DECENTRALISED RELIABILITY OPTIONS - SECURING ENERGY MARKETS

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Energy markets are being challenged by new uncertainties

Reliability of our electricity supply is of vital importance to modern society. In the decades since liberalisation, most European markets have relied on market incentives – to some extent – to keep the lights on, although generally starting from a situation with wide reserve margins and – at times – using out-of-market tactics to smooth the path.

The established cycle of investing in new baseload capacity and using older low-merit plants for peaking operation and reserve appeared sustainable, in a world of steadily growing demand. Prices were generally expected to return to long run marginal costs and reward investment, despite weak supporting evidence. The main commercial risk related to market price (for electricity, fuel and latterly CO_2). Price risk was hedged through forward contracts spanning a few years or vertical integration against a retail portfolio, while more risk-averse investors sought long term power purchase agreements.

Hundreds of new power plants have been built around the world under these conditions. What has changed?

The theory behind an energy-only market is straightforward. Capacity is needed until the point where its marginal cost[1] equals its marginal value[2] (i.e. of avoiding capacity shortage). Any market intervention to limit the hours of scarcity or the level of pricing in these hours will lead to 'missing money'; i.e. a situation where systematically, the market arrangements fail to reward adequate investment to meet the desired security standard.

In Europe, a sustained reduction in demand due to energy efficiency and the prolonged impact of the financial crisis has been coupled with a sharp increase in weather variable renewable generation – principally wind and solar. These new technologies make a greater contribution to energy delivery (MWh) than to peak demand (MW). Any new build generation can no longer expect to achieve baseload operation, and is heavily reliant on capturing peak (scarcity) prices. Meanwhile, the number of peak hours diminishes, as the variable renewable generation covers some (but not all) of the demand peaks. For new plants to recover investment costs from fewer peak hours, the prices in these hours would have to be far higher than previously encountered.

Increased price risk is compounded by **volume risk**. The output of most generation will depend on patterns of wind and solar generation. However, the standard market contracts – for firm patterns of delivered energy – do not give market participants appropriate tools to hedge their risk through forward contracting. Such a combination of price and volume risk is dealt with in other commodity markets by trading options, but options are not widespread in European energy markets. Irrespective of whether they face 'missing money', European energy markets appear to have 'missing contracts'.

For most European markets, Day-Ahead markets have become the predominant source of spot pricing and dispatch patterns, with intraday trading and redispatch at low levels. As variable renewable generation grows its market share, its contribution to forecast error will grow sharply. For thermal generators, this means that, in addition to lower output levels, the timing of production will become more unpredictable, based on short term weather patterns. This uncertainty continues even close to delivery time as the weather forecast changes. Such variations are expected to be met by flexible capacity, able to respond to such fluctuations at short notice as the forecasts and market prices change within day.

Are national solutions the answer?

Market participants and the financial community across Europe are now questioning whether reliance on infrequent scarcity pricing is a credible basis for investment. Concerns about brown-out risks and a threat to security of supply are raised, and increasingly policy makers believe in a need for a separate mechanism to reward capacity. Capacity Remuneration Mechanisms ('CRMs'), once a feature only of the countries at the edges of Europe, are now in process or under serious debate in the largest European electricity markets, including GB, France, and Germany, as well as the more established capacity markets in Spain, Italy and Ireland.

There is widespread discussion on whether any 'missing money' is inevitable, or due to avoidable market distortions; e.g. limits on the formation of scarcity prices, or interventions which prevent scarcity from occurring. Such distortions exist in many markets, and are generally intended to protect consumers. Consumer protection is an essential part of a reliability options scheme.

Many CRMs under consideration in European markets are national, different in design from neighbouring countries and with no arrangements yet in place[3] for cross-border participation. Yet this outbreak of national markets takes place in the face of strong agreement by virtually all stakeholders to complete the European Internal Market for Electricity effectively.

Reward capacity or the right type of capacity?

Nearly all the CRM schemes under construction fail to recognise the additional value that flexible capacity brings to the system, treating all available capacity alike. Focus of CRMs has traditionally been on generation adequacy, meaning ensuring that sufficient capacity is on the system to meet peak demand.

In order to incentivise the right type of capacity markets in a world with increasing levels of weather variable generation, CRMs will need to be able to cope with emergent system performance requirements, and in particular should consider flexibility as one of the parameters of their design.

Nationally based Capacity Remuneration Mechanisms can distort their markets

The EC has designed a Target Model[4] to govern cross-border trading of electricity. It includes a coordinated process to determine price areas[5] and allocate forward capacity rights for interconnection, with any unused physical capacity being released to the day-ahead market[6] under 'use-it-or-sell-it' rules. All areas are to be coupled in a single pan-European Day-Ahead market. There will be a coordinated continuous intraday market until close to real time, with cross-border trading permitted as long as unused interconnector capacity remains. All participants should face balancing responsibility, with organised markets for energy balancing which determine imbalance prices. The heart of the concept is cross-border trading in which market prices alone determine the flow of energy.

Progress towards the Target Model is underway but key components are already in place. Day-ahead market coupling is now active in most parts of the EU[7], and intraday and balancing markets are progressing slowly.

However, national CRMs will challenge the effectiveness of the Internal Market for Electricity. The Target Model sets Day-Ahead electricity prices as the governor of trade flows, but most designs of CRM risk distorting these prices at critical times. Instead of scarcity prices, most CRMs are intended to provide a supplementary revenue stream to reward capacity. To date, cross-border participation has not been implemented in any of the national CRMs under design and there has not been an attempt to create a regional CRM.

European organisations are aware of the threat which the uncoordinated development of CRMs brings to the Internal Market for Electricity. ACER and ENTSO-E have each published their own analysis, noting the potential risk of market distortions arising from national CRMs.

The EC has produced a Staff Working Document[8] and has imposed revised State Aid Guidelines[9] to cover capacity adequacy mechanisms. These documents set out a number of criteria intended to limit the potential negative impact that a national CRM would have on the Internal Market for Electricity.

A coordinated approach to CRMs could be highly beneficial

If security of supply is threatened, national political intervention is inevitable, with the threat that existing investments are undermined. Electricity markets need to move to a sustainable model for investment with less reliance on policy and regulatory decisions. Not all European markets are considered to need a specific CRM but others are certain to proceed. The EU needs to find a blueprint for a CRM which permits national governments to take action to protect electricity reliability without counteracting the internal market or causing distortions to trade at national borders.

In this paper we consider some of the underlying of features of existing and proposed CRMs and offer a new model – **decentralised reliability options** – for consideration as a potential basis for a European RM blueprint. Decentralised reliability options would permit a wide degree of freedom to implement designs which meet national needs, without causing significant distortions between markets, while allowing a transition to a 'smarter' future where customers can determine their chosen level of reliability with reduced administrative input.

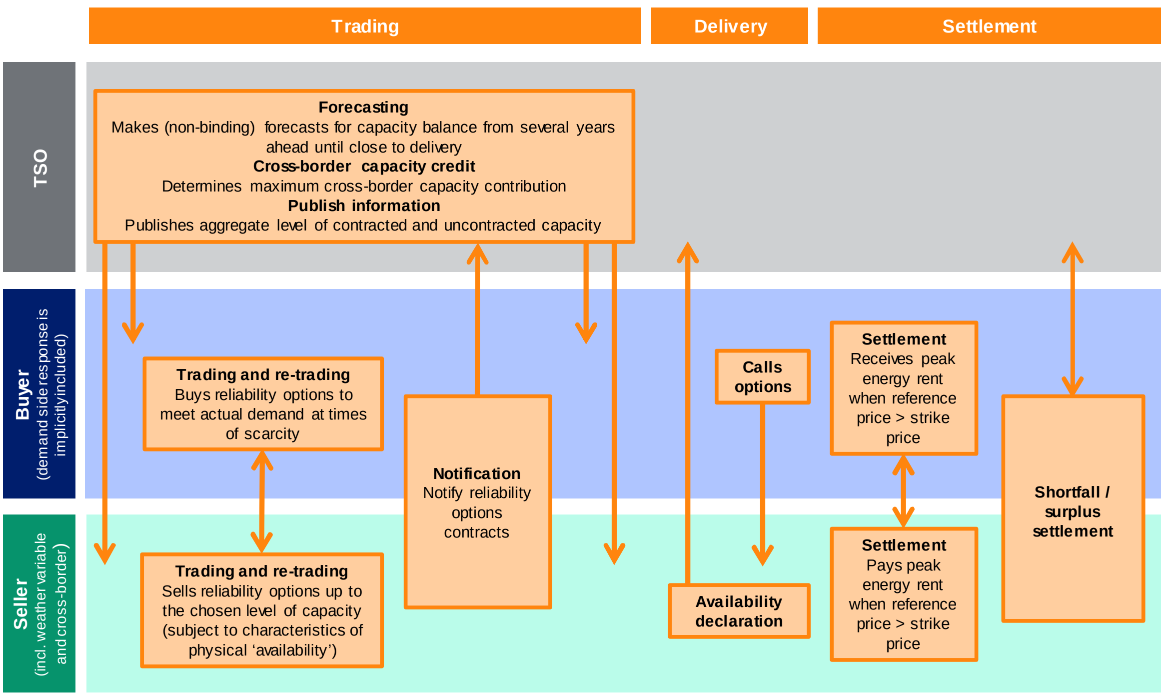
Decentralised reliability options – How do they work?

Capacity schemes take various forms, often categorised into ‘targeted’ (paying specific types of capacity) or ‘broad’ (paying market-wide); and price-based (prices are centrally determined and paid to all) or quantity-based (prices arrived at through competition between providers). A decentralised reliability option scheme is a market-wide, quantity-based scheme.

At its simplest, a decentralised reliability option scheme introduces a set of contracts between capacity providers and (indirectly) consumers. Retailers are required to buy reliability options to meet their demand at critical times. Sellers of reliability options commit their availability at critical periods and forego revenue from price spikes, in return for which they receive a stable revenue stream.

The contracts are a hybrid between a call option (which is essentially commercial) and a physical commitment to make capacity available to the system at key times. The call option introduces a financial settlement (aside from the physical commitment and penalty arrangements), whereby the seller of the option returns the difference between the reference market price and the strike price, if any, to the buyer[10]. Customers benefit from security of supply to an agreed standard, and their exposure to scarcity pricing is reduced in return for an up-front fee.

Figure 1 – Straw man design of decentralised reliability options scheme



Although many details of the scheme could be altered to suit local circumstances, a straw man design for a decentralised reliability options scheme is presented in Figure 1 and may be summarised as follows:

- The TSO makes available forecasts and information on its view of the capacity balance from several years ahead until close to delivery, in order to aid transparency and price discovery:

  - these are forecasts and do not define obligations for buyers or sellers of reliability options;
  - however, the maximum contribution of interconnected capacity is determined by the relevant TSOs.
- Energy retailers[11] are required to buy reliability options adequate to meet their actual demand at times of scarcity:
  - retailers may choose the level of capacity to buy, at their own risk;
  - this structure ensures that demand side response is implicitly included in the scheme, to the extent that the actual demand would be reduced at times of scarcity.
- Capacity providers[12] (including weather variable providers) may sell reliability options based on their actual contribution to system capacity at times of scarcity:
  - providers may choose the level of reliable capacity to sell, at their own risk;
  - to measure their contribution, capacity providers are committed to meet pre-agreed characteristics relating to physical 'availability' of the contracted capacity.
- Administered penalties are applied at critical periods for under-procurement by energy retailers or under-performance by capacity providers:
  - to facilitate this, reliability option contracts must be notified to a central agency;
  - contract notifications are permitted after the event, to allow capacity shortages and surpluses to be resolved by market participants.
- Aside from the physical commitment and its associated penalties, a reliability option includes a call option held by the buyer, with an agreed spot (reference) market and expiry time, an agreed strike price and other terms (e.g. contract duration). In exchange for an upfront payment (option fee):
  - option holders are hedged against price spikes (above the strike price) in the reference market; and
  - option sellers forego market revenue from such price spikes.
- A decentralised reliability option market permits buyers and sellers to agree their own contract details; notably the expiry time and reference market, as well as the contract duration, strike price and the time when they conduct the trade:
  - an upper limit would be set centrally for the option strike price;
  - due to the importance of Day-Ahead markets, we expect that many reliability options would take the form of a financial option settled against the Day-Ahead market; but options may also be struck for physical settlement intraday, or financially against a balancing or imbalance price;
  - by agreement, strike prices may either be fixed or indexed (e.g. to some fuel or price indicator or even to the Day-Ahead price);
- Cross border participation would be possible by capacity providers, subject to:
  - securing the agreement of the interconnector operator for the use of the capacity (whether through purchase of a forward transmission right or other agreement);

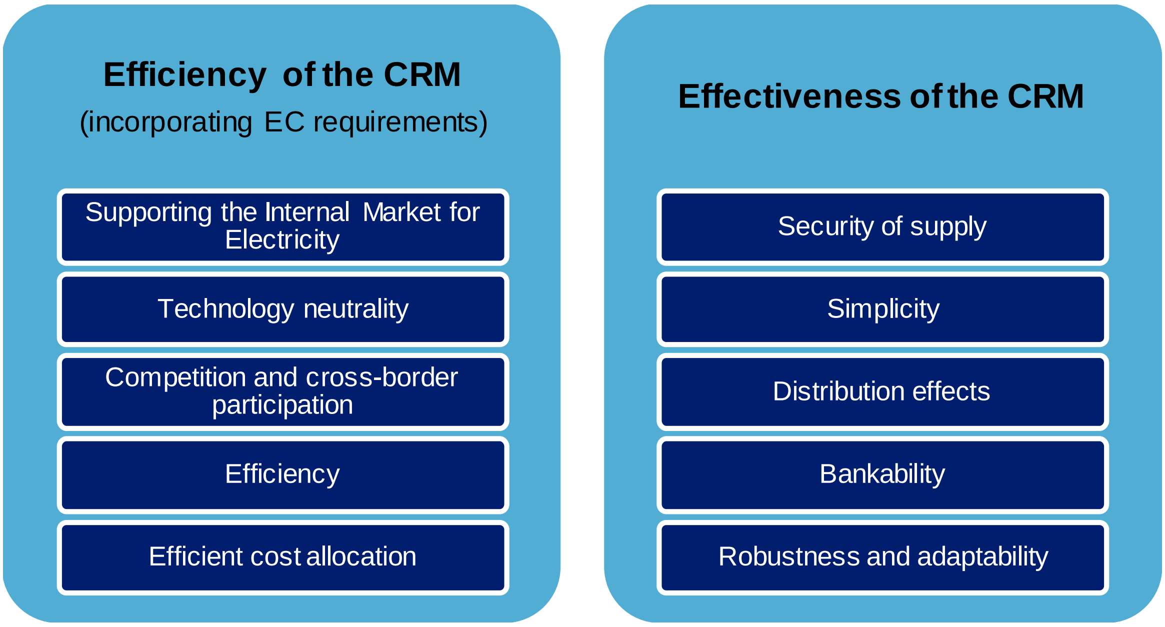
eligible capacity to be limited to the TSOs' estimates of the capacity contribution of the interconnector(s) at times of scarcity

Decentralised reliability options – Why?

CRMs should meet policy and commercial goals

In order to assess the merits of decentralised reliability options, we have drawn up a set of evaluation criteria. Market design assessments are by definition subjective, but we have selected a set of issues designed to test the differences between schemes. Ultimately these relate to the often repeated objectives of achieving a “secure, affordable and sustainable energy market”[13]. The EC has put in place State Aid guidelines covering capacity adequacy mechanisms[14] which have legal force from 2014 to 2020. The requirements may be summarised as dealing with the **efficiency** of any scheme (which is related to the underlying objective of affordability), within the context of the Internal Market for Electricity. As well as a scheme being efficient, it needs to be **effective** in delivering the objective of security**.** We consider that the role of a CRM is not to promote environmental sustainability directly but rather to ensure that capacity is built to to meet demand amidst a changing generation mix. From these high level principles we have created a set of evaluation criteria, as presented in Figure 2, against which to compare designs of CRM.

Figure 2 – Evaluation criteria for assessing different CRM designs



Different scheme designs fit different circumstances, but the design of decentralised reliability options is intended to be a market-wide, quantity-based scheme and in this paper we have chosen to evaluate it against similar designs. We have made two comparisons; a capacity ticket (e.g. a capacity auction or capacity obligation) against a reliability option, and a centralised against a decentralised scheme.

Reliability options deliver security of supply, protect consumers and can help avoid energy price distortions

Most market-wide CRMs are intended to supplement ‘missing money’ without addressing the underlying causes which limit or prevent scarcity prices. These limits – where they exist – are generally measures to protect consumers from price shocks or poor reliability.

