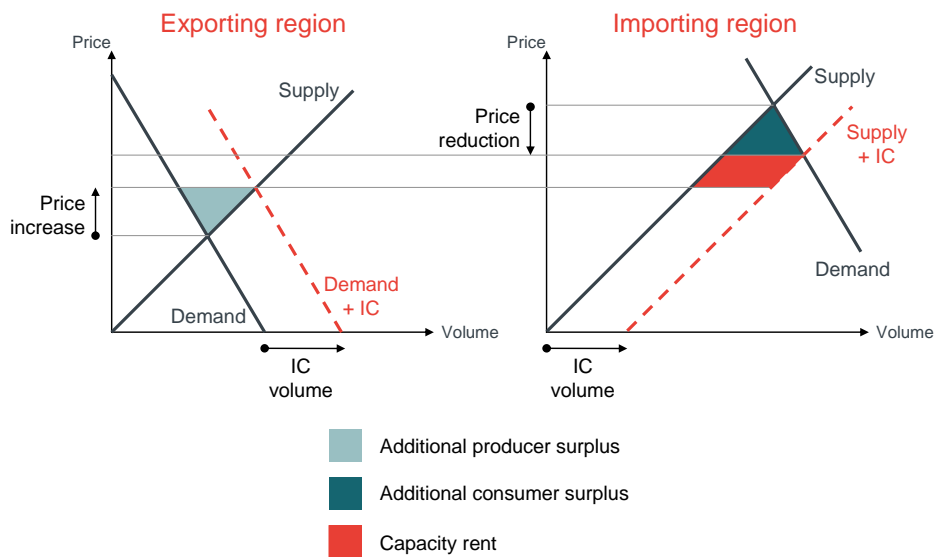
Source: Frontier Economics

For an exporting region, the use of interconnection capacity at the day ahead stage (or at any time) can be considered as a shift of the regional demand curve to the right. As shown in Figure 2, there are a number of impacts of additional volumes exported:

- as indicated above, price increases, which reduces the consumer surplus of customers in the exporting region, but at the same time increases producer surplus by the same amount;
- producers generate additional volumes at a higher price, and therefore secure further producer surplus.

To understand the full effect, however, the impact on the importing region also has to be considered.

Figure 3. Welfare impact of interconnection - exporting and importing regions



Source: Frontier Economics

Just as the interconnector volume is considered as a shift in the demand curve in the exporting region, it is considered as a shift in the supply curve for the importing region⁴. This shift results in a price reduction, and hence:

- a reduction in regional producer surplus which is matched by an increase in regional consumer surplus (not shaded on the diagram); and
- a further gain in regional consumer surplus as customers consume higher volumes at lower prices.

⁴ In reality, the shifts would only be as shown for levels of price in the importing region above those in the exporting region. For simplicity of exposition, we have ignored this. This simplification has no impact on the results.

There is a final welfare gain resulting from the incremental flow – namely the capacity rent that accrues because customers in the importing region are paying a higher price than those in the exporting region. This will accrue to the owners of access rights on the scarce interconnection capacity⁵.

The total increase in welfare resulting from an additional interconnector flow in the direction of the price difference is therefore the sum of the shaded areas in Figure 3. This welfare gain arises because there is greater competition in the importing market from cheaper resources in the exporting region, and this competition results in a more efficient use of resources overall.

3.3 Assessment of the welfare impact of capacity reservations for balancing services

Having set out this framework, we first consider the static impact of reservations of capacity from the day ahead market for balancing services – in other words, considering only existing resources. We then consider the dynamic impact over the medium term, in terms of investment in new sources of flexible generation.

3.3.1 Static analysis

Using this framework, it is possible to consider the welfare impact of capacity reservation for the purpose of balancing exchange.

Suppose the situation in Figure 3 represented the use of interconnector capacity for additional flow in the day ahead market – in other words, suppose the demand and supply curves for both countries depicted in the figure were day ahead curves. This would also imply that the price differential shown was a day ahead price differential.

There will be related but *separate* demand and supply curves for balancing products. There may be a number of important differences between the day ahead demand and supply curves and those for balancing products:

The **demand** for balancing energy is a function of the forecast errors in trading and scheduling prior to gate closure⁶. If there is significant forecast error (e.g. if generation were scheduled to meet a demand level which turned out to be significantly below that which actually materialises) then there will be a large demand for balancing energy.

There is therefore not a clear link between the day ahead demand for energy and that likely to emerge in balancing timescales. For any given day ahead demand,

⁵ We have shown it on the diagram for the importing region – it could equally well be shown on the diagram for the exporting system.