A reliability option is a hybrid between a physical commitment and a commercial option. The physical commitment is intended to deliver security of supply. It creates a supplementary revenue stream to deliver missing money (as for other market-wide CRMs), but the inclusion of the commercial option has an important influence:

- customers are protected from scarcity prices in the spot market; and
- spot price volatility can be hedged by the seller through the sale of the option in a “fixed-for-floating” swap of revenues, lowering the risks (and cost of capital) for investment in capacity.

These two effects mean that a reliability option scheme can reduce missing money from the energy market both indirectly and directly. Reliability options put in place the customer protection which permits the regulators to remove any underlying distortions to energy price formation. If this is done, price volatility will reveal the value of demand side management, interconnection and intraday flexibility.

As a result, the reliance on the physical commitment could be made transitional, leading to an improved version of the energy-only market in which investment risks could be managed through sale of a combination of forward sales of call options and fixed volume energy contracts.

From a consumer perspective, reliability options remove any incentive for generators to exercise market power over periods of scarcity and offer a hedge to consumers through direct compensation over periods of short-term price spikes. Capacity tickets, on the other hand, present the risk of overcompensation for generators at the expense of consumers as, in the absence of regulatory measures to limit price spikes, generators may attempt to exercise market power over periods of scarcity in addition to receiving the upfront capacity payment.

On the other hand, reliability options present a more complex solution when compared to capacity tickets and may perceived as ‘riskier’ by investors as both a penalty and a commercial incentive for performance are in place.

Ultimately, the benefits of avoiding distortion of competition and trade, protecting consumers and better facilitating innovative technologies may outweigh the downsides of a reliability options scheme.

Table 1 shows the appraisal of capacity tickets against reliability options.

Table 1 – Comparison between capacity tickets and reliability options

EC key CRM features	Criteria	Capacity tickets	Reliability options	Comment
	Security of supply	✓	✓	ROs provide for stronger incentives for capacity providers to perform as both a penalty and a commercial incentive exist
Competition and trade / Cross-border participation	Internal Market for Electricity	✓	✓✓	Capacity tickets risk damaging the underlying energy price signals at times of scarcity, limiting effectiveness of demand side and interconnection. ROs allow for the removal of regulatory interventions, which could result in energy market price distortions, while protecting consumers. Both options could provide for cross-border participation
Technology neutrality and decarbonisation	Technology neutrality	✓	✓✓	ROs protect the underlying energy price signals and avoid price distortions, better facilitating DSR. ROs are more easily adapted to appropriately reward flexible capacity
Competition and trade	Competition	✓	✓	Both schemes allow for competition within the scheme. ROs, however, better facilitate competition in the energy market through limiting energy price distortions over scarcity periods
Competition and trade / Time-bound intervention	Efficiency	✓	✓✓	ROs have the potential to deliver a more efficient outcome in terms of capacity on the system by allowing option contracts with different parameters (strike price, duration and expiry time). ROs protect consumers, making explicit regulatory set price caps redundant
Allocation of costs	Efficient cost allocation	✓	✓	Both schemes aim at targeting costs associated with funding capacity contracts over periods of scarcity and in proportion to the consumers contribution to demand over peak periods
	Simplicity	✓	✗	ROs are more complex than tickets as option settlement has to be considered
	Distributional effects	✗	✓	With capacity tickets there is a risk of overcompensation towards generators (paid by consumers), limited in the RO scheme as there is direct compensation for short-term price spikes
	Bankability	✓✓	✓	In both schemes, penalties should be strong enough to incentivise performance but should also be manageable. The presence of both a penalty and a commercial incentive under ROs may present additional risk for investors
	Robustness and adaptability	✓	✓✓	Both schemes require regulatory intervention and centrally determined parameterisation. ROs provide for flexibility to be adapted to reward capability more appropriately and can more easily be adapted to meet national needs.

Decentralising reliability options promotes 'active' role for market participants and allow for the value of different types of capacity to be revealed

The underlying intent of a decentralised CRM (whether for capacity tickets or reliability options) is to minimise the importance of central decisions and design parameters, and thereby reduce regulatory risk. Gains can potentially be realised from a decentralised approach in setting the capacity requirement and the terms of procurement.

A centralised approach can accommodate the introduction of long-term contracts for new generating units, providing for greater investment certainty and resulting in a lower cost of capital. However, a central agency is more likely to over-procure capacity when compared to market participants, meaning that security of supply is better guaranteed, but that the outcome may be less efficient (with the associated cost borne by customers).

In terms of competition, a centralised platform for selling capacity means there is a common route to the market for all capacity providers, and a simpler product design promotes liquidity. A decentralised approach, on the other hand, adds complexity, and challenges liquidity as the number of products traded increases.

The decentralised model places greater responsibility on market participants and allows them to better optimise their own portfolios. Demand side response is implicitly included whether it participates directly in the scheme or not.

Decentralised reliability options have further advantages over a centralised reliability option scheme. The use of reliability options tends to fit with centralised energy markets, with a 'spot' price which represents the value of energy.

However, under the European Target Model, with Day-Ahead, continuous intraday trading and balancing energy markets, there is no single 'spot' price. The most convenient reference market for a centralised reliability option would be the Day-Ahead market, which will generally have good liquidity. However, the Day-Ahead market is too early for real scarcity to be revealed, and the use of Day-Ahead as the sole choice of reference price would mean that the reliability option does not distinguish between flexible and less flexible capacity. This seems to lose one of the advantages of trading capacity in the form of an option.

The principal advantage of decentralised reliability options is that the options can be struck against different markets, including intraday and imbalance. Therefore, investments in flexibility will also benefit from being able to lock in fixed revenue streams, as well as investments in capacity. Participants may also choose the timing and duration of their contracts and the level of the strike prices contracted, making the trading of reliability options a part of the portfolio of traded products. This freedom will allow value to be revealed for different types of capacity, while allowing the value to adapt to changing system requirements.

Overall, it can be argued that centralised reliability options naturally fit better with more centralised energy trading arrangements, whereas decentralised reliability options are more in line with most European electricity markets, which value bilateral trading and place greater responsibility on market participants.

Table 2 shows our appraisal of centralised against decentralised reliability options.

Table 2 – Comparison between centralised and decentralised reliability options

EC key CRM features	Criteria	Centralised	Decentralised	Comment
	Security of supply	✓✓	✓	A central agency is more likely to over-procure capacity, thus providing for greater security of supply, which may however mean overcapacity and a less efficient outcome, in contrast to a decentralised approach.
Competition and trade / Cross-border participation	Internal Market for Electricity	✓	✓✓	A decentralised approach is more in line with the thinking of the EU Target Model of placing increased responsibility on market participants, whilst allowing them to hedge their position through traded instruments
Technology neutrality and decarbonisation	Technology neutrality	✓	✓✓	A decentralised approach may prove better at facilitating demand side response as retailers have better information regarding their customers' demand elasticity
Competition and trade	Competition	✓✓	✓✓	Centralised procurement provides common route to market for all capacity providers and a simpler product design promotes liquidity. Demand side response is implicitly included (and better facilitated) with a decentralised approach
Competition and trade / Time-bound intervention	Efficiency	✓	✓✓	Decentralised procurement allowing different strike prices, contract duration and expiry of options should allocate resources more efficiently and more appropriately reward capacity for its value to the system
Allocation of costs	Efficient cost allocation	✓	✓	Both options aim at targeting costs associated with funding capacity contracts over periods of scarcity and in proportion to the consumers contribution to demand over peak periods
	Simplicity	✓	✗	(Potential) additional complexity in decentralised option as there may be a variety of contract types
	Distributional effects	✓	✓✓	In a decentralised environment, assuming the development of more than one product, capacity will be rewarded for its real value to market participants and by extension to the system
	Bankability	✓✓	✓	Longer term signals to investors with centralised procurement. More difficult to impose long term obligations on retailers in a decentralised option. However, regulatory risk increases in a centralised scheme due to the importance of centrally determined parameters
	Robustness and adaptability	✗	✓	Decentralised procurement provides for a more flexible framework, able to adapt to evolving market conditions

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Decentralised reliability options – Way forward

We have outlined a straw man design for decentralised reliability options, building on the centralised schemes which have been implemented elsewhere. We have adapted the design to the circumstances in EU electricity markets; with continuous traded markets, growing needs for flexibility, and increasing shares of non-conventional capacity. Crucially, **decentralised reliability options meet the EC's stated requirements** under the State Aid guidelines (which ultimately require efficient operation in the context of the Internal Market for Electricity), while also delivering capacity effectively.

By decentralising the design, the arrangements place less reliance on administrative and policy decisions (with the regulatory risk that this brings), and greater reliance on the decisions of market actors, more in line with the spirit of the EU's Target Model for electricity trading.

Capacity gives an option to deliver energy. By basing the scheme around the pricing of options, the scheme reflects the underlying economics of different types of capacity. As markets change, the value of flexibility inherent in the options will change without the need for clumsy regulatory intervention.

Reliability options are a hybrid, containing commercial and physical (administered) obligations. This hybrid nature is a strength. It makes the scheme suitable for markets with different degrees of sophistication, and allows a transition towards more market based arrangements; moving away from reliance on the physical commitments and penalties, towards reliance on the commercial incentives which are more consistent with the operation of the underlying energy markets.

The underlying principle of decentralisation is that market actors will use innovative means to deliver the necessary level of system reliability, whereas a centralised system will tend to act conservatively and underwrite overcapacity at the expense of consumers. Demand-side response is fully facilitated (both implicitly and explicitly) – a crucial step towards a mature energy market with a fully active demand-side.

In the initial design, an appropriate set of penalties is required to ensure that the market actors meet their obligations, but there is scope to vary the design to strengthen the physical commitment if it is deemed necessary. In time the penalties may be lifted and the commercial incentives, which are inherently part of the option contracts, may suffice for delivering the required amount of reliable capacity.

To underpin these proposals, it is essential that any other distorting features of the electricity markets are removed, in particular balance responsibility for all participants, marginal pricing for balancing energy and imbalance, effective intraday markets and the relaxation of controls or TSO policies which constrain the ability of the market to reveal scarcity. In a further phase of development, the markets would be strengthened by the use of shorter settlement periods and gate closure, by moving the 'main' traded market closer to real-time and by improving the performance of intraday markets.

Ultimately, this blueprint can be applied to all European countries (or regional markets) or just a subset of these. It creates a framework where different countries (or regional markets) can adopt this blueprint or continue with an energy-only market without distorting trade and competition in the underlying energy markets.

Endnotes

1 In principle, under an 'energy-only' market, prices are expected to follow short-run marginal production costs at most times, but when the capacity margin becomes tight, the prices should also reflect the possibility of scarcity. In the short term, these scarcity prices provide incentives for imports from neighbouring areas and for reduction in price-sensitive demand. Over the long term the returns should balance the marginal cost of capacity with its marginal value. In this context, the marginal cost of capacity includes amortised investment cost (net of other revenue), converted to a cost per MWh of delivered energy. The key unknown is the number of hours in which the marginal capacity is needed.

2 Ideally, the marginal value would be defined by price-responsive customers, but in practice most demand does not face spot prices, and electricity markets generally use a deemed 'value of lost load' and an administrative process for disconnections at times of scarcity.

3 DECC has confirmed that in the next GB capacity auction to be held later in 2015, interconnectors will be eligible for one year contracts.

4 The Target Model is a combination of (to be) legally binding Codes on Forward markets, Capacity Allocation Congestion Management and Balancing. In addition to the Target Model, the vision of the Internal Market for Electricity is being built through the creation of ACER and ENTSO-E, with their specific obligations on cross-border network coordination, planning and pricing; and a series of additional Codes (under development) which improve coordination in planning and operational timescales.

5 Price areas are intended to reflect network congestion (subject to national approval) and the areas may join or subdivide countries. For convenience we will use the terms "cross-border" and "interconnector" to denote the price areas and the network capacity between them.

6 Physical forward capacity rights give the holder an option to nominate a physical flow between the two price areas. If the right is not exercised, the capacity is allocated to the day-ahead market and the holder receives payment for the use of the capacity based on the price differential (if any) between the two areas.

7 At the time of writing (January 2015), day-ahead electricity market coupling is in place across 17 countries, with Italy and Slovenia expected to join shortly. There is a separate Czech-Slovak-Hungarian-Romania market coupling process and another for Italy-Slovenia, with plans for continued integration.

8 Generation Adequacy in the internal electricity market – guidance on public interventions; Commission Staff Working Document; 2013

9 Guidelines on State Aid For Environmental Protection And Energy 2014-2020; European Commission; 286.2014

10 Decentralised reliability options may also be settled physically, in which case the holder of the option may choose to exercise the option in the form of a notified energy trade.

11 Also, the obligation may extend to potentially large customers and distribution companies if they have to buy losses.

12 Capacity providers may potentially include generation, storage demand side providers and interconnected capacity.

13 These objectives are often repeated, and were set out (for example) in EC Communication 'Energy 2020 – A strategy for competitive, sustainable and secure energy' – ref COM(2010) 639, 10 November 2010.

14 The State Aid Guidelines are part of an initiative which "aims to create a framework for policies to support the shift towards a resource-efficient and low-carbon economy which helps to: (a) boost economic performance while reducing use of resources; (b) identify and create new opportunities for economic growth and greater innovation and boost the Union's competitiveness; (c) ensure security of supply of essential resources; (d) fight against climate change and limit the environmental impacts of the use resources.

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1. BACKGROUND: WHAT A CAPACITY MECHANISM SHOULD ACHIEVE

1.1 Introduction

This paper describes a new form of capacity remuneration mechanism – **decentralised reliability options** – which is intended to meet the requirements of the Internal Market for Electricity. Electricity is traded across Europe across a range of timeframes, in the face of growing levels of weather variable renewable generation, and this presents challenges for existing designs of capacity market. The design is compared with similar schemes and we outline its relative advantages and disadvantages, and a potential transition path which would allow the scheme to become streamlined as conditions permit.

1.1.1 Background

The EU is moving towards greater harmonisation of electricity markets through the implementation of the EU Target Model. At its heart is a system for trading energy between price zones (or countries), in which the spot market prices determine the flow of energy between zones. The Internal Market for Electricity is intended to be the central element of an integrated pan-European market which supports integration of renewables.

Generation adequacy is a highly political issue for Member States. As a consequence, any material risk of disruption to supply carries a high probability of intervention by Member States. This issue in itself could undermine the prospect of an energy only market delivering adequate generation capacity. It also creates a tension between the EU Target Model – with its vision that security of supply can be most efficiently met by a regional approach – and national considerations over generation adequacy. As a result of this tension, the European Commission ('EC') has published regulation covering national generation adequacy mechanisms, requiring that they respect cross-border integration and avoid market distortions[1].

From an investor's point of view, investments in new thermal generation capacity have traditionally been based on the expectation of future returns. Implicitly, in the revenue forecasts was an expectation of some level of scarcity revenue, which ultimately would permit timely investments in generation to recover their long run marginal costs.

The introduction of large volumes of renewable generation has challenged this investment paradigm. The volumes generated by thermal operators are decreasing, and instead of meeting system demand; conventional plants now need to meet system demand less weather variable renewable generation. However, from a system security point of view thermal generation is still required to cover periods of low renewable generation. Thermal plants are becoming increasingly risky investments as their revenues are squeezed into fewer hours of operation.

In order to secure generation adequacy, a number of Member States are introducing Capacity Remuneration Mechanisms ('CRMs'), with advanced schemes for EU countries including GB, Ireland, France, Belgium, Italy, Spain, Greece and a lively discussion

[1] A summary of the European Commission's guidance for CRMs is provided in Annex A, based on the 'Guidelines on State Aid for environmental protection and energy 2014-2020' and the working document 'Generation Adequacy in the internal electricity market – guidance on public interventions'.

underway in Germany. These Member States are each proposing (or implementing) different designs of CRMs based on national circumstances and to address specific national problems, with little consideration for the implications for trade. Other countries maintain their confidence in the ability of energy only markets to maintain security of supply and are unlikely to introduce CRM schemes.

There are growing concerns that these interventions will hamper progress towards the Internal Energy Market, with the European Commission, ACER, ENTSO-E, EURELECTRIC and EFET all voicing concerns about the impact of unharmonised CRMs and the need to respect cross border trade and competition. Although there has been some discussion of regional approaches to capacity adequacy, there have been no concrete steps in this direction even between adjacent markets which are (separately) planning to introduce their own schemes.

1.1.2 Complicated problem, complicated solutions

There are concerns over whether or not a form of energy-only market will solve the capacity adequacy problem. In theory, an energy-only market should produce an efficient market and create the right investment signals when scarcity exists in the market, but this relies on a series of supporting assumptions which are not met in many markets. In particular, there is concern that the very high prices needed for the very few hours to incentivise new capacity will not be politically acceptable or deemed commercially viable by investors.

In an energy-only market, thermal plant operators must rely on capturing very high prices when there is real scarcity in the system (when the wind is not blowing and the sun not shining) to cover investment costs and fixed operating costs. However, with increasing renewable generation, this carries far higher risks and uncertainties as there are fewer hours to capture the revenues which have to cover fixed and capital costs. In an energy-only market, price volatility would need to reach extremely high levels for investment in new capacity to be viable. At the same time, hedging instruments to protect against this volatility are not widespread. Moreover, there are systematic issues in some markets which mean that scarcity pricing is unlikely to deliver the prices necessary to build and maintain adequate capacity.

CRMs could help solve the problem of generation adequacy by ensuring a separate revenue stream to enable owners of (existing and new) capacity to cover fixed and capital costs. However, CRMs bring other risks, including:

- market distortions;
- hindering progress towards the Internal Market for Electricity;
- disruption of cross-border trade;
- supporting the wrong type of capacity; and
- blocking demand responsiveness to market conditions.

Potential distortions to cross-border trade could be severe if a patchwork of national CRMs is introduced, and this could set back the vision of the Internal Market for Electricity, replacing it with one in which each individual country seeks to be self-reliant. There are concerns that Europe is heading in this direction at the moment. The proposed CRM schemes each have different designs, complicating or even blocking trading of capacity between countries while distorting energy trading. Each of the CRM designs currently under discussion is expected to have its own distinct influence on spot energy prices. Under the EU Target Model, the spot price is intended to determine the direction of trade between different EU price zones. A further unintended consequence of national CRMs could be that by distorting cross-border trade, unharmonised CRMs could undermine their own operation and threaten investment in interconnection, further damaging system adequacy.

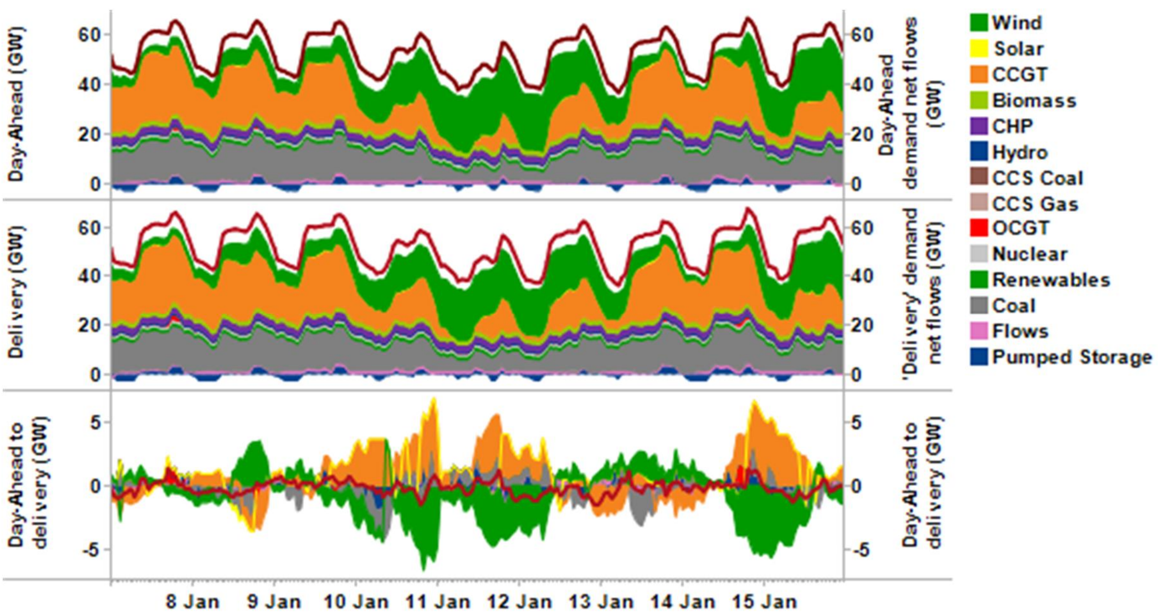
CRMs will have to be flexible enough to cope with structural shifts in power markets without regulators altering the design of the scheme. In some markets there is a perceived overcapacity, which could turn into under-capacity if extensive closures are implemented. In other markets, retirement of existing plant (due to legislation or profitability issues) is already leading to fears of a shortage of supply.

While a clear, transparent and credible CRM could encourage investment in generation capacity, there are still questions around whether any scheme will incentivise enough of the right type of capacity (determined by market needs at the time). The latter point is especially relevant as numerous market simulations point toward the need for greater flexibility in the future system.

1.1.3 The need for flexibility

For conventional generators, the continued growth of renewables means that output levels are expected to further decrease, and the level and timing of production will become more unpredictable. This uncertainty continues close to delivery time as the forecast weather patterns change. Figure 3 gives a flavour of the future expected generation patterns as well as the expected scale of re-scheduling between Day-Ahead and delivery due to wind and demand forecast error and generation plant failure.

Figure 3 – GB plant operating patterns for a sample week in January 2020



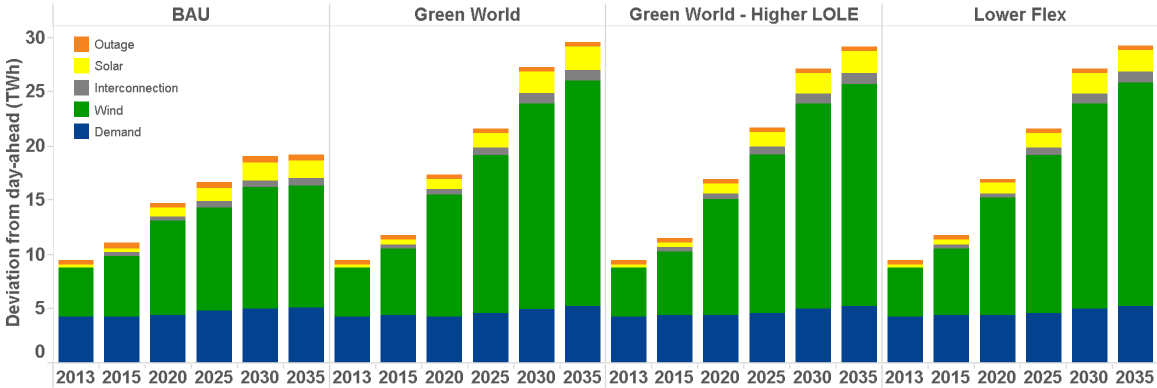
Source: Pöyry Management Consulting (The value of within-day flexibility in the GB electricity market', February 2014)

As forecasts continue to be updated within-day for growing volumes of renewables, the need for flexibility from conventional generation – and other sources such as demand side response – will continue to rise.

The new system dynamics will bring about changes in trading and contracting. As output from conventional generation falls, traditional fixed volume forward contracts for baseload or block production patterns become less appropriate as a hedging instrument. The need for intraday trading, with instruments to hedge intraday volume risk, will also grow. The timing of production for many plants will become very unpredictable until a few days ahead, meaning that any forward commitments will have to be re-traded as forecasts mature to fit conventional plant output around the variable renewable generation. Existing energy markets can be used hedge price risk, but new instruments will be needed to cover the growing volume risk.

For most of Europe, Day-Ahead markets have become the predominant source of spot pricing and dispatch patterns, with intraday trading and re-scheduling at low levels (arising mainly from generation failure and demand forecast error). As variable renewable generation grows in importance, its contribution to forecast error will grow sharply. We have modelled this for GB and Ireland (which have high wind and moderate levels of solar generation)[2] and the breakdown of intraday deviations for GB is presented in Figure 4. In summary; by 2015, wind will surpass demand as the biggest cause of intraday uncertainty, with total intraday re-trading requirements almost doubling by 2020 in most scenarios tested.

Figure 4 – Projected annual intraday deviations (from Day-Ahead to out-turn) in GB



Source: Pöyry Management Consulting ('The value of within-day flexibility in the GB electricity market', February 2014)

Not all capacity provides the same contribution to system reliability. Having adequate capacity (measured in MW) does not guarantee security of supply. What is needed is capacity which is capable of responding to changing circumstances, accommodating shocks from increasing levels of weather variable generation on the system. However, the system needs for flexibility will change as the generation mix evolves, as demand becomes more responsive and as forecasts improve.

CRMs – if they are to be effective long-term elements of the market design – will need to have the capability to accommodate the changing needs for flexibility, complementing the operation of the energy market.

1.1.4 Is there a more long lasting design of a CRM?

There is a need for an alternative market-based solution to the national solutions being considered and implemented, which could be adopted as a Europe wide CRM reference

2 An equivalent chart for Germany would show an even larger contribution to this forecast error from solar generation.

model that does not require all markets to adopt a CRM. This CRM reference model should be implemented without causing distortions with neighbouring energy-only markets.

At a high level, the reference model should fully embrace the concepts of CRMs while delivering an investable market solution, and at the same time address the generation adequacy issues that are currently driving the development of CRMs. However, the ways in which the high level requirements filter down to choices in CRM design are not straightforward. The next section presents the key principles that a reference model CRM should adhere to.

This concept of a CRM is ultimately founded on concerns that ‘the lights will go out’. This could arise if real time demand response to prices is not enough to balance the system. In these circumstances the selection of demand to be curtailed and the assumed cost of this curtailment are administrative decisions. With a fully functioning demand side to the market, the market could clear at any price and the need for mandatory capacity arrangements would diminish. This should be the ultimate goal for energy markets.

1.2 Evaluation criteria for comparing CRM designs

The three underlying objectives of European energy policy are security, affordability and sustainability[3]. In order to assess the merits of decentralised reliability options against alternative forms of CRMs, we have drawn up a set of evaluation criteria. Market design assessments are by definition subjective, but we have selected a set of issues derived from the three underlying objectives which are designed to test the differences between schemes.

The EC has produced a Staff Working Document[4] and has implemented revised State Aid Guidelines[5] covering capacity adequacy mechanisms[6] which have legal force from 2014 to 2020. These documents set out a number of criteria intended to limit the potential negative impact that a national CRM would have on the Internal Energy Market, and we present a summary of their conditions and recommendations in Annex A.

The EC requirements may be summarised as dealing with the **efficiency** of any scheme (which is related to the underlying objective of affordability), within the context of the Internal Market for Electricity. As well as a scheme being efficient, it needs to be **effective** in delivering the objective of security**.** We consider that the role of a CRM is not to promote environmental sustainability directly but rather to ensure that capacity is built to support the changing generation mix. Figure 5presents the criteria which we

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3 These objectives are often repeated, and were set out (for example) in EC Communication ‘Energy 2020 – A strategy for competitive, sustainable and secure energy’ – ref COM(2010) 639, 10 November 2010.

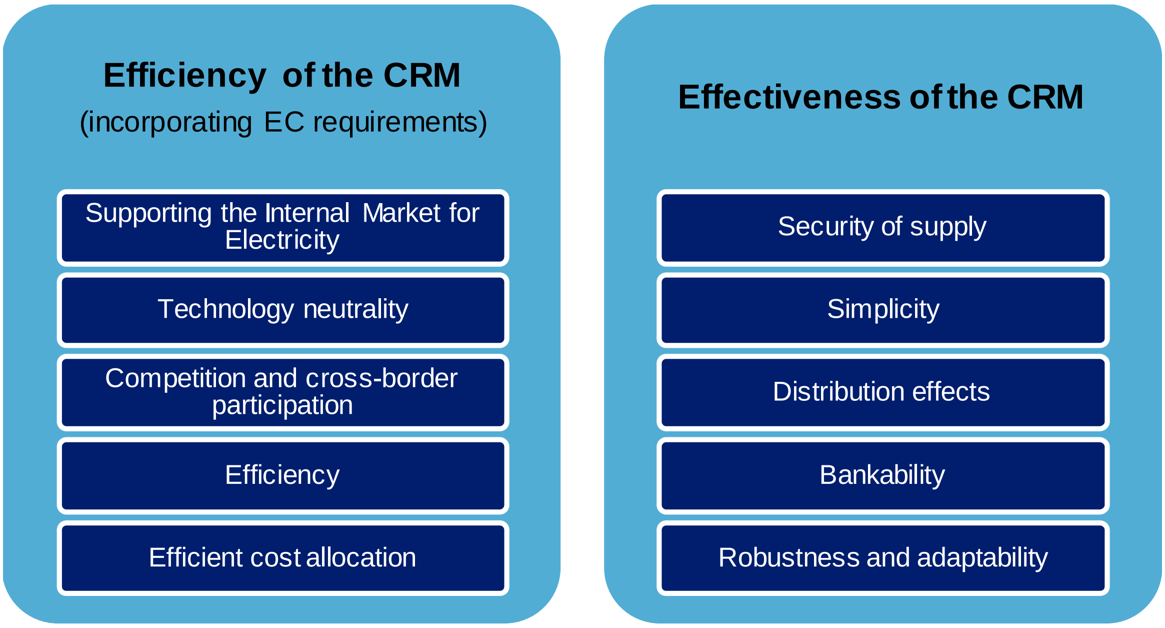
4 Generation Adequacy in the internal electricity market – guidance on public interventions; Commission Staff Working Document; 2013

5 Guidelines on State Aid For Environmental Protection And Energy 2014-2020; European Commission; 286.2014.

6 The State Aid Guidelines are part of an initiative which “aims to create a framework for policies to support the shift towards a resource-efficient and low-carbon economy which helps to: (a) boost economic performance while reducing use of resources; (b) identify and create new opportunities for economic growth and greater innovation and boost the Union’s competitiveness; (c) ensure security of supply of essential resources; (d) fight against climate change and limit the environmental impacts of the use resources.

have selected against which to compare different designs for CRMs, with further detail below.

Figure 5 – Evaluation criteria for assessing different CRM designs



1.2.1 Description of evaluation criteria

1.2.1.1 Supporting the Internal Market for Electricity

The reference model should facilitate cross border trading in all timeframes: forward, day-ahead, intraday, balancing (of capacity as well as energy). It should avoid boundary effects which create distortions (including if adjacent markets do not adopt a similar scheme). There should be no national price caps or bidding restrictions. Ultimately, the CRM should not distort energy trade or investment decisions across borders, either directly or indirectly.

1.2.1.2 Technology neutrality

The reference model should be technologically neutral, open to both new and existing capacity. Technology types eligible for participation should not be predefined, but rather criteria for participation should be based on technical characteristics required to meet the system requirement and ensure generation adequacy and reliability of the system. Discrimination against (or for) demand-side or other innovative technologies should be avoided. Demand-side response, in particular, can play a particularly important role[7].

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[7] Any customers whose consumption responds to the spot price can effectively declare their own requirement for security of supply, and a medium term goal should be to increase the scale of demand response. With smart metering it would be theoretically possible to target selective disconnections of customers with a different value for reliability.

1.2.1.3 Competition and cross-border participation

The reference model should promote competition between market participants both within the scheme and in the energy markets. The scheme should be market-based, revealing equal value for equal service and the price should be responsive to market conditions. Capacity across borders should be able to participate in the scheme on equal terms, as long as cross-border network capacity is made available.

1.2.1.4 Efficiency

The reference model support efficient decisions on market entry and exit. Market distortions should be minimised, so as to facilitate market based decisions both within the CRM and the energy-only market. Scarcity in spot energy pricing should be maintained and price caps should be avoided. Aspects of the scheme, including penalty arrangements, should not result in inefficient short-term production patterns by generating units.

1.2.1.5 Efficient cost allocation

The reference model should allocate costs of the scheme to consumers in proportion to their contribution to demand over periods of scarcity. Cost allocation should be carried out in a transparent and non-discriminatory manner.

1.2.1.6 Security of supply

The reference model, in conjunction with the energy market, should ensure security of supply, meaning that enough of the right type of capacity is invested in or maintained on the system, as determined by market fundamentals. These requirements may change over time as the system evolves.

1.2.1.7 Simplicity

The reference model should be simple for market participants and investors to understand and to participate in, as well as straightforward to set up and administer.

1.2.1.8 Distribution effects

The reference model should manage the distribution of surplus between consumers and generators in an equitable manner, without facilitating the exercise of market power8.

1.2.1.9 Bankability

The reference model should be deemed stable, reliable, transparent and credible by investors, therefore creating an investable environment with minimal regulatory intervention and avoiding retroactive changes. Regulatory risk should be minimised by including forward visibility for key parameters and decisions and minimising the impact of regulatory choices, thus avoiding replacing market risk with regulatory risk. This implies that decisions should be decentralised where possible, allowing participant's opportunities to hedge market risk. Transparency and liquidity are important features for investors.