⁶ This may include forecast errors in relation to demand, wind and generation plant availability.

balancing energy demand could be high or low, depending on forecast accuracy. On the coldest of winter days, there may be low demand for balancing energy; in contrast, there may be extremely high levels of balancing energy during a summer night.

In the future, with greater levels of intermittent generation on the system, it is reasonable to expect the volatility of the demand for balancing energy to increase.

The **supply** of balancing energy is arguably more closely related to the supply of day ahead energy, in that the sources of energy are – at least in today’s markets – likely to be similar.

However, even for the supply of energy, there are important differences. Balancing energy (e.g. tertiary reserve) cannot be provided by all plant on the system – it is only plant that can meet the technical characteristics of the product that feature in the balancing energy supply curve. Therefore, it is likely that the supply curve will be much more inelastic – in other words, significantly higher prices will be needed to secure incremental balancing energy volumes than would be required to secure incremental day ahead volumes.

In the future, balancing energy supply may come from sources which do not participate in the day ahead markets. For example, if small scale localised energy storage devices proliferated, while they would be unlikely to supply bulk energy into the day ahead markets, they may well be important suppliers of balancing energy.

There are therefore major differences in the drivers of day ahead and balancing demand and supply curves. In turn, it is highly likely that there will be a large number of occasions in which there are significant differences between the shape and position of the day ahead and balancing demand and supply curves, and hence between the day ahead and balancing price levels.

Returning to the welfare analysis above, this means that it is perfectly possible for the level of welfare resulting from increased interconnector flow to be different according to whether the exchange for day ahead or balancing energy.

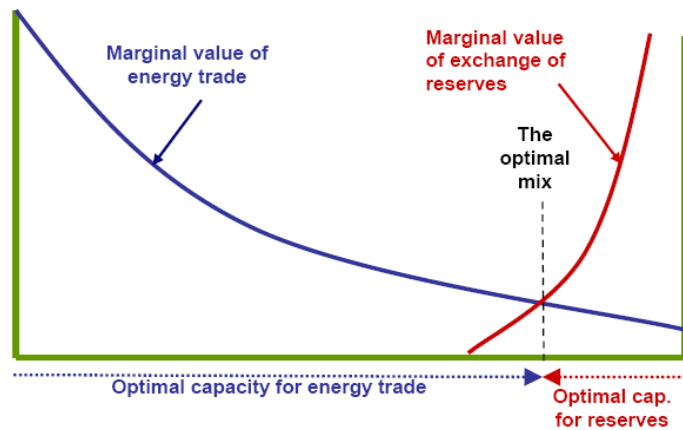
For example, assume that the positioning of the day ahead and balancing demand and supply curves was such that the price difference in balancing timescales was greater than the price difference day ahead – specifically, suppose that the day ahead prices were €50/MWh and €60/MWh respectively, but that the prices in balancing timescales were €50/MWh and €90/MWh respectively.

At the margin, therefore, capacity used for day ahead purposes would have a value of €10/MW/hr. In contrast, at the margin, capacity used for the exchange of balancing energy would have a value of €40/MW/hr.

The interconnector rent component of the welfare described in the framework above resulting from the exchange of balancing energy would be higher than that resulting from day ahead trade.

Making the (unlikely) assumption that the shape of the day ahead and balancing demand and supply curves is the same, it is clear that the same could easily be true of the total welfare position. In this situation while the increase in consumer and producer surplus resulting from the interconnector flow would be the same irrespective of whether the flow was for day ahead or balancing exchange, *the level of congestion rent would be greater for balancing exchange*. Failure to use the interconnector for balancing exchange would therefore, at the margin, reduce social welfare by €30/MW/hr.

Figure 4. Achieving the optimal mix of day ahead and balancing exchange



For energy trade the blue curve goes from left to right and for exchange of reserves the red curve goes from right to left.

Source: ETSO 2006, "Key issues in Facilitating Cross-Border trading of Tertiary Reserves and Energy Balancing"

It is clearly also conceptually possible to envisage situations in which both the interconnector rent *and* the consumer and producer surplus arising from the exchange of balancing energy are greater than those arising from day ahead trading. In such cases, the rationale for the use of the interconnector for balancing exchange would be even stronger.

In all such situations, welfare would be maximised by allowing for use of the interconnector for the provision of balancing services. Or put another way, *prohibiting such a use would reduce overall economic welfare by reducing the scope for exchange of balancing services when this is exchange creates more economic welfare than that of day ahead energy*.