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[8] Ultimately, market power cannot be remedied by design of the market arrangements alone – separate competition or regulatory processes may be required – but ideally the design of the scheme would not aid and may help to mitigate the exercise of market power.

1.2.1.10 Robustness and adaptability

The reference model should be stable (in the long term) but also adaptable (including to the circumstances of different Member States). The reference model needs to have the flexibility to evolve and respond to market changes (for example, the expected increasing need for flexible capacity) through shifts in the value of the products rather than through regulatory rule changes.

2. DECENTRALISED RELIABILITY OPTIONS

2.1 Alternative CRM designs– focus on quantity-based schemes

Capacity schemes take various forms, often categorised into ‘targeted’ (paying specific types of capacity) or ‘broad’ (paying market-wide); and price-based (prices are centrally determined and paid to all) or quantity-based (prices arrived at through competition between providers). A decentralised reliability option scheme is a market-wide, quantity-based scheme.

We consider that price-based schemes are *de facto* excluded by the State Aid Guidelines based on a combination of requirements: that the mechanisms should be designed to deliver a price of zero when there is sufficient capacity available; that price caps or bidding restrictions should not be implemented to offset impact of mechanisms on prices; and that mechanisms should not adversely affect the operation of market coupling. Such schemes are not considered further in this paper.

Targeted CRMs are designed to support specific capacity. If this capacity also operates in the wider energy markets, then in most circumstances the result will be to undermine the resulting energy prices for remaining capacity, ultimately leading to a need to extend the scheme towards a market-wide design.

A more sophisticated design for a targeted CRM is a strategic reserve mechanism, which is in operation in a number of countries including Sweden and Finland. Strategic reserve is contracted capacity which is ring-fenced from the energy market, and the scheme is intended to safeguard customers against supply interruptions while allowing market prices to reflect scarcity. Strategic reserve may be a useful measure in certain circumstances (e.g. as a transitional measure or to isolate the energy market from political intervention), but it is a separate market and cannot substitute for a mainstream energy market which has sustainable investment incentives.

Therefore, within this paper we focus our efforts on market-wide, quantity-based schemes. This covers reliability options (whether centralised or decentralised) as well as centralised capacity auctions and decentralised capacity obligations. A brief comparison of these designs is provided in Annex C.

Reliability option schemes are a form of CRM which are in operation in Colombia and New England, and proposed for Italy and Ireland. They combine market-based incentives to build and maintain capacity to a centralised security standard with incentives and commitments for that capacity to be available to the system at critical periods. These dual incentives are achieved through a combination of a commercial ‘option’ contract and a physical commitment.

Reliability options have until now been implemented as a centralised system in which generation is contracted by a central agency on behalf of customers. The details of schemes differ but the designs implemented to date are similar, with the option contracts linked to a single spot energy market (typically day-ahead). The physical obligations in the existing schemes are linked to a concept of ‘availability’[9].

9 The physical commitment in existing schemes is defined in terms of MW “available” without conditions on notice to deliver, which does not necessarily mean that the capacity makes a useful contribution to system reliability at critical times.

This section outlines a concept for **decentralised** reliability options, which are intended for energy markets in which trading takes place continuously across a range of timeframes rather than a single spot market.

At its simplest, a decentralised reliability option scheme introduces a set of contracts between capacity providers and (indirectly) consumers. Retailers are required to buy reliability options to meet their demand at critical times. Sellers of reliability options commit their availability at critical periods and forego revenue from price spikes, in return for which they receive a stable revenue stream.

The contracts are a hybrid between a call option (which is essentially commercial) and a physical commitment to make capacity available to the system at key times. The call option introduces a financial settlement (aside from the physical commitment and penalty arrangements), whereby the seller of the option returns the difference between the reference market price and the strike price, if any, to the buyer[10]. Customers benefit from security of supply to an agreed standard, and their exposure to scarcity pricing is reduced in return for an up-front fee.

The decentralised nature of the scheme leaves local policymakers freedom to choose important implementation details (which include the degree of decentralisation itself). The following section describes one variant of a decentralised reliability options scheme, while noting possible design choices.

2.2 High level description of reliability options

At its simplest, a reliability option scheme introduces a set of contracts between capacity providers and (indirectly) customers. The total capacity requirement is centrally calculated by the TSO to meet a policy-defined security standard, either expressed as fixed MW total, or with an in-built price-quantity demand relationship[11].

Sellers of reliability options commit their availability at critical periods and forego revenue from price spikes, in return for which they receive a stable revenue stream. Customers benefit from security of supply to an agreed standard, and their exposure to scarcity pricing is reduced in return for an up-front fee.

The contracts are a hybrid between an option contract (which is essentially commercial) and an obligation to make physical capacity available to the system at key times. The contract includes two main commitments.

- The first (commercial) element of the contract is a call option, settled against a reference spot energy market. The strike price and the reference market are determined when the contract is agreed. When the contract is operational, during the commitment period it gives the holder the right to call for energy (or cash settlement) at the agreed strike price. The option would be exercised (i.e. the seller would have to make a repayment) when the spot price s rises above the strike price k.
- The second (physical) element of a reliability option is an obligation for the capacity to be available when required. This physical element means that the contracts cannot be sold by purely financial players, but must ultimately be backed by ‘real’

10 Decentralised reliability options may also be settled physically, in which case the holder of the option may choose to exercise the option in the form of a notified energy trade.

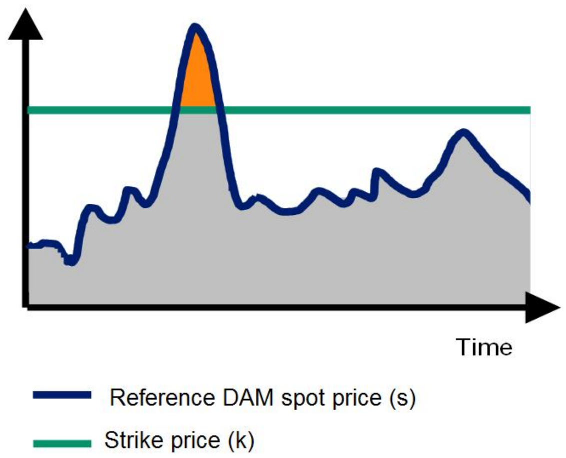
11 Also known as capacity demand curve.

physical capacity. Adherence to physical conditions would require validation by a central body (e.g. TSO), with penalty arrangements for failure to deliver at critical periods.

In return for these commitments, a fixed fee is paid to the seller of the option, agreed at the beginning of the contract. Other terms would also be defined, including the contract duration, any restrictions on the delivery periods for the option and/or the obligation, and any indexation terms for the strike price.

While the contracts are in place (during the commitment periods), each time the spot energy price rises above the predetermined strike price for the contract, the seller is obliged to compensate the holder of the option for the difference between the strike price *k* and the actual spot price *s,* as shown in Figure 6.

Figure 6 – Illustration of reliability option operation in Day-Ahead Market



In an example from the Day-Ahead market timeframe, the reliability option is automatically activated whenever the reference spot price exceeds the strike price. During these periods, the RO is exercised, and the sellers must compensate option holders for the differential between spot and strike price (the orange area).

The physical conditions would apply only at or close to times of capacity shortage (which could be measured in terms of energy curtailment or a shortage of operating reserves). If contracted capacity is unavailable at these critical periods, additional penalties would be applied[12]. The terms would be defined at the outset of the contract (although the actual penalty price might be set based on market outcomes).

Existing reliability option schemes do not place obligations on energy delivery or flexibility, just for the capacity to be operational (i.e. available, although not necessarily capable of responding in time to prevent the capacity shortage[13]). Performance against this obligation would be assessed by the TSO after the event. In a decentralised

12 It has to be noted that the New England scheme did not use to have additional penalty arrangements in the past. Such penalties have been recently introduced.

13 In New England there has been a reduction in generator reliability over time despite the use of a reliability options capacity mechanism. The problem is attributed to a range of design factors; insufficient penalties, a low likelihood that the physical conditions will be invoked (free-riding), with exclusions from penalties, as well as targeting “availability” rather than useful capacity. A revised scheme is under consideration (subject to FERC approval) which would require the capacity to be useable at critical periods; i.e. delivering either energy or reserve, and strengthen the penalty provisions.

scheme, the degree of flexibility of the capacity can be determined by the buyer and seller of the reliability options in their choice of reference market and expiry time.

Together, the commercial and physical commitments ensure that consumers receive compensation at times of price spikes, with a guarantee of physical availability to the system to meet an agreed reliability standard (although as noted above, with no specific requirements on flexibility or usability of the capacity).

Any uncontracted capacity (i.e. capacity without a reliability option) may have an opportunity to sell later in a secondary market, to profit from any spot price spikes, or to receive over-delivery payments at times when there is a capacity shortage.

2.3 Mechanics of reliability options

2.3.1 Features specific to a centralised reliability options scheme

In a centralised system, an agent would act on behalf of customers by conducting an auction between capacity providers to buy the overall capacity requirement (explicitly allowing for contingencies to meet the agreed security standard). Typically, the auction would be held several years in advance of the commitment period, to allow time for new capacity to be built after the auction.

Auction participants could include generation, demand reduction, and potentially cross-border capacity; subject to meeting eligibility criteria. Each eligible provider would be given a de-rating factor by the TSO[14], reflecting the reliability of the capacity resource at critical times. Any cross-border capacity would also have a limit based on the TSO's expected contribution of interconnection at the critical periods[15].

The contract would include a definition of physical availability, to be applied once the contract is operational (during the commitment periods), and the penalty arrangements for failure to deliver would be defined. If the arrangements are intended to deliver new capacity, it is essential that any liabilities under the scheme are defined, understood and manageable. Unlimited liability is not conducive to investment. That said; liabilities should be sufficient to incentivise delivery of capacity in the long term and availability and usability in the short term so that reliability options do not become 'free' options.

The central agent would set the strike price for the options[16] and the chosen spot energy market against which the contracts are called. The contract duration, commitment periods and other terms would be defined (perhaps with longer contracts offered for new build[17] or refurbished capacity). The strike price in a central scheme is set at an agreed level above the marginal cost of the most expensive capacity.

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14 This de-rating factor would be calculated by the TSO (based on historic contribution) and could be technology-specific or unit-specific. In New England the derating factor is open to negotiation based on past trends, planned improvements etc.

15 Contracts with interconnected capacity could in principle be sold by the generator or the interconnector operator.

16 The strike price should be set at a level intended to be high enough to avoid distorting dispatch in the spot market, while giving customers protection from high spot prices. The strike price for longer term contracts might include indexation terms.

17 New build contracts are available for up to seven years in New England.

Would-be sellers submit competing bids for their fixed option fee. The auction would be cleared, resulting in a set of contracts for the target volume (perhaps using some administrative price/quantity trade-off), with a single clearing price for the option fee for contracted capacity. Capacity which is unsuccessful in the auction would remain uncontracted, although there may be opportunities to sell later in a secondary market.

There would need to be a mechanism to allow committed capacity providers to re-trade their reliability options, (e.g. to reflect changes alterations in plant reliability, embodied in the plant de-rating factors; changes in maintenance plans or delays in construction).

In a centralised system, a mechanism would be required to recover the cost of buying the options from customers (net of receipts from the option payments and any penalties). These costs would typically levied on retailers based on their share of consumption at the times of peak demand (or minimum system margin)[18].

2.3.2 Features specific to a decentralised reliability options scheme

In a decentralised system, an obligation would be placed on each supplier[19] to buy reliability options to meet its total MW requirement, measured against its out-turn demand. To aid transparency, the total system-wide obligations at critical peaks would be forecast by a central agent a few years in advance[20]. Procurement of reliability options would be carried out directly by retailers or other agents responsible for demand.

In terms of capacity requirements, our reference point is a scheme in which retailers are obliged to cover their **actual demand** over periods of scarcity without any additional security margin[21].

Capacity providers would be entitled to sell reliability options based on their **own firm capacity estimates**. There would be no enforced reductions in capacity (de-rating) based on actual performance, and any capacity sales would be firm (at the risk of the

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18 The cost allocation to retailers is important, as it provides incentives for demand response. As far as possible, this mechanism should be cost reflective, to give efficient incentives for demand response.

19 The obligations would be placed on all parties with responsibility for procuring energy at wholesale level. In some markets this is limited to licenced (or licence-exempt) retailers. In other markets it could include large customers and/or grid operators which must buy energy to cover losses.

20 The overall forecasting of demand and capacity requirements would be done by the TSO, to cover demand conditions which match the policy standard for reliability. For France this is deemed to be a one-in-ten year winter (initially assuming a peak demand temperature of -2.6°C). The actual obligations on retailers would only be binding close to delivery.

21 Under a slightly more centralised design, retailers could be required to meet a reliability margin on top of their actual demand. This is not a fundamental design choice; under either alternative we expect that the penalties for under-procurement would lead retailers to procure a margin over their actual demand.
For example, in the proposed French capacity mechanism (which is a reliability obligation rather than a reliability options), retailers are required to buy capacity certificates which cover an extreme (one-in-ten year) winter demand. To measure compliance, their actual demand is adjusted to match the extreme winter level (using a predetermined temperature adjustment). The adjustment is applied to different classes of demand depending on their weather sensitivity. This is possible because temperature is the major determinant of electricity demand uncertainty (due to a prevalence of domestic electric heating) and because the sensitivity to temperature is well understood.

provider). Sellers of capacity must meet the physical conditions at the delivery time but would not otherwise be subject to binding eligibility criteria[22].

Even though procurement is carried out in a decentralised fashion; a central agency would have a key role in facilitating the market, and a central platform with some standard products could be provided to aid liquidity and transparency.

2.3.2.1 Role of the TSO in a decentralised reliability option scheme

As in a fully centralised scheme, the definition and measurement of supplier obligations and physical obligations for capacity providers, rules for performance testing, and the settlement for failing to meet commitments (or over-delivering on the physical obligation) would be defined by the TSO or another central agent.

Market participants would collectively be responsible for ensuring that the capacity market was in balance. This requires a high level of transparency. To aid market discovery[23] the TSO would forecast total system demand 3-4 years in advance and could also publish indicative de-rating factors for capacity providers (not binding for trading) to inform retailers and capacity providers.

Buyers and sellers could choose when to conduct trades, but would be obliged to notify both contracted and cumulative open volumes up to a few years in advance. At all times a central agent would log trades between market participants and would publish information on the cumulative and net expected position, with regular updates[24]. With appropriate incentives for under- and over-provision of reliability compared to contracted levels, and good systems tor transparency, the system should ensure that there is no under-provision or over-provision of capacity.

For the commercial aspect of the options, the central agency would define a default (minimum) specification of the 'quality' of the options which must be bought by retailers, both in terms of the (maximum) strike price and the reference market against which the options would be called. This minimum specification is intended to ensure that no party can free-ride on the reliability provided by other market participants.

As in the centralised scheme, there would also need to be a mechanism for participants to re-trade the reliability options (e.g. to reflect changing market shares or changes in maintenance plans).

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22 We expect that generators which had entered firm contracts would buy back-up options from other providers (in advance or close to real time) to ensure that they had an appropriate safety margin. Under a more centralised design, capacity providers would only be entitled to sell reliability options only up to a centrally calculated limit, based on a calculated derating factor. Again, this is not considered a fundamental design choice; under either alternative the penalties for under-delivery should lead capacity providers only to sell according to their level of reliability and not to (collectively) over-commit.

23 The TSO will have its own view on the collective forecast level of demand and weather variable generation, as well as plant reliability. If information is based on conducted trades then it can provide with a cumulative view of whether the system is long or short and the amount of uncontracted capacity.

24 This could draw on the provisions of Transparency Regulation 543/2013 under which all generation units larger than 100MW must report their availability with forecast 3 years ahead, with additional information on interconnector flow, outages etc. The provisions could be extended to all providers of decentralised reliability options.

2.3.2.2 Nature and terms of the reliability option contracts

The default contract type would be for financial settlement against the Day-Ahead price, in addition to the physical obligation. Market participants could trade these default contracts or opt for higher quality options (in terms of lower strike prices, or later notice periods). Trades of reliability options would be 'firm', and the physical obligations (and any penalties) would ultimately be the responsibility of the sellers. By allowing different strike prices to be set, the buyers are able to choose their level of cover against price volatility, rather than having a one-size-fits-all approach. This would permit a higher (maximum) strike price to be set in a decentralised scheme than under a centralised reliability option, with a lesser impact on the formation of spot energy prices.

In addition to agreeing different strike price for the reliability option contracts, buyers and sellers could also opt for a different reference market for the spot price (i.e. the expiry time or maturity of the contract), which could include the Day-Ahead, intraday (at any agreed time) or even balancing/imbalance markets. As with any other bilateral contract, participants could also agree when to conduct trades and the contract duration[25], as well as any restrictions on ramping, minimum take provisions etc. The physical conditions of the reliability option scheme must still be met for the trade to count as a qualifying trade against the supplier's obligation. 0 presents a set of worked examples illustrating a range of contracts.

Unlike a fully centralised scheme, which we anticipate would adopt a Day-Ahead market as the reference for settlement of the options, a decentralised scheme would find a balance between the flexibility needs of the buyers (e.g. demand uncertainty at different times) and the flexibility of the sellers, and a balance of contracts would be struck with different degrees of flexibility. A shortage of flexibility in a particular timeframe would lead to that class of decentralised reliability options increasing in price.[26] As the market need for flexibility changes, the prices would reveal the need for different types of capacity without the need for regulatory intervention.

Ultimately, the need for real-time flexibility is dealt within the commercial aspect of the options; market participants who need flexibility can buy options with delivery close to real time. This would give strong incentives for the capacity provider to be capable of delivering in the time for expiry of the option contract. Participants with demand uncertainty (or seeking cover for short term generation failure) would be incentivised to buy more flexible options.

2.3.2.3 Reliability options settlement

Traditionally, reliability options have been implemented as financial derivative contracts (one-way CFDs settled against a physical spot market), with the seller paying the holder in cash the difference between the spot price s and the strike price k (when $s > k$); as illustrated in Figure 4 above.

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[25] For longer term contracts, provisions would be needed in case the physical obligations and/or penalty arrangements changed during the contract term.

[26] Some centralised capacity schemes do attempt to distinguish between different classes of plant, but in a highly administered way. The existing Greek scheme offers double certificates to plants declared 'flexible', and the latest proposals for the future Greek market would limit the capacity scheme only to flexible generation. For the proposed Italian RO scheme, there have been discussions around having a two-tier system, with separate auctions for capacity and flexible capacity.

Decentralised reliability options could also use physical settlement[27]. A physically settled option contract would need a strike price and an expiry time (notice period), but not necessarily a reference price. The holder could, at his discretion, call the option at (or before) the expiry time [28] (subject to any agreed conditions on exercise of the contract), irrespective of the spot market price at that time.

For options which expire intraday, there is unlikely to be a robust reference price against which to settle a financial derivative due to the continuous nature of the intraday market[29]. We expect that intraday option contracts would be 'physical' in nature.

If the option is settled against the balancing and/or imbalance price then the contract could be financial or physical in nature, depending on the precise arrangements for balancing and also for imbalance pricing in the market[30].

2.3.2.4 Obligation for delivery and penalty arrangements

The ultimate obligation to hold the capacity options would apply to retailers *ex-post*, based on metered demand. Any supplier which had failed to meet its obligations to procure capacity (according to its actual demand at the critical period) would be subject to a capacity settlement.

Similarly, capacity providers which failed to meet the physical conditions for availability would also face capacity settlement arrangements. The physical conditions of the reliability options contracts should be designed to ensure that the contracted capacity is available at critical system periods and also capable of meeting the flexibility requirements consistent with the expiry of the commercial option[31].

Trading of reliability options would be permitted after the event to allow any surplus and shortfall to be re-traded between participants before the capacity settlement arrangements apply. The capacity settlement mechanism should be designed to incentivise retailers not to under-procure, capacity providers not to over-commit and perhaps to compensate any customers which are involuntarily disconnected.

Ultimately the settlement prices could be based on the value of lost load in the event that there was a shortage of capacity, with lower charges for less extreme events. The capacity settlement mechanism should also reward any over-performance from uncommitted capacity providers at these times.[32]

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27 An option is 'physical' in the sense that when it is exercised by the buyer, it is treated as a firm energy trade, and notified as a MWh transfer between their balancing accounts.

28 Call options can take various forms. European options may only be called at the expiry time (maturity). American options may be called any time until maturity, and Asian options are financially settled against an average price over a time window. In principle any of these could be used for intraday trading, although the American option seems to be the best fit.

29 If liquid intraday auctions for energy trading are developed, then financial intraday option contracts could be struck against them.

30 These issues were described in our 2011 paper on Balancing Resource Options www.tinyurl.com/poyryPOVBRO

31 Some US capacity schemes are proposing changes to their physical conditions, to require delivery of energy or reserve at critical times.

32 Note that for any physical energy contract (transfer of MWh between balancing accounts), a failure to deliver would bring exposure to imbalance prices (which could be far more severe than the prices in the reference market). At times of scarcity these prices could be

Any net financial surplus from the settlement regime could potentially be recycled to holders of valid reliability options, or returned to customers.

2.3.2.5 Interaction with forward energy trading

Firm forward contracts[33] could also qualify under the obligation to strike reliability contracts[34], subject to meeting the physical conditions of the reliability option scheme.

2.3.2.6 Cross-border participation

Under the European market coupling arrangements, any capacity scheme which requires delivery (whether of energy or reserve) across a border at a specific time cannot easily be fulfilled, without reservation of capacity and/or a guarantee of energy flow irrespective of price differentials.

Therefore, the use of physical conditions based on 'availability' has strong attractions to permit cross border trading of capacity. European transparency regulations now require data on generator availability to be recorded and published, which would provide a basis for validation without the need for new reporting, and Day-Ahead reliability options would form the principal basis for cross-border trading of capacity (unless access arrangements for intraday trading are formalised).

2.3.2.7 Treatment of weather variable renewables

Weather variable generation could participate in the scheme on the same terms as other providers of capacity. As output from weather variable generation is uncertain in the forward timescales, such generators may choose to contract only a fraction[35] (if any) of their capacity forward and further commit capacity (or alternatively trade any shortfall from its contracted capacity) closer to real time. Ex-post trading of capacity certificates would be permitted, and ultimately, any uncontracted usable capacity would be picked up in the capacity settlement arrangements.

The inherent difficulty of weather variable generators to commit capacity forward raises the question of whether this would lead to capacity overprocurement. The transparency provisions by the TSO are intended to mitigate against this possibility. The TSO will, at all times, publish its own view of the total required capacity and the contribution of different resources (at an aggregated level) as well as the aggregate level of contracting. From this, retailers (and generators) will have an expectation of the degree of uncontracted capacity which will become available closer to real time.

Any potential capacity availability shortfall from weather variable generators could potentially be covered by demand side response close to real time. This illustrates a strength of the decentralised nature of the CRM – market participants are in a better position to optimise resources both within their portfolio or through contractual

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extremely high, and any energy imbalance exposure might be considered to be part of a non-delivery penalty.

33 A call option with a very low strike price (whether physical or financial) is effectively a firm contract (since it is certain that it will be exercised).

34 The notification system must track the (de-rated) physical capacity element of the obligation independently from the forward energy contracts, since not all balance-responsible trading parties have physical capacity.

35 The level of contracted capacity would depend on how risk averse weather variable generators are and their ability to forecast output.

agreements with other parties than a central body. A centralised scheme, on the other hand, may tend to overprocure capacity by adopting a more conservative approach to the estimating the capacity credit of weather variable generation or not implicitly allowing for the demand side response to weather or price patterns.

2.3.2.8 Treatment of demand-side response

Demand response is essential to meeting security of supply in an efficient manner and in principle the scheme should be open to all providers of reliability, including demand side providers (some of which relates to on-site generation). Demand response is implicitly included in any decentralised scheme; those retailers with the ability to call demand response have reduced need to buy reliability options to meet their obligations, since at critical periods the demand response would be used. Given this, care must be taken so that if demand response is able to sell reliability options, it must be subject to conditions to avoid double payment or any perverse incentives.

However, the (maximum) strike price for reliability options has an important interaction with demand response. If the (maximum) strike price sets a *de facto* energy price cap that is lower than the value of lost load, then any demand response which has a cost of delivery above this maximum level but below VOLL is excluded from the market. For this reason, high limits for the strike prices are desirable. Ultimately it may be possible to remove any upper limit for strike prices.

2.3.2.9 Kick-starting a decentralised reliability options market

Ideally, the capacity markets would achieve a high degree of liquidity and transparency. To support this, we would suggest that at least initially, all trading would be conducted on a central platform with a limited number of strike prices, and a small number of reference markets (which define the option expiry): Day-Ahead, balancing/imbalance and (say) two expiry times intraday. There could be regular auctions for these products based on market demand (up to 3-4 years in advance), with market clearing prices for settlement of the option fees, and a clearing auction close to (or after) delivery. The market could be further liberalised as liquidity develops.

2.3.3 Regional coordination

By design, the scheme blueprint does not require all neighbouring countries to adopt the scheme, and is compatible with a boundary with an energy-only market, because the intention of the design is ultimately that the spot energy prices fully reflect scarcity whereas the option fees are just a hedging instrument.

Capacity from other price zones would be eligible to sell reliability options, up to a capacity limit declared jointly by the TSO(s)[36], based on the expected contribution of interconnection to reliability at the critical periods. This would need an agreed methodology between the TSOs concerned, ideally on a regional basis.

36 Ultimately, this restriction may be relaxed, if the sellers of capacity are prepared to take responsibility for delivery risk across an interconnector. The sales of cross-border capacity would then be limited to the capacity of the cross border connections (or the firm capacity sales by the interconnector operator).

The seller would be the ultimate provider of capacity, not the interconnector operator[37]. Any participating capacity from another price zone would otherwise be treated equally to local capacity, with the same eligibility criteria, an equivalent methodology to determine adherence to physical conditions at the time of delivery.

The physical conditions applied to the capacity seller would not require the flow of energy to the buying price area, but would be based on availability (including availability of the cross-border capacity). Therefore, the conditions would be deemed to be met if the generator were available in its local market at any critical delivery time; and if the cross-border capacity were available.

The capacity seller should be required to secure agreement of the cross-border capacity operator for use of its transmission network to meet the physical conditions of reliability options. This may be covered by the purchase of cross border capacity rights, or some other agreement with the interconnector operator if these forward rights are not marketed. In the event that cross-border capacity is unavailable at a time of system stress in the zone with the reliability option, then the usual capacity settlement mechanism would apply. This would be at the risk of the seller of the reliability option[38].

In the event that cross-border capacity was over-delivering at a critical period when penalties applied, the capacity settlement arrangements could also apply (perhaps with any surplus being used for network investment).

The commercial obligations for out-of-zone sales of reliability options would also be at the seller's risk. It is expected that they would seek to hedge these risks by buying forward capacity on the interconnectors (e.g. in the form of FTRs or PTRs) but this would be their responsibility. Given that there is currently no provision for allocation of cross-border capacity to the period after Day-Ahead, it is expected that (for now) out-of zone providers would be unwilling to sell options with intraday or balancing expiry[39]. In future, the market coupling arrangements might evolve to allocate interconnector capacity intraday[40], which would permit intraday cross-border reliability options to operate.

A desirable scheme would adopt a coordinated regional approach, in which each market within a region would agree a common security standard. However, this is unlikely to happen in the short term – ENTSO-E is currently trying to create common agreed metrics (and methodologies) to measure system reliability standards in different markets.

Assuming that a common reliability target cannot be achieved, then real time system operation procedures should be put in place under the Network Codes which respect the differing security standards. One idea would be to use strategic reserve as the buffer

37 For simplicity, we use the term 'interconnector' to refer to network capacity between price zones.

38 The arrangements for forward access rights will include arrangements for firmness; i.e. compensation for non-availability of the interconnection.

39 Pöyry wrote a paper in 2014 which outlined alternative methods for market based allocation of interconnector capacity to the optimal timeframe, which could be a blend of day-ahead, intraday and/or balancing. The results were summarised at www.tinyurl.com/poyryflexibility. The concepts outlined in that paper (and the more detailed project report) could permit the sale of intraday options between price zones.

40 If cross-border capacity could be allocated between timeframes in an economically efficient way, this would be a desirable development to allow flexible capacity to trade between markets. Pöyry outlined a market-based mechanism to allow this, in its 2014 paper "Revealing the value of flexibility": www.tinyurl.com/poyryflexibility

between different reliability standards in neighbouring countries. The reliability option targets in a region would be set for each market to achieve the lowest common security standard, and those markets which target a higher standard would be permitted to introduce a supplementary scheme of strategic reserve.

For example, both the Netherlands and Germany adopt a common security standard of 4 hours of loss-of-load expectation. If Germany in future chooses a stricter security standard, for example 3 hours, it could then contract sufficient capacity in the form of strategic reserve to over the additional 1 hour LOLE. Once (and if) there is scarcity in both markets, the Netherlands would reduce load, whereas Germany would first deploy its strategic reserve before reducing load.

2.4 Issues and incentives relating to reliability options

In 0 we present a set of worked examples which illustrate how a decentralised reliability option scheme could operate. We consider reliability options which expire Day-Ahead (settled physically or financially), intraday (settled physically), or against balancing/imbalance (settled financially). We also illustrate the potential operation of cross-border reliability options which expire day-ahead (whether settled financially or physically).

2.4.1 Value of reliability options

The price of reliability options has two distinct elements. The first (commercial) arises from the financial value of the call option, which relates to the expectation of how often the market price will be higher that the strike price and how much the seller will have to pay out at those times. In a decentralised market, the buyer would value the options based on its expected exposure to price spikes, and there would be a risk premium on both sides. The net revenue of this financial element, after paying out when the spot price exceeds the strike price, could be close to zero; but the fixed-for-floating swap of the most unpredictable part of a generator's market revenue could reduce its risk and lower its cost of capital. As with any hedging contract, the trade of the option could reduce risk on the part of both buyers and sellers, who would agree a stable fee in return for insurance against scarcity (and scarcity pricing).

Options with a very high strike price would have lower value than those with a lower strike price. Similarly, options settled against a market with low price volatility would have a lower value than options settled against a very volatile market. Therefore, the value of the option would also depend on the notice period for delivery, because markets become more volatile as they trade closer to delivery.

The second (physical) element of value is created by the requirement to buy a quantity of options from sellers underpinned by physical capacity which must be available at times of system stress (with the additional risk of penalty payments for under-delivery). If there is a surplus of capacity then this value could be low or zero; but at times when new capacity is required this element of value could rise to cover (part or all of) the fixed and capital costs of new plant.

The balance between these two elements depends ultimately on the scale and frequency of price spikes. Even if the option strike prices were set at a very high level (meaning that the financial value of the reliability option is very low or zero) there would still be a price for the options based on the physical requirement to ensure availability at a minimum MW level.

The obligation to settle under the option regardless of whether the capacity is available creates a strong incentive for contracted capacity to be made operational at peak times in the timeframe for expiry of the option. There would be additional penalties for failure to meet physical conditions at critical periods, and we advocate that these conditions should be based on availability, leaving the commercial aspect of the contract to incentivise flexibility. This dual obligation gives a balance between the financial and physical elements (although even penalties are ultimately commercial).

2.4.2 The need for a physical condition

The hybrid nature of reliability options stems from the dual commercial and physical requirements of the contract. Much of the complexity of the scheme (especially cross-border) stems from the physical conditions, and a purely commercial scheme would have certain attractions. Whether commercial obligations alone would be sufficient to deliver the required level of system reliability, without physical obligations and a system of penalties, depends on a number of underlying factors.

System reliability is governed by the balance between two values; the cost of maintaining capacity and the (assumed) value of lost load to customers, which determine the optimal level of reliability[41]. Generally, analysis of the economically optimal level of system reliability in European systems results in a target loss of load expectation of 3-4 hours per year (8 hours in Ireland), with high figures for the value of lost load (e.g. €10,000/MWh in Ireland). As a consequence, on average there should be some capacity shortages and demand curtailment[42] for these hours. At these times, for the balance to be maintained, the spot price should rise to very high levels (theoretically up to the assumed value of lost load as the expectation of scarcity increases).

A voluntary market for commercial options (with no physical requirements or penalties) could in theory deliver security of supply, but the conditions would be similar to that for an energy-only market: principally a credible expectation that market prices could rise to scarcity levels at times of capacity shortage, without regulatory intervention.

With a mandate on retailers to buy options to cover their peak load, this credibility is improved, as all demand has insurance against price spikes and therefore their political significance is reduced.