It is therefore conceptually possible to consider an optimum use of interconnector capacity between day ahead and balancing exchange – a fact highlighted by ETSO as long ago as 2006 (as shown in Figure 4). ETSO's description of "marginal value" can easily be re-interpreted as "marginal increase in economic welfare".

Critically, the welfare maximising mix of uses of the interconnector will depend on demand and supply conditions for day ahead and balancing markets for each hour of the day in each of the interconnected countries. It seems highly unlikely that always allocating 100% of capacity to the day ahead exchange and, restricting the use of capacity for the provision of balancing services would result in a welfare maximising outcome.

3.3.2 Dynamic effects

The above analysis is “static” in nature – in other words, it does not consider the broader changes which the optimisation of interconnector use between day ahead trade and trade in balancing services would create.

One such important factor is that it should encourage more efficient investment in sources of flexible energy provision, to the extent that the scope for such production varies geographically.

Certain sources of flexible energy – e.g. hydro generation – are only available for exploitation in specific locations. If there is demand for such flexibility elsewhere, the availability of interconnector capacity allows their value to be fully exploited (including, if this were the value maximising approach, through exchange of balancing services). This should in turn result in greater investment than would otherwise be the case⁷.

Importantly, given the future outlook for the European energy markets, encouraging more efficient investment in sources of flexible energy provision will reduce the likely cost of managing increasingly significant levels of intermittency from renewable generation.

Equally, by ensuring that the value from a given interconnector capacity can be maximised, such optimisation should also lead to more efficient investment levels in international transmission capacity.

Therefore, as well as maximising welfare in a “static” sense (i.e. given existing resources), ensuring interconnector capacity can be used where its value is highest should also maximise welfare over the longer term, in a “dynamic” sense.

3.4 Qualitative conclusions on capacity reservations for balancing services

It is clear that there were good reasons for the regulatory drive to avoid the sterilisation of interconnector capacity. Using the framework above, it is clear that additional interconnector flows in the direction of the price difference have a

⁷ Provided such flexible energy sources were indeed cheaper than others available more generally.

positive impact on economic welfare. Were incumbents able to foreclose access to interconnector capacity, it would reduce welfare.

However, by the same logic, regulation should not foreclose access to capacity when it can contribute to economic welfare.

If it were clear that the demand and supply conditions for day ahead and balancing markets were likely to be identical, then there would be little or no welfare loss from arrangements which meant that capacity could not be reserved for the exchange of balancing products.

It is almost impossible to envisage this condition being met, however. There are clearly different drivers of day ahead and balancing energy demand, and balancing energy supply is distinct from day ahead supply (and may become more so over time).

Presuming that use of capacity for day ahead energy exchange should take priority over its use for balancing services therefore carries the risk of allocating the capacity to non-welfare maximising services, and reducing welfare overall. It will also distort investment incentives over the medium term..

At the conceptual level, therefore, there would appear to be a rationale to implementing arrangements which:

- mitigate the risk of foreclosure of day ahead markets by incumbents; and
- allow the flexibility for interconnector capacity to be reserved for balancing exchange where it is likely that there will be value in so doing.

However, it is clearly important to understand whether the issue is likely to be material in reality. It is to an examination of this issue which we now turn.

4 Empirical analysis of interconnector reservation

In this chapter, we describe and present the results of a stylised simulation model we have developed in order to assess the likely materiality of the welfare effects discussed at a conceptual level in the previous chapter.

The chapter is structured as follows:

- we present an overview of our quantitative analysis;
- we set out the quantitative scenarios we have considered and the results obtained; and
- finally, we summarise our conclusions from the stylised analysis

4.1 Overview of our analysis

It is beyond the scope of this study to undertake detailed market simulations of the operation of existing and potential interconnectors between electricity systems in Europe. Instead, we have developed a simple model of an interconnector between hypothetical countries, and based on analysis of historic market data for sample countries, attempted to simulate a range of stylised yet credible market outcomes.

In this section, we describe:

- the key conceptual assumptions behind our model; and
- the structure of the model.

4.1.1 Conceptual assumptions

In the preceding chapter, we concluded that the welfare impact of flow over an interconnector in the direction of the price difference was a function of:

- the change in producer and consumer surplus in the exporting and importing country respectively; and
- the rent on the scarce interconnector capacity.

If interconnector capacity was to be reserved for balancing exchange, it is unlikely that the volumes being taken out of the day ahead market would be large. While balancing energy can command high prices, the volumes typically required by TSOs are usually small relative to the total system.