We note that even if the above balance were achieved under an energy-only market, then the addition of a reliability options scheme could deliver welfare improvements by lowering the risk profile and therefore the cost of capital of a marginal capacity provider, and also by lowering the exposure to volatile imbalance prices of other market participants. Compared with a pure energy-only market, the introduction of market-wide (financial) option contracts would make the existence of price spikes more legitimate (because all consumers would hold a hedge against price spikes at their own chosen level). In this scenario, there would be no missing money. In equilibrium, selling options to hedge scarcity pricing would give enough revenue to maintain capacity to meet the target reliability level. The financial value of the option would match the expected value of the foregone price spikes, dependent on volatility in the underlying spot prices. Of the

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41 In theory, these three values should create an equilibrium; so for any reduction in the cost of capacity (at the margin), then a higher level of reliability could be achieved for a given value of lost load.

42 Under the assumption that any demand response to prices in real time is not enough to balance the system.

two sources of value for the reliability options (described above in section 2.4.1; the commercial element (relating to the expected value of price spikes) would dominate and the physical element would be fall to zero, meaning that the physical condition could be removed.

However, such extreme prices may not be considered credible[43], either from a political or an investment perspective and it may be assumed that a country which decides to implement a capacity mechanism has already concluded not to rely on this balance.

The balance could be disturbed, and the physical value of the reliability options would increase (i.e. requiring the physical commitment to be maintained), as a result of any of the following.

The first issue relates to how much capacity is required. If the targeted level of reliability (for political reasons) is higher than the economic optimum (based on the marginal cost of capacity and the value of lost load), then price volatility and the financial value of the reliability options would be insufficient. Again, without a physical condition, the target reliability would not be achieved.

The second issue is the freedom for the spot price to reflect scarcity when capacity shortages occur. Any restrictions (real or perceived) on scarcity pricing would lower the price volatility and thereby devalue the financial aspect of energy options; a parallel argument to the “missing money” discussion around energy-only markets.

Restrictions on spot prices might arise because of other measures to mitigate market power or the threat of regulatory intervention. The European day-ahead market coupling algorithm (‘Euphemia’) will apply a price cap of €3000/MWh, which most observers agree is below the value of lost load. TSOs have reserve policies and imbalance pricing calculation which might feed through to damped imbalance prices at critical times.

The existence of the reliability options themselves may influence the spot market prices. In principle under a centralised scheme, all capacity will have sold an option contract at a common market-wide strike price. If the market price were to rise above this level, sellers would be unable to profit (as they have to repay any excess above the strike price). However, if their capacity becomes unavailable, then they are still obliged to make the option repayments. The effect of this would be to (weakly) cap the spot prices (although uncontracted capacity and price coupling to neighbouring markets could still drive prices above the market-wide strike price). The decentralised reliability options scheme still relies on a backstop strike price, but the freedom for participants to choose strike prices means that the limit could perhaps be higher than under a centralised scheme.

The third issue is the choice of reference market for the spot price. Reliability options in their simplest form are financial options which must be settled against a liquid reference price. This market price has to be accessible to the sellers of the options; otherwise they will be exposed to risks which they cannot cover (i.e. repaying against a price spike which they did not receive).

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43 Ref. Stoft et al: “circumstances do not permit a price cap to be credibly set at VoLL. It may be politically difficult to allow the price of a MWh that normally sells for $40 to reach $20,000 simply because some committee has estimated that $20,000/MWh is the average value of lost load. And even if this is allowed initially, investors may not believe that the policy is durable” http://stoft.com/wp-content/uploads/2013-05_Cramton-Ockenfels-Stoft_Capacity-market-fundamentals.pdf

The most obvious choice of reference market for a financial option is day-ahead, based on the Euphemia day-ahead market coupling arrangements. In centralised schemes trading is channelled only to the Day-Ahead market, to avoid basis risk.[44] Trading is conducted at noon for a calendar day starting at midnight, which is around 30 hours ahead of the evening peak period prevalent in most European markets. System scarcity will rarely emerge this far ahead. Instead, scarcity generally results from real-time issues including inaccurate demand and wind forecasts and the failure of generation capacity; and intraday and balancing prices are expected to be far more volatile than day-ahead. A Day-Ahead option alone will not properly cover the risk of on-the-day generation shortfall.

Hence, in a centralised reliability options scheme, the financial aspect of the contracts (settled against day-ahead price) do not adequately cover the risk of on-the-day shortfall, which requires centralised reliability options to have a second, physical obligation.

2.5 Transitional arrangements and detailed design considerations

This is not a fully detailed blueprint for a decentralised reliability options scheme, but rather a high level description of how such a scheme could operate. The design of a decentralised reliability option scheme has lots of in-built flexibility and could be implemented in different ways without fundamentally altering the outcomes.

If there is ‘missing money’ in the spot markets due to distortions, the decentralised reliability options concept will compensate to deliver the necessary level of reliability, because of the physical commitment and administered penalty arrangements. However, with effective spot price formation (including scarcity pricing), the reliance on the administered aspect of the reliability options diminishes, and the purely commercial incentives take precedence. This is self-reinforcing. The existence of the decentralised reliability options (which allow participants to have insurance against price volatility) makes it more acceptable to have very volatile market and imbalance energy prices, thus allowing the causes of missing money to be addressed.

To underpin these proposals, it is essential that other distorting features of the electricity markets are removed. The decentralised reliability option, with its choice of expiry time and strike price is referenced against the underlying spot markets and these need to work effectively to allow the scheme to deliver its full benefits.

We recommend that the implementation of the decentralised reliability options should be coupled with other measures to improve spot price formation:

- remove barriers (if any) for active demand response to spot prices; in this way individual consumers may signal their own willingness to pay;
- full balance responsibility for all market participants;
- marginal pricing for both balancing energy and imbalances, minimising the distorting impact of any TSO reserve procurement on the imbalance prices; and

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44 Ref Batlle et al p15 “the mechanism discriminates in favour of trading at the reference market and this is a problem with the proposed design”. P28 talks about the damaging effect on intraday liquidity “we see no way of avoiding this feature” http://www.hks.harvard.edu/hepg/Papers/Vazquez.Batlle.Rivier.PerezArriaga_Secutiry_Supply_Dutch.pdf

- introducing an appropriate regime for pricing and allocating interconnector capacity, ideally including consideration of allocations to support intraday trading where it is valuable[45].

If necessary, for a transitional period, the strength of the reliability options scheme could be enhanced by 'centralising' further. Transitional measures could include:

- retailers being obliged to buy a margin above their demand;
- generators being prevented from overcommitting against TSO-calculated reliability factors (perhaps as part of a penalty regime for failure to meet previous commitments); and /or
- retailers being obliged to commit some of their purchases early.

The decentralised reliability option design supports a transition towards a fully market based scheme, in which the central actors **guide** rather than **mandate** the actions of the market participants. Eventually, the physical conditions could be dropped (as price volatility becomes a normal and accepted part of market operation).

45 As noted above, Pöyry set out ideas on the allocation of capacity between timeframes in a 2014 paper "Revealing the value of flexibility"

3. EVALUATION OF MARKET-BASED CRMS

Quantity-based CRMs can be grouped in:

- **capacity tickets**, an arrangement in which capacity providers sell a firm physical commitment to be available at critical periods (with an administered penalty in the event of non-compliance); and
- **reliability options,** which combine the firm physical commitment of a capacity ticked with a commercial option.

Furthermore, we distinguish between the responsibilities of market actors and central agents as follows:

- **centralised**, where a central agency determines the capacity requirement and contract terms and acts as a single buyer for capacity, and controls the reliable quantity that capacity providers may offer; and
- **decentralised**, where retailers are obliged to procure capacity based on their actual load; capacity providers choose the volume which they sell and buyers and sellers have greater freedom to agree contract duration and other terms.

The evaluation criteria are outlined in section 1.2. Below we present the questions that each of the criteria is attempting to address:

- Security of supply:
  - How effectively does the scheme ensure security of supply?
  - Does the scheme meet political or consumer preference for the security standard?
  - Does the scheme promote the right type of capacity?
- Promoting the Internal Market for Electricity:
  - Does the scheme distort energy trading across any of the market timeframes (forward, Day-Ahead, intraday)?
  - How effectively can the scheme integrate cross border/regional capacity including between markets (with and without CRMs)?
- Technology neutrality:
  - Does the CRM discriminate against different types of capacity?
  - Is DSR included?
- Competition and cross-border participation:
  - Does the scheme increase or decrease competition in the energy market and separately, the capacity market?
  - Does the scheme promote market based behaviour (allow scarcity in spot energy pricing, avoid price caps, inclusion of the contracts as part of the hedging strategy)?
  - Is cross border capacity eligible to participate in the scheme?
  - Is the value of the cross-border capacity contribution recognised in the scheme?
- Efficiency:
  - How efficiently and cost-effectively does the scheme deliver security of supply?

- Does the scheme promote efficient investments or is it susceptible to over investment?
- Does the scheme promote the right technology for system needs?
- Does the scheme result in inefficient short-term plant operation?

- Efficient cost allocation:
  - Is the cost of the scheme targeted over periods of scarcity?
  - Do consumers face the associated cost in proportion to their contribution to demand over periods of scarcity?
- Simplicity:
  - How easy is the scheme to understand (and for market participants to operate within)?
  - How complicated is the scheme to set up and administer?
- Distributional effects:
  - How does the CRM manage the balance between consumer and producer surplus?
  - Is the scheme robust against the exercise of market power?
- Bankability:
  - Is the scheme credible to investors?
  - Does the scheme provide long term price signals?
  - What is the degree of the perceived regulatory risk?
  - Does the scheme promote transparency and liquidity?
- Robustness and adaptability:
  - How flexible is the scheme?
  - Can the scheme adapt to changing market environment without regulatory intervention?
  - Is the scheme capable of valuing capacity and capability?
  - How much regulatory intervention is required?
- The above evaluation criteria are used to assess the different options under the type of the scheme (capacity tickets against reliability options) and requirement setting and procurement options (centralised against decentralised). The criteria are also mapped against the EC's guidance on CRMs.

The evaluation, which follows, firstly illustrates the merits of the reliability option concept against a more conventional capacity ticket approach, and secondly, the additional benefits and challenges that may be realised from a decentralised approach to capacity procurement.

3.1 Comparison between capacity tickets and reliability options

First, we consider the relative merits of capacity tickets and reliability options, as shown in the decision tree in Figure 7.

Figure 7 – Decision tree for development of a quantity-based CRM

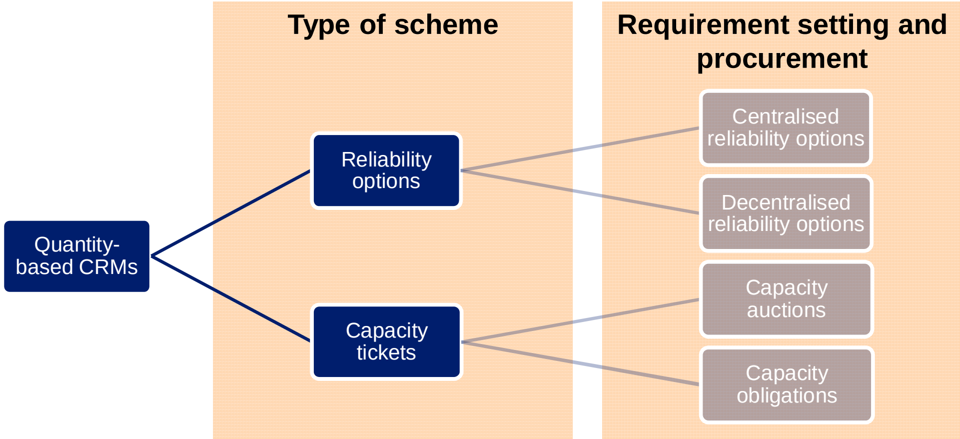

Table 1 shows the comparison between capacity tickets and reliability options.

Table 3 – Comparison between capacity tickets and reliability options

EC key CRM features	Criteria	Capacity tickets	Reliability options	Comment
	Security of supply	✓	✓	ROs provide for stronger incentives for capacity providers to perform as both a penalty and a commercial incentive exist
Competition and trade / Cross-border participation	Internal Market for Electricity	✓	✓✓	Capacity tickets risk damaging the underlying energy price signals at times of scarcity, limiting effectiveness of demand side and interconnection. ROs allow for the removal of regulatory interventions, which could result in energy market price distortions, while protecting consumers. Both options could provide for cross-border participation
Technology neutrality and decarbonisation	Technology neutrality	✓	✓✓	ROs protect the underlying energy price signals and avoid price distortions, better facilitating DSR. ROs are more easily adapted to appropriately reward flexible capacity
Competition and trade	Competition	✓	✓	Both schemes allow for competition within the scheme. ROs, however, better facilitate competition in the energy market through limiting energy price distortions over scarcity periods
Competition and trade / Time-bound intervention	Efficiency	✓	✓✓	ROs have the potential to deliver a more efficient outcome in terms of capacity on the system by allowing option contracts with different parameters (strike price, duration and expiry time). ROs protect consumers, making explicit regulatory set price caps redundant
Allocation of costs	Efficient cost allocation	✓	✓	Both schemes aim at targeting costs associated with funding capacity contracts over periods of scarcity and in proportion to the consumers contribution to demand over peak periods
	Simplicity	✓	✗	ROs are more complex than tickets as option settlement has to be considered
	Distributional effects	✗	✓	With capacity tickets there is a risk of overcompensation towards generators (paid by consumers), limited in the RO scheme as there is direct compensation for short-term price spikes
	Bankability	✓✓	✓	In both schemes, penalties should be strong enough to incentivise performance but should also be manageable. The presence of both a penalty and a commercial incentive under ROs may present additional risk for investors
	Robustness and adaptability	✓	✓✓	Both schemes require regulatory intervention and centrally determined parameterisation. ROs provide for flexibility to be adapted to reward capability more appropriately and can more easily be adapted to meet national needs.

A reliability option is a hybrid between a physical commitment and a commercial option. The physical commitment is intended to deliver security of supply. It creates a supplementary revenue stream to deliver missing money (as for other market-wide CRMs), but the inclusion of the commercial option has an important influence:

- customers are protected from scarcity prices in the spot market; and
- spot price volatility can be hedged by the seller through the sale of the option in a "fixed-for-floating" swap of revenues, lowering the risks (and cost of capital) for investment in capacity.

These two effects mean that a reliability option scheme can reduce missing money from the energy market both indirectly and directly. Reliability options put in place the customer protection which permits the regulators to remove any underlying distortions to energy price formation. If this is done, price volatility will reveal the value of demand side management, interconnection and intraday flexibility.

As a result, the reliance on the physical commitment could be made transitional, leading to an improved version of the energy-only market in which investment risks could be managed through sale of a combination of forward sales of call options and fixed volume energy contracts.

From a consumer perspective, reliability options remove any incentive for generators to exercise market power over periods of scarcity and offer a hedge to consumers through direct compensation over periods of short-term price spikes. Capacity tickets, on the other hand, present the risk of overcompensation for generators at the expense of consumers as, in the absence of regulatory measures to limit price spikes, generators may attempt to exercise market power over periods of scarcity in addition to receiving the upfront capacity payment.

On the other hand, reliability options present a more complex solution when compared to capacity tickets and may perceived as 'riskier' by investors as both a penalty and a commercial incentive for performance are in place.

Ultimately, the benefits of avoiding distortion of competition and trade, protecting consumers and better facilitating innovative technologies may outweigh the downsides of a reliability options scheme.

3.2 Comparison between centralised and decentralised reliability options

We now consider two different ways for procurement; a centralised and a decentralised approach, as illustrated in Figure 8. Although the majority of the arguments when assessing a centralised and a decentralised approach also apply for capacity tickets, we include the differences between a centralised and a decentralised reliability options scheme, as presented in Table 2.

Figure 8 – Decision tree for reliability option scheme approaches

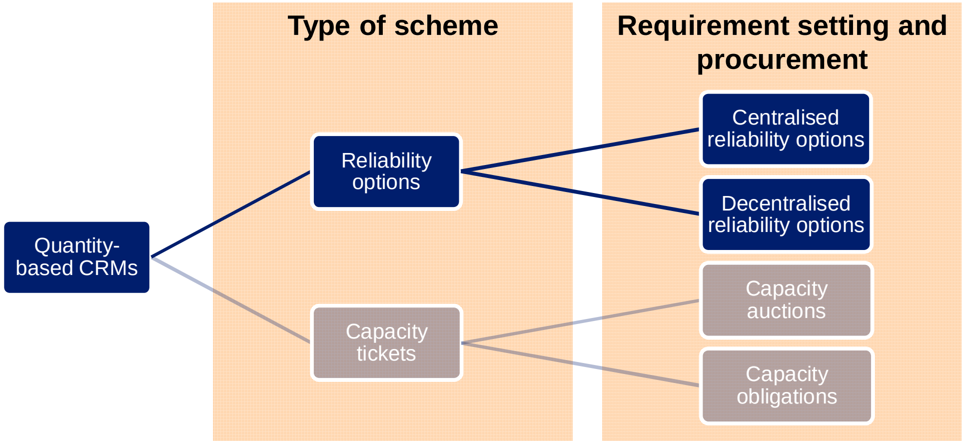

Table 4 – Comparison between centralised against decentralised reliability options

EC key CRM features	Criteria	Centralised	Decentralised	Comment
	Security of supply	✓✓	✓	A central agency is more likely to over-procure capacity, thus providing for greater security of supply, which may however mean overcapacity and a less efficient outcome, in contrast to a decentralised approach.
Competition and trade / Cross-border participation	Internal Market for Electricity	✓	✓✓	A decentralised approach is more in line with the thinking of the EU Target Model of placing increased responsibility on market participants, whilst allowing them to hedge their position through traded instruments
Technology neutrality and decarbonisation	Technology neutrality	✓	✓✓	A decentralised approach may prove better at facilitating demand side response as retailers have better information regarding their customers' demand elasticity
Competition and trade	Competition	✓✓	✓✓	Centralised procurement provides common route to market for all capacity providers and a simpler product design promotes liquidity. Demand side response is implicitly included (and better facilitated) with a decentralised approach
Competition and trade / Time-bound intervention	Efficiency	✓	✓✓	Decentralised procurement allowing different strike prices, contract duration and expiry of options should allocate resources more efficiently and more appropriately reward capacity for its value to the system
Allocation of costs	Efficient cost allocation	✓	✓	Both options aim at targeting costs associated with funding capacity contracts over periods of scarcity and in proportion to the consumers contribution to demand over peak periods
	Simplicity	✓	✗	(Potential) additional complexity in decentralised option as there may be a variety of contract types
	Distributional effects	✓	✓✓	In a decentralised environment, assuming the development of more than one product, capacity will be rewarded for its real value to market participants and by extension to the system
	Bankability	✓✓	✓	Longer term signals to investors with centralised procurement. More difficult to impose long term obligations on retailers in a decentralised option. However, regulatory risk increases in a centralised scheme due to the importance of centrally determined parameters
	Robustness and adaptability	✗	✓	Decentralised procurement provides for a more flexible framework, able to adapt to evolving market conditions

The underlying intent of a decentralised CRM (whether for capacity tickets or reliability options) is to minimise the importance of central decisions and design parameters, and thereby reduce regulatory risk. Our assessment shows the potential further gains that can be realised from a decentralised approach in setting the capacity requirement and in terms of procurement.

A centralised approach, on the other hand, has some strengths. It can accommodate the introduction of long-term contracts for new generating units, providing for greater investment certainty and resulting in a lower cost of capital. However, a central agency is more likely to over-procure capacity than market participants, meaning that security of supply is better guaranteed, but that the outcome may be less efficient (with the risk borne by customers).

In terms of competition, a centralised platform for selling capacity means there is a common route to the market for all capacity providers. Liquidity will be improved by narrowing the range of products traded. A decentralised approach, on the other hand, adds complexity, and challenges liquidity as the range of products traded increases.

A decentralised approach places greater responsibility on market participants and allows them to better optimise their own portfolios. Demand side response is implicitly included whether it participates directly in the scheme or not.

Decentralised reliability options have further advantages over a centralised reliability option scheme. The deployment of reliability options to date tends to fit with centralised energy markets, with a single spot price which represents the value of energy.

However, under the European Target Model, with day-ahead, continuous intraday trading and balancing energy markets; there is no single spot price. The most convenient reference market for a centralised reliability option would be the day-ahead market, which will generally have good liquidity. However, the day-ahead market is too early for real scarcity to be revealed, and the use of day-ahead as the sole choice of reference price would mean that the reliability option does not distinguish between flexible and less flexible capacity. This seems to lose one of the advantages of trading capacity in the form of an option.

Reliability options, by nature, allow for the development of options with different strike prices, duration and expiry times. This flexibility can deliver different value for different types of capacity resulting in a more efficient outcome, as well as allowing for greater adaptability for meeting national needs or changing future requirements.

The principal advantage of decentralised reliability options is that the options can be struck against different markets, including intraday and imbalance. Therefore, investments in flexibility will also benefit from being able to lock in fixed revenue streams, as well as investments in capacity. Participants may also choose the timing and duration of their contracts and the level of the strike prices contracted, making the trading of reliability options a part of the portfolio of traded products. This freedom will allow value to be revealed for different types of capacity, while allowing the value to adapt to changing system requirements.

Overall, it can be argued that centralised reliability options naturally fit better with more centralised energy trading arrangements, whereas decentralised reliability options are more in line with most European electricity markets, which value bilateral trading and place greater responsibilities on market participants.

4. CONCLUSIONS AND WAY FORWARD

We have outlined a straw man design for decentralised reliability options, building on the centralised schemes which have been implemented elsewhere. We have adapted the design to the circumstances in EU electricity markets; with continuous traded markets, growing needs for flexibility, and increasing shares of non-conventional capacity. Crucially, the design meets the EC's stated requirements under the State Aid guidelines (which ultimately require efficient operation in the context of the Internal Market for Electricity), while also delivering capacity effectively.

By decentralising the design, the arrangements place less reliance on administrative and policy decisions (with the regulatory risk that this brings), and greater reliance on the decisions of market actors, more in line with the spirit of the EU's Target Model for electricity trading.

Capacity gives an option to deliver energy. By basing the scheme around the pricing of options, the scheme reflects the underlying economics of different types of capacity. As the markets change, requiring more (or less) flexibility over different timescales, the value of flexibility inherent in the options will change without the need for clumsy regulatory intervention.

Reliability options are a hybrid, containing commercial and physical (administered) obligations. This hybrid nature adds complexity but is ultimately a strength. It makes the scheme suitable for markets with different degrees of sophistication, and allows a transition towards more market-based arrangements; moving away from reliance on the physical commitments and penalties towards reliance on the commercial incentives which are more consistent with the operation of the underlying energy markets.

The underlying principle of decentralisation is that market actors will use innovative means to deliver system reliability, whereas a centralised system will tend to act conservatively and underwrite overcapacity at the expense of consumers. Demand-side response is facilitated (both implicitly and explicitly) in a decentralised scheme, a crucial step towards a mature energy market with a fully active demand-side.

In the initial design which we outline, a set of penalties is required to ensure that the market actors meet their obligations, but there is scope to vary the design to strengthen the physical commitment if it is deemed necessary. Conversely; over time the penalties may be lifted, and the commercial incentives, which are inherently part of the option contracts, may suffice for delivering the required amount of reliable capacity.

To underpin these proposals, other distorting features of the electricity markets should be removed, in particular allowing balance responsibility for all participants, marginal pricing for balancing energy and imbalance, effective intraday markets (including allocation of cross-border capacity intraday) and the relaxation of controls or TSO policies which constrain the ability of the market to reveal scarcity. This is the true advantage of a reliability option scheme; it protects consumers and thereby allows regulators to remove distortions and allow price volatility to deliver efficiency.

In a further phase of development, the markets could be strengthened by the use of shorter settlement periods and gate closure, by moving the 'main' traded market closer to real-time and by improving the performance of intraday markets.

The ultimate goal of policy makers should be the full involvement of customers in a smarter energy system which will ultimately reduce the concern over system reliability.

No price-responsive customer needs to be ‘cut off’; but would instead choose the price that they are willing to pay for energy at the critical times.

Decentralised reliability options can be applied to all European countries (or regional markets) or just a subset of these. It creates a framework where different countries (or regional markets) can adopt this blueprint or continue with an energy-only market without distorting trade and competition in the underlying energy markets.

ANNEX A – STATE AID GUIDANCE

A.1 Guidance on state aid intervention for capacity adequacy

The EC has produced a Staff Working Document[46] and has imposed revised State Aid Guidelines[47] which cover capacity adequacy mechanisms. These documents set out a number of features a CRM should have to limit the potential negative impact on the Internal Energy Market. These key guidance points are summarised in Table 5 and mapped against the evaluation criteria we have used for our assessment of CRMs.

Table 5 – Key State Aid guidance points

Guidance	Evaluation criterion
Technological neutrality and decarbonisation	
Open capacity mechanisms to demand side participation and fully take account of their particular characteristics.	Technology neutrality
Ensure consistency with decarbonisation objectives to avoid the lock in effect of new high carbon generation capacity.	
Open capacity mechanisms to new and existing generation capacity.	Technology neutrality
Base restrictions on participation in a mechanism to ensure generation adequacy on the technical performance required to fill the identified adequacy gap and not on predefined technology types.	Technology neutrality
Time-bound intervention	
Capacity mechanisms should be designed to deliver a price of zero when there is sufficient capacity available.	Competition and cross-border
Capacity mechanisms should be subject to regular review in line with a roadmap for addressing underlying market and regulatory failures.	(Not an evaluation criterion)

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46 Generation Adequacy in the internal electricity market – guidance on public interventions; Commission Staff Working Document; 2013

47 Guidelines on State Aid For Environmental Protection And Energy 2014-2020; European Commission; 286.2014

The lead time for a capacity mechanism should correspond to the time needed to realise new investments, that is 2-4 years.	(Not an evaluation criterion, but covered in the CRM design)
Cross-border participation	
Mechanisms to ensure generation adequacy should be open to all capacity which can effectively contribute to meeting the required generation adequacy standard, including from other Member States.	Competition and cross-border
Member states should allow the participation of cross border capacity based on holding of (financial or physical) interconnection capacity rights, or alternatively implement reliability options which ensure that participants are incentivised to hold capacity rights.	Competition and cross-border
If the security of supply benefit of electricity imports can only be accounted for implicitly, this benefit should be calculated and these funds used to for the development of additional interconnection capacity.	Competition and cross-border
Member States considering interventions to ensure generation adequacy should cooperate with Member States in their region at an early stage, to examine the potential of implementing cross-border mechanisms.	Competition and cross-border
Avoiding distortion of competition and trade	
There should be no procedures to reserve electricity for the domestic market where a capacity mechanism is in place.	Internal Market for Electricity
There should be no export restrictions or surcharges from the operation of capacity mechanisms.	Internal Market for Electricity
Price caps or bidding restrictions should not be implemented to offset impact of mechanisms on prices.	Internal Market for Electricity
Penalties for non-availability should not lead to inefficient production decisions by operators, reliability strike price options should be significantly above expected market prices.	Efficiency

Capacity mechanisms should not adversely affect the operation of market coupling, including intra-day and balancing markets.	Internal Market for Electricity / Efficiency
Allocation of costs	
Costs of the capacity mechanism should be allocated in a transparent and non-discriminatory manner	Efficient allocation of costs
Costs of capacity mechanisms should be allocated to consumers in proportion to their contribution to demand during periods of scarcity or system stress.	Efficient allocation of costs

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ANNEX B WORKED EXAMPLES

This section presents a series of worked examples of how decentralised reliability options of different types could operate:

- financially settled, day ahead, single price zone;
- physically settled (immediately following) day ahead, single price zone;
- physically settled intraday, single price zone;
- financially settled, balancing/imbalance, single price zone;
- financially settled, day ahead, two price zones (using FTR); and
- physically settled, day ahead, two price zones (using PTR).

These examples are not considered to be definitive, but are intended to illustrate the key features of a decentralised reliability options scheme.

B.1 Single bidding zone reliability option with DA expiry, financially settled

The key elements of this option are as follows:

- Financially settled option (one-way CFD) against DA price, with fixed strike price.
- Physical commitment to be available at times of system stress (scarcity situation) or pay penalty.
- Fixed fee paid, in return for which:
  - Seller foregoes uncapped spot market revenue and physical commitment
  - Buyer hedges price risk for the buyer's DA purchases
  - TSO: gains commitment of availability at scarcity situation
- Penalty defined as compensation to the TSO for generator's unavailability in scarcity situation (e.g. VOLL).

Figure 9 displays the market conditions on the Day-Ahead market and the generator's availability, while Table 6 and Table 7 display the cash flows for the option buyers and sellers.

Figure 9 – Day-Ahead market and generator availability

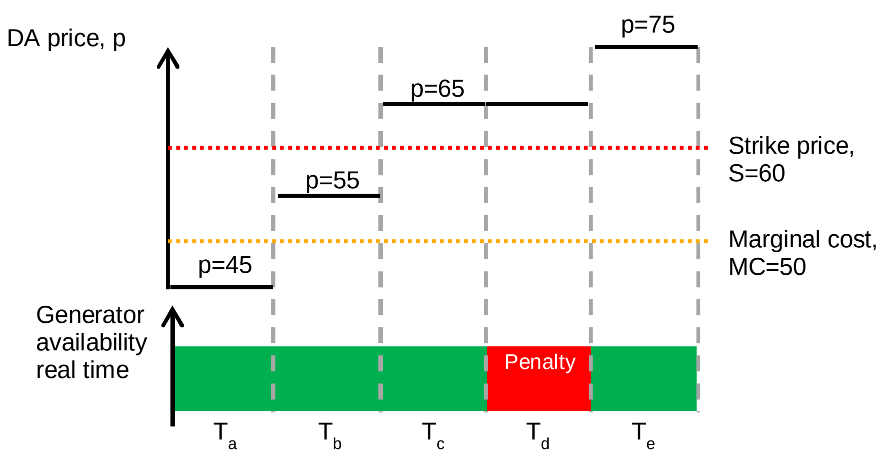

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Table 6 – Option seller's cash flows

	Option seller	T_a	T_b	T_c	T_d	T_e
Option	Option fee			Fixed fee		
Option	**Option Settlement$_{PX\ DA}$**	**0**	**0**	**-5**	**-5**	**-15**
Energy	Settlement$_{PX\ DA}$	0	55	65	65	75
Cost	Fuel cost	0	-50	-50	0	-50
Cost	Settlement$_{IMB*}$	0	0	0	-100*	0
Cost	Penalty (only in scarcity situation)				0 Or Penalty	
	Net revenue (with RO, excl. Fixed Fee)	0	5	10	-40 -Penalty?	10
	Net revenue (w/o RO)	0	5	15	-35	25

*Imbalance price for T_d assumed €100/MWh

Table 7 – Option buyer's cash flows

	Option buyer	T_a	T_b	T_c	T_d	T_e
Option	Option fee			Fixed fee		
Option	**Option Settlement$_{PX\ DA}$**	**0**	**0**	**5**	**5**	**15**
Energy	Settlement$_{PX\ DA}$	-45	-55	-65	-65	-75
Energy	Settlement$_{IMB}$					
	Net revenue (w/ RO excl. Fixed Fee)	-45	-55	-60	-60 +Penalty	-60
	Net revenue (w/o RO)	-45	-55	-65	-65	-75

B.2 Single bidding zone reliability option with DA expiry, physically settled

The key elements of this option are:

- Physically settled option called against DA price, with fixed strike price.
- Physical commitment to be available at times of system stress (scarcity situation) or pay penalty.

- Fixed fee paid, in return for which:
  - Seller foregoes uncapped spot market revenue and physical commitment
  - Buyer hedges price risk for the buyer's DA purchases
  - TSO: gains commitment of availability at scarcity situation
- Penalty defined as compensation to the TSO for generator's unavailability in scarcity situation (e.g. VOLL).

Figure 10 displays the market conditions on the Day-Ahead market and the generator's availability, while Table 8 and Table 9 display the cash flows for the option buyers and sellers.