In order to simplify the modelling, we have therefore made the assumption that reserving capacity from the day ahead market does not result in a change in day ahead price levels in either of the interconnected markets⁸. This is a reasonable assumption, as the volumes being considered are likely to be small relative to the total day ahead market.

To further simplify the modelling, we have made the same assumption in relation to the market for balancing energy. This simplification is less justifiable – as the “depth” of balancing energy markets is low, a small change in demand or supply could easily result in a significant change in prices.

As a result, our results should be interpreted as a *conservative* view on the likely welfare gain from allowing the reservation of capacity from the day ahead market for balancing exchange. This is because by making this assumption, we effectively ignore the likely increase in consumer and producer surplus arising from the use of the capacity for balancing energy exchange.

The combination of these two assumptions means that we assess the welfare impact of reserving capacity from the day ahead market for balancing exchange by comparing:

- the welfare loss from rent on access to scarce interconnector capacity in the day ahead market; and
- the welfare gain from rent on access to scarce interconnector capacity in relation to balancing exchanges.

If the difference between this welfare gain and loss could be expected to be material for a significant number of hours during a year, then an approach which prohibited capacity use optimisation could be expected to have a significant negative impact on overall welfare.

4.1.2 Structure of the model

The structure of the model is relatively simple. It takes as inputs:

- a distribution of day ahead market prices in two countries (A and B); and
- a distribution of prices for balancing products in the same countries.

The model takes a draw from each of the distributions of day ahead market prices and calculates a day ahead interconnector rent from the two draws.

At the point at which day ahead prices are known (or at least can be predicted with high certainty), the levels of balancing prices in each market will remain

⁸ This is equivalent to assuming that the supply and demand curves in the exporting and importing country respectively are horizontal around the point of day ahead interconnector utilisation.

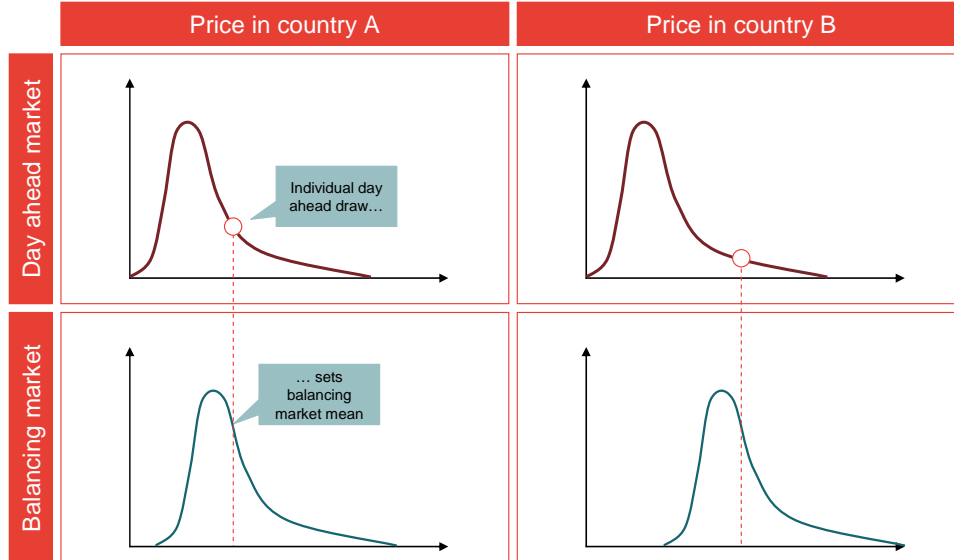
uncertain. As discussed in the previous chapter, they will be driven by the outturn of a variety of factors.

Therefore, any difference between day ahead prices needs to be compared against a distribution of possible prices for balancing energy. It is the uncertainty in relation to the price of balancing energy which can give reserved interconnector capacity option value.

However, if day ahead prices are known or highly predictable, then the mean of the distribution of balancing energy prices should also be known or be predictable. If, at the day ahead stage, there were a systematic difference between the day ahead price and the expected balancing energy price, then there would be an arbitrage gain to be exploited.

Having drawn day ahead prices, the model therefore compares the day ahead price spread to a distribution of possible outturn prices for balancing energy. These distributions are calibrated by assuming that the two day ahead draws represent the best predictor of the expected prices of balancing products in each of the countries. The means of the two distributions of prices of balancing products are adjusted to the value of each of the day ahead draws, as shown in Figure 5.

Figure 5. Representation of modelling approach



Source: Frontier Economics

Then, to calculate the option value of capacity reserved for balancing exchange, the model takes a large number of draws from the resulting balancing price distributions and for each draw calculates an interconnector rent resulting from

balancing exchange. This generates a distribution of balancing interconnector rents, from which the mean is calculated.

The difference between the day ahead market interconnector rent and the expected balancing market interconnector rent is then calculated and logged.

The model then takes successive further draws from the day ahead market distributions and repeats the process.

This output of the model is a distribution of differences between day ahead and balancing market interconnector rents. This distribution indicates the probability with which, seen from the point in time of the day ahead market, it would be optimal to reserve capacity from the day ahead market or use it day ahead and forego any balancing exchange⁹.

The expected value of this final distribution is the expected value of reserving 1MW of interconnector capacity for balancing timescales for one hour.

4.2 Quantitative scenarios and results

In modelling stylised price distributions for both day ahead and balancing prices, we have assumed that prices follow a lognormal distribution. This is clearly a simplification – electricity price formation is likely to be more complex. However, it is beyond the scope of this study to estimate detailed price formation processes, and log normality captures a number of basic characteristics of price distributions (i.e. that they are typically bounded at zero, and have a long positive tail).

In order roughly to calibrate our assumed price distributions to realistic levels, we calculated the mean and standard deviations of day ahead prices and imbalance prices (as a proxy for balancing prices) in a number of predominantly thermal power systems in Europe in 2008.

The statistics for day ahead prices are shown in Table 2.

⁹ We assume that the interconnector would, save for a capacity reservation, be fully utilised at the day ahead stage.

Table 2. Day ahead price statistics

€/MWh	France	UK	Germany	Holland	Average
Mean	69.1	86.7	65.8	70.2	73.0
Standard deviation	28.6	41.0	28.6	28.9	31.8

Source: Elexon, Euronext, Energate

The statistics for imbalance prices are shown in Table 3.

Table 3. Imbalance price statistics (upwards imbalance)

€/MWh	France	UK	Germany	Holland	Average
Mean	84.8	102.9	86.1	86.4	90.1
Standard deviation	33.8	60.0	52.4	62.3	52.1

Source: Elexon, RTE, RWE, Tennet

Based on these figures, we ran a number of scenarios through the model. These scenarios are set out in Table 4¹⁰.

¹⁰ There is no requirement for a mean for imbalance prices, as the mean is set automatically by the model based on day ahead draws.

Table 4. Input assumptions for scenarios tested

Scen.	Country A			Country B		
	Day ahead price mean	Day ahead price standard deviation	Imbalance price standard deviation	Day ahead price mean	Day ahead price standard deviation	Imbalance price standard deviation
Base	70	25	40	70	25	40
2	70	25	25	70	25	25
3	70	25	60	70	25	60
4	50	25	40	150	25	40

Source: Frontier Economics

The **base case** scenario is intended to be a reasonable representation of the experience from 2008, being conservative in relation to balancing price volatility. However, it explicitly assumes that the means of the day ahead prices in the two systems are equal – in other words, on average there is no *ex ante* expectation of the direction of flow of the interconnector.

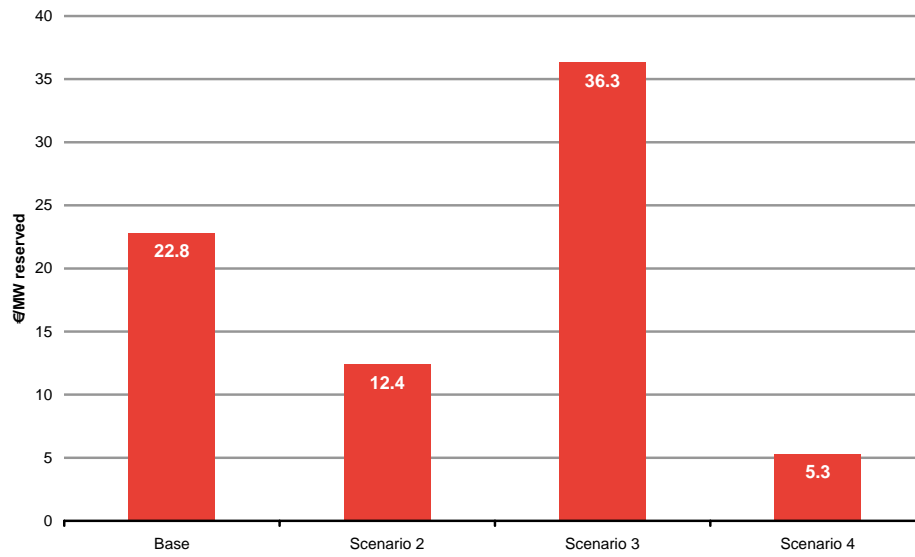
Scenario two considers the implications of an imbalance price which is much less volatile than those observed – specifically, its volatility is similar to that experienced in the day ahead market. The difference between the base case and scenario two is therefore a reflection of the impact of the additional volatility of balancing prices.

Scenario three examines the implications of further growth in the volatility of balancing prices – representing either the more extreme observations from 2008 or, potentially, the impact of greater intermittency on the system driving up the demand for balancing energy.

Finally, **scenario four** represents a scenario where there is a clear expected flow direction on the interconnector (from country A to country B). The volatility of prices in scenario four is the same as that in the base case.

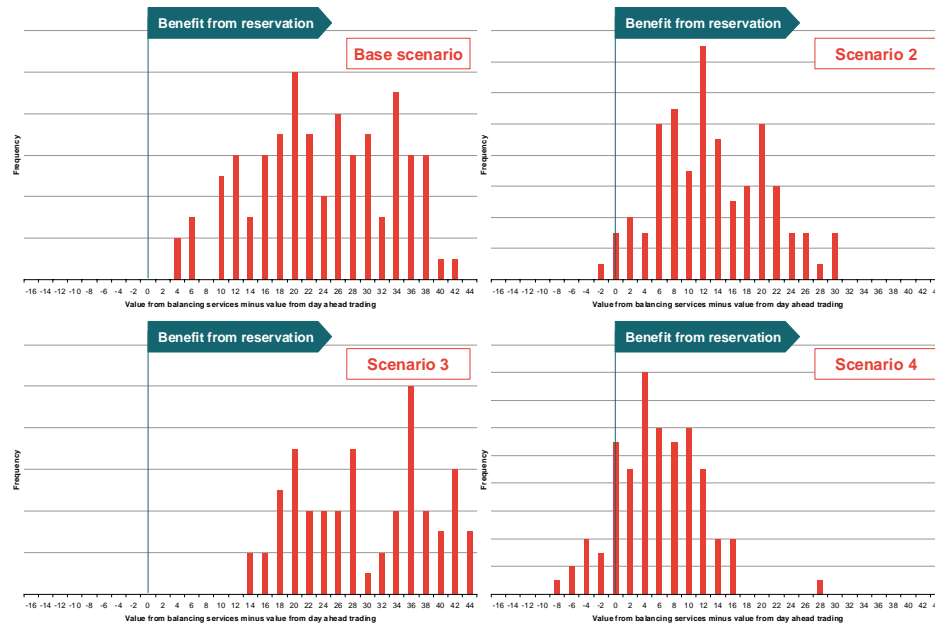
The results of our analysis are set out in Figure 6 and Figure 7.

Figure 6 shows the expected value of the distributions resulting from our stylised model in each of the scenarios (with a positive value indicating a benefit from retaining the option to use capacity for balancing exchange rather than in the day ahead market).

Figure 6. Results of stylised modelling

Source: Frontier Economics

Figure 7 shows the distribution of the difference between the value of capacity day ahead and for balancing services.

Figure 7. Distribution of outcomes from stylised modelling

Source: Frontier Economics

The results show that across all of the scenarios analysed, there would be an expected benefit (i.e. an option value) to retaining the option to use capacity for the purpose of balancing trade.

The magnitude of this benefit clearly varies from case to case. As could be expected, it is lowest when:

- balancing prices are less volatile (e.g. scenario 2 relative to the base case or scenario 3). This is because it is the volatility of balancing prices (and hence the probability that the balancing price spread is higher than the day ahead spread) that drives the option value of reserving capacity for balancing services¹¹; and
- the day ahead spread is highest (e.g. the base case and scenarios 2 or 3 relative to scenario 4). This is because a high day ahead spread means sacrificing a high value against the possibility that the balancing spread is higher.

¹¹ It is worth noting that there is positive option value from reserving capacity for balancing services even when the standard deviation of balancing prices is assumed to be the same as that of the day ahead markets (scenario 2).

However, it is clear that it can be material. For illustrative purposes, if we take the lowest and the highest of the scenarios where the two market prices are equal (i.e. scenarios 2 and 3), and assume that up to 50MW of capacity could be reserved in each hour of the year¹² for balancing purposes, the benefit could be in the range €5.4-€15.9m per annum. Over an assumed 40 year lifetime of an interconnector, the benefit could be between €217m and €636m.

Indeed, over the years to 2020 across Europe, along with the connection of significant volumes of intermittent renewable generation, a large number of interconnector projects are being considered – over 40GW of new capacity is being considered, which would bring total interconnector capacity to near 110GW. The combination should tend to result in greater day ahead price convergence (as a result of increased transport capacity) but also increased balancing volatility (as a result of intermittency). A future which has some of the characteristics of scenario 3 is therefore not unthinkable.

As we indicated above, the optimum mix of capacity can only be determined on a case by case basis. However, to indicate the potential materiality of the sums involved, consider a hypothetical situation in which 5% of total interconnector capacity was used for balancing purposes rather than day ahead exchange throughout the year¹³. Using our results from scenario 3, this would result in an economic welfare gain for Europe as a whole of €1.7bn per annum.

4.3 Conclusions from stylised simulation

The outputs of this stylised modelling indicate that, using credible estimates of volatility for day ahead and balancing prices, and even when the potential for any gain in consumer or producer surplus associated with balancing service trade is ignored, there is the potential for a significant increase in welfare arising from retaining the option to use interconnector capacity for balancing exchange.

The results also indicate that it is likely that the level of welfare increase will vary between interconnectors. The expected day ahead price difference, and the volatility of the prices of balancing services are likely to be key drivers of the level of welfare increase.

If a universal prohibition on the reservation of capacity prevented the ability to retain the option to use interconnector capacity for balancing, it would therefore

¹² As we indicated in the previous chapter, the optimal mix of uses will depend on the demand and supply curves for day ahead and balancing energy which will vary by hour. Equally, the scenarios results used in the calculation are clearly highly stylised, and when larger volumes are considered, it is more important to consider the effect on expected prices in the importing and exporting systems.

¹³ Again, we note this calculation is illustrative – the optimal mix will vary by interconnector and over time.

appear to be likely to result in materially sub-optimal outcomes¹⁴. It is to this question which we now turn.

¹⁴ It is important to note that the modelling undertaken estimates the option value of use of an interconnector for balancing services. Not all of this value would be jeopardised by the prohibition of reservations for balancing services. For example, if interconnector capacity is left unused day ahead, no reservation would be required to allow trading in balancing services. Similarly, counterflow trade in balancing services should not require a reservation. However, the values obtained from the stylised modelling appear sufficiently significant that even if only a proportion of them are put at risk, it would be significant from a societal viewpoint.

5 Implications for policy

The analysis set out above indicates that for some interconnectors, there is highly likely to be both a conceptual and empirically justifiable case for reserving capacity to facilitate exchange of balancing products.

In this chapter we make some high level observations on the implications for policy of our findings first in relation to the proposed policy on capacity reservation and then on wider policy implications

5.1 Implications for policy on reservation of capacity

Our understanding of the proposed policy on reservation of capacity is that it would prohibit the *a priori* reservation of interconnector capacity intended to be used for the provision of balancing services. Instead, at the day ahead stage all capacity that is not intended to be utilised for flows of bulk energy (i.e. which has been nominated for use under long term contracts) would have to be made available to the day ahead market.

This policy would prevent TSOs reserving capacity on a long term basis to be used to facilitate procurement of balancing services for other TSOs or participants (as presumably any capacity so acquired would be subject to use it or lose it rules). This may, in itself, be an issue as many TSOs strike longer term (option) contracts for the provision of balancing services.

Even if the inability to secure capacity long term did not foreclose opportunities for use of interconnectors for balancing exchange, there is also a risk that the policy prevents TSOs from securing capacity at the day ahead stage.

Where interconnector capacity is allocated through explicit auctions, the issues may be fewer. For example, it is not clear to us that such a prohibition would prevent TSOs from operating in the day ahead market place for capacity in a similar manner to any other market participant¹⁵. The difference would be that, instead of the using the capacity for the flow of bulk energy, it would, instead be used for the provision of balancing services.

In this way, the TSO would not need to rely on an *a priori* reservation of interconnector capacity that would effectively exclude the capacity from the rest of the market. Instead, the TSO would acquire the capacity if it was willing to pay more for the capacity than other market participants in the day ahead auction.

However, if the capacity is allocated through implicit auctions, it would be considerably less straightforward for TSOs to operate in the market as per any

¹⁵ Provided this were consistent with local TSO regulations.

other market participant to secure capacity, or indeed for participants to secure capacity which is left unused in order to create the option of providing balancing services.

A notable (and indeed beneficial) feature of implicit day ahead auctions is that the interconnector capacity is bundled together with the energy to flow across it. It would not be possible, therefore, for a TSO or participant to buy simply the capacity in the auction¹⁶.

Given the general trend towards implicit auctions in Europe, a significant implication of the proposed policy prohibiting the reservation of capacity for balancing services is that it may effectively prevent TSOs or participants securing capacity for use for balancing exchange even at the day ahead stage.

Therefore, before implementing proposals in relation to capacity reservations, policy makers need to think carefully about the risk of an adverse and material impact on social welfare.

5.2 Wider policy implications

The analysis presented in previous chapters has indicated that it is relatively straightforward to conceive of pricing scenarios (that are not atypical of prices in European markets) that would mean that it is welfare enhancing for interconnector capacity sometimes to be used for trade in balancing services.

However, our understanding is that such trades are today relatively infrequent – even before the implementation of the proposals for the outright prohibition of using capacity for this purpose.

This gives rise to two further policy implications arising from our analysis:

- first, it is important that TSOs be incentivised to procure balancing services as economically as possible. In many jurisdictions, the costs that TSOs incur in the procurement of reserve are passed through to customers and recovered through network charges. Many TSOs will operate under procurement guidelines and, no doubt, will tend to try to minimise costs of procurement. Nonetheless, it seems likely that not being financially exposed to the cost of their purchasing decisions might serve to discourage TSOs

¹⁶ It is perhaps possible to envisage a process in which, either the market coupling algorithm is changed to optimise bids for pure capacity alongside capacity and energy, or even that after market coupling has taken place, the TSO unwinds the energy components through a series of other energy transactions with participants in each country. However, this would result in a more complex process (it has to date proved difficult to agree on basic market coupling algorithms) or would involve potentially high transactions costs, and potentially also create a question as to whether the TSO necessarily had the property rights to the spare interconnector capacity created as a result of such “unwinding” trades. It would also need to be consistent with local regulations

from thinking innovatively when procuring reserve (such as securing services from other countries).

- second, a TSO in one jurisdiction might have concerns over the extent it can rely on the reserve provided from a neighbouring jurisdiction. That is to say, it might value balancing services provided from a participant in another country less than the same services provided by a participant in its own country. This might be driven by concerns that, in tight situations in both jurisdictions, the services might not be made available for export despite contractual obligations. To reduce this risk, there may be benefit in considering the establishment of European-wide commercial and operational protocols to govern the international sharing of reserve.

6 Conclusions

Since the start of liberalisation of European energy markets, the risk of hoarding and sterilisation of interconnector capacity has been a key focus of regulators and traders alike. It is clear that, were incumbent operators able to foreclose access to interconnector capacity, it would reduce the potential for competition and reduce overall economic welfare.

As market arrangements for the allocation of longer term and day ahead capacity have become more common, the debate on interconnector use has moved on to more detailed aspects, including the use of capacity for the trading of intraday energy and balancing products. Based on discussions at a workshop facilitated by the EC, there appears to be an emerging consensus that forward and day ahead energy should, in some way, be given priority over the use of interconnector capacity, and that it should not be possible to reserve capacity from the day ahead market to guarantee its availability for the exchange of balancing products.

Our analysis indicates that there is no conceptual justification for such a prohibition:

- the magnitude of the welfare benefit from the exchange of balancing services over interconnectors is driven by different factors to that from day ahead energy exchange. Therefore it is conceptually possible for the welfare benefit from balancing exchange to be greater than that from day ahead exchange; and
- the implementation of a prohibition would remove the ability of the TSO to arrange long term options for balancing exchange internationally, and particularly where interconnector capacity is allocated through implicit auctions, would also significantly reduce the ability to secure capacity for short term balancing exchange.

Further, our stylised modelling indicates that for credible ranges, the magnitude of the benefit of a reservation for balancing exchange could be significant. For a hypothetical system, using simple but credible assumptions, a 50MW reservation on one interconnector could yield a benefit of over €500m.

Our analysis does not indicate that there should *always* be a presumption that a reservation is beneficial. This will vary by interconnector, and over time. However, our analysis does show that the universal presumption that day ahead trade should take priority over balancing exchange will not lead to a welfare maximising outcome.

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FRONTIER ECONOMICS EUROPE

BRUSSELS | COLOGNE | LONDON | MADRID

Frontier Economics Ltd 71 High Holborn London WC1V 6DA

Tel. +44 (0)20 7031 7000 Fax. +44 (0)20 7031 7001 www.frontier-economics.com