Figure 10 – Day-Ahead market and generator availability

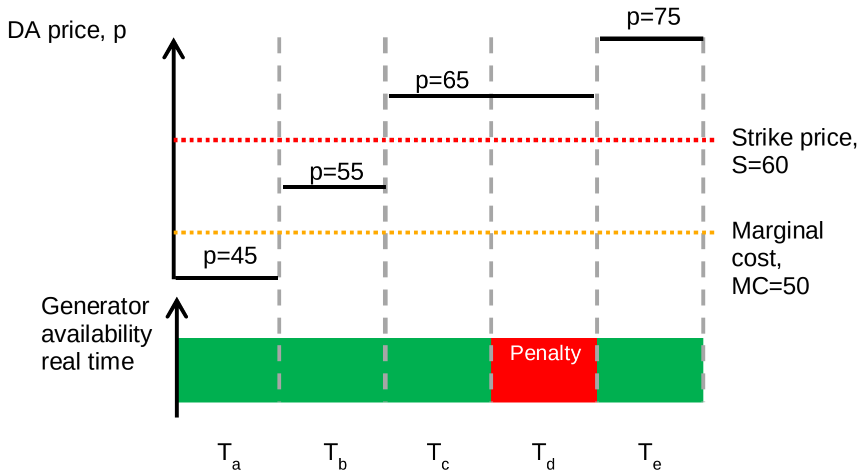

Table 8 – Option seller's cash flows

	Option seller	**T_a**	**T_b**	**T_c**	**T_d**	**T_e**
Option	Option fee			Fixed fee		
	Option Settlement$_{PX\ DA}$	**0**	**0**	**60**	**60**	**60**
Energy	Settlement$_{PX\ DA}$	0	0	0	0	0
	Settlement$_{PX\ ID}$	0	55 (+/-)	0	0	0
Cost	Fuel cost	0	-50	-50	0	-50
	Settlement$_{IMB*}$	0	0	0	-100*	0
	Penalty (only in scarcity situation)				0 Or Penalty	
	Net revenue (with RO, excl. Fixed Fee)	0	5 (+/-)	10	-40 -Penalty**?**	10
	Net revenue (w/o RO)	0	5 (+/-)	15	-35	25

*Imbalance price for T_d assumed €100/MWh, ID price denoted as DA price (+/-)

Table 9 – Option buyer's cash flows

	Option buyer	**T_a**	**T_b**	**T_c**	**T_d**	**T_e**
Option	Option fee			Fixed fee		
	Option Settlement$_{PX\ DA}$	**0**	**0**	**-60**	**-60**	**-60**
Energy	Settlement$_{PX\ DA}$	-45	-55	0	0	0
	Settlement$_{IMB}$					
	Net revenue (with RO, excl. Fixed Fee)	-45	-55	-60	-60 +Penalty	-60
	Net revenue (w/o RO)	-45	-55	-65	-65	-75

B.3 Single bidding zone reliability option with ID expiry, physically settled

The key elements of this option are:

- Physically settled option called against ID market, with fixed strike price.

- Physical commitment to be available at times of system stress (scarcity situation) or pay penalty.
- Fixed fee paid, in return for which:
  - Seller foregoes uncapped spot market revenue and physical commitment
  - Buyer hedges price risk for the buyer's DA purchases
  - TSO: gains commitment of availability at scarcity situation
- Penalty defined as compensation to the TSO for generator's unavailability in scarcity situation (e.g. VOLL).

Figure 11 displays the market conditions on intraday market and the generator's availability, while Table 10 and Table 11 display the cash flows for the option buyers and sellers.

Figure 11 – Intraday market and generator availability

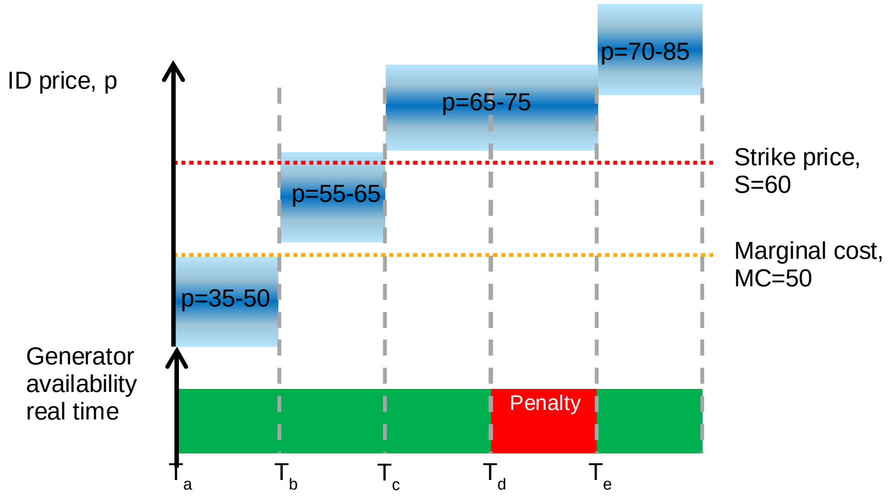

Table 10 – Option seller's cash flows

	Option seller	T_a	T_b	T_c	T_d	T_e
Option	Option fee			Fixed fee		
	Option Settlement$_{PX\ ID}$	**0**	**0**	**60**	**60**	**60**
Energy	Settlement$_{PX\ DA}$	0	0	0	0	0
	Settlement$_{PX\ ID}$	0	55 (+/-)	0	0	0
Cost	Fuel cost	0	-50	-50	0	-50
	Settlement$_{IMB*}$	0	0	0	-100*	0
	Penalty (only in scarcity situation)				0 Or **Penalty**	
	Net revenue (with RO, excl. Fixed Fee)	0	5 (+/-)	10	-40 -**Penalty?**	10
	Net revenue (w/o RO)	0	5 (+/-)	15	-35	25

*Imbalance price for T_d assumed €100/MWh, ID price denoted as DA price (+/-)

Table 11 – Option buyer's cash flows

	Option buyer	T_a	T_b	T_c	T_d	T_e
Option	Option fee			Fixed fee		
	Option Settlement$_{PX\ ID}$	**0**	**0**	**-60**	**-60**	**-60**
Energy	Settlement$_{PX\ DA}$	0	0	0	0	0
	Settlement$_{ID}$	-45(+/-)	-55 (+/-)			
	Net revenue (with RO, excl. Fixed Fee)	-45(+/-)	-55 (+/-)	-60	-60 +**Penalty**	-60
	Net revenue (w/o RO)	-45(+/-)	-55 (+/-)	-65(+/-)	-65(+/-)	-75(+/-)

*ID price denoted as DA price (+/-)

B.4 Single bidding zone reliability option with IB expiry, financially settled

The key elements of this option are:

- Financially settled option (one-way CFD) against balancing/imbalance price, with fixed strike price.

- Physical commitment to be available at times of system stress (scarcity situation) or pay penalty.
- Fixed fee paid, in return for which:
  - Seller foregoes uncapped balancing market revenue and physical commitment
  - Buyer hedges imbalance price risk
  - TSO: gains commitment of availability at scarcity situation
- Penalty defined as compensation to the TSO for generator's unavailability in scarcity situation (e.g. VOLL).

Figure 12 displays the market conditions on balancing/imbalance market and the generator's availability, while Table 12 and Table 13 display the cash flows for the option buyers and sellers.

Figure 12 – Balancing/imbalance market and generator availability

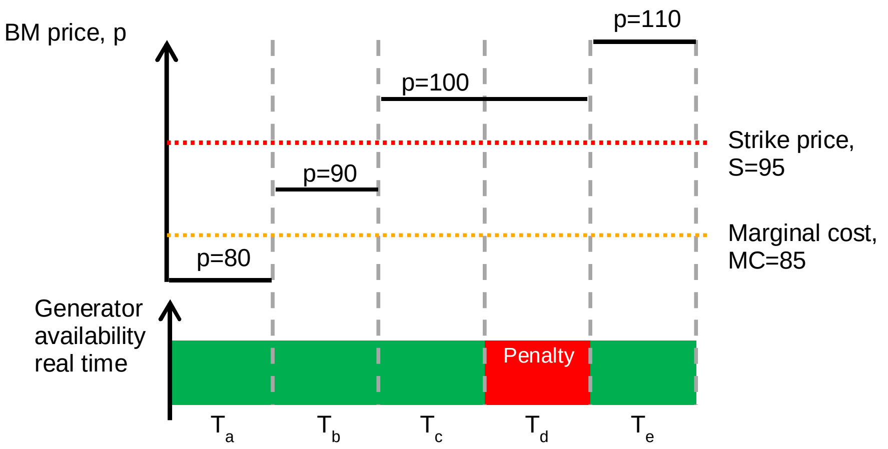

Table 12 – Option seller's cash flows

	Option seller	T_a	T_b	T_c	T_d	T_e
Option	Option fee	Fixed fee				
	Option Settlement$_{IMB}$	**0**	**0**	**-5**	**-5**	**-15**
Energy	Settlement$_{BM}$	0	90	100	100	110
Cost	Fuel cost	0	-85	-85	0	-85
	Settlement$_{IMB*}$	0	0	0	-100*	0
	Penalty (only in scarcity situation)				0 Or **Penalty**	
	Net revenue (with RO, excl. Fixed Fee)	0	5	10	-5 -**Penalty?**	10
	Net revenue (w/o RO)	0	5	15	0	25

* Imbalance price for T_d assumed €DA + €35/MWh for illustrative purposes

Table 13 – Option buyer's cash flows

	Option buyer	T_a	T_b	T_{c**}	T_d	T_e
Option	Option fee	Fixed fee				
	Option Settlement$_{IMB}$	**0**	**0**	**5**	**5**	**15**
Energy	Settlement$_{PX\ DA}$	-45	-55	0	-65	-75
Cost	Settlement$_{IMB}$			-100		
	Net revenue (with RO, excl. Fixed Fee)	-45	-55	-95	-60 +**Penalty**	-60
	Net revenue (w/o RO)	-45	-55	-100	-65	-75

** The buyer is in balance in all periods except Tc where no volumes were bought at DA stage. For clarity, the buyer receives the option settlement in Tc, Td, and Te, irrespective of the buyers own imbalance position.

B.5 Two bidding zone reliability option with DA expiry, financially settled

The key elements of this option are:

- Financially settled option (one-way CFD) against DA price, with fixed strike price.
- Physical commitment to be available at times of system stress (scarcity situation) or pay penalty.
- Fixed fee paid, in return for which:
  - Seller foregoes uncapped spot market revenue and physical commitment
  - Seller must buy an FTR to cover price exposure
  - Buyer hedges price risk for the buyer's DA purchases
  - TSO: gains commitment of availability at scarcity situation
- Penalty defined as compensation to the TSO for generator's unavailability in scarcity situation (e.g. VOLL).

Figure 13 displays the market conditions on the Day-Ahead market in bidding zone A and B, and the generator's availability, while Table 16 and Table 17 display the cash flows for the option buyers and sellers.

Figure 13 – Day-Ahead market in bidding zone A and B, and generator availability

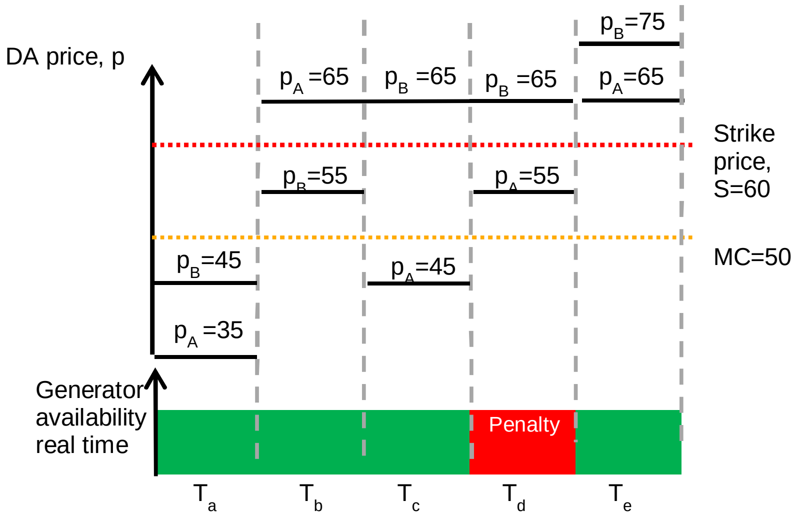

Table 14 – Option seller's cash flows

	Option seller	T_a	T_b	T_c	T_d	T_e
Option	Option fee			+ Fixed fee		
	Option Settlement$_{PX\ DA\ (B)}$	**0**	**0**	**-5**	**-5**	**-15**
X-Brdr.	FTR fee zone A → B			- Fixed fee		
	FTR Settlement$_{PX\ DA\ (A \to B)}$	**10**	**0**	**20**	**10**	**10**
Energy	Settlement$_{PX\ DA\ (A)}$	0	65	0	55	65
Cost	Fuel cost	0	-50	0	0	-50
	Settlement$_{IMB*}$	0	0	0	-90*	0
	Penalty (only in scarcity situation)				0 Or **Penalty**	
	Net revenue (w/ RO + FTR)	10	15	15	-30 - **Penalty?**	10
	Net revenue (w/o RO)	10	15	20	-25	25
	Net revenue (w/ RO and w/o FTR)	0	15	-5	-40	0

*Imbalance price for T_d Price A + €35/MWh

Table 15 – Option buyer's cash flows

	Option buyer	T_a	T_b	T_c	T_d	T_e
Option	Option fee			- Fixed fee		
	Option Settlement$_{PX\ DA\ (B)}$	**0**	**0**	**5**	**5**	**15**
Energy	Settlement$_{PX\ DA\ (B)}$	-45	-55	-65	-65	-75
	Settlement$_{IMB\ (B)}$					
	Net revenue (with RO, excl. Fixed Fee)	-45	-55	-60	-60 +**Penalty**	-60
	Net revenue (w/o RO)	-45	-55	-65	-65	-75

B.6 Two bidding zone reliability option with DA expiry, physically settled

The key elements of this option are:

- Physically settled option called against DA price, with fixed strike price.
- Physical commitment to be available at times of system stress (scarcity situation) or pay penalty.
- Fixed fee paid, in return for which:
  - Seller foregoes uncapped spot market revenue and physical commitment
  - Seller must buy a PTR to cover price exposure.
  - Buyer hedges price risk for the buyer's DA purchases
  - TSO: gains commitment of availability at scarcity situation
- Risk for RO seller: physical cross-border capacity assumed nominated by option seller before DA price is known. Also risks not being called in Tc and Tb after nomination if Pb drops below strike price.
- RO buyer can decide whether to call the option after DA price is known.

Figure 14 displays the market conditions on the day ahead market in bidding zone A and B, and the generator's availability, while Table 16 and Table 17 display the cash flows for the option buyers and sellers.

Figure 14 – Day-Ahead market in bidding zone A and B, and generator availability

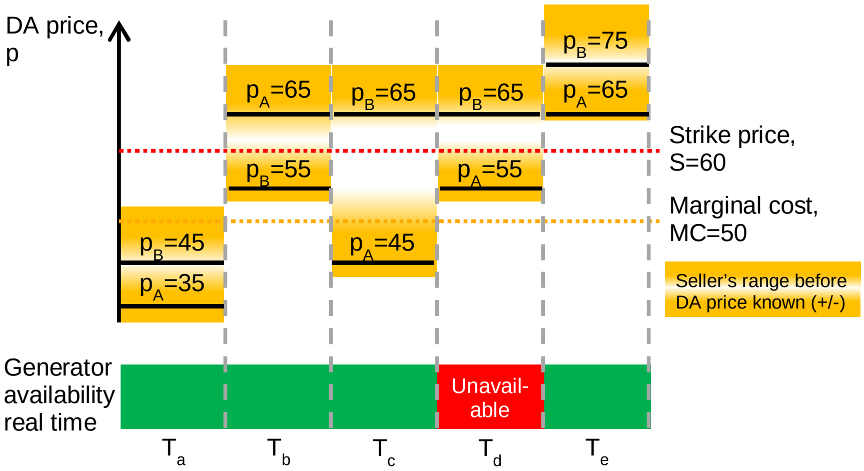

Table 16 – Option seller's cash flows

	Option seller	T_a	T_b	T_c	T_d	T_e
Option	Option fee			+ Fixed fee		
	Option Settlement$_{PX\ DA\ (B)}$	**0**	**0**	**60**	**60**	**60**
X-Brdr.	FTR fee zone A → B			- Fixed fee		
	PTR Settlement$_{PX\ DA\ (A \to B)}$	**10(+/-)** [1)]	**0** [1)]	**0**	**0**	**0**
Energy	Settlement$_{PX\ DA\ (A)}$	0	0	-45	0	0
Cost	Settlement$_{PX\ iD\ (A)}$	0	65(+/-)	0	0	0
	Fuel cost	0	-50	0	0	-50
	Settlement$_{IMB*}$	0	0	0	-90 [2)]	0
	Penalty (only in scarcity situation)				0 Or **Penalty**	
	Net revenue (w/ RO + FTR)	10(+/-)	15 (+/-)	15	-30- **Penalty**?	10
	Net revenue (w/o RO)	10(+/-)	15 (+/-)	20	-25	25

ID or uncertain DA price denoted price (+/-). (1) Flow not nominated, i.e. financial settlement (vs. nomination + physical usage). (2) Imbalance price Zone A is Price A + €35/MWh in Td. (3) DA no cross-border capacity is available anymore, e.g. option settled financially and intraday market is used to generator revenues in A

Table 17 – Option buyer's cash flows

	Option buyer	T_a	T_b	T_c	T_d	T_e
Option	Option fee			- Fixed fee		
	Option Settlement$_{PX\ DA\ (B)}$	**0**	**0**	**-60**	**-60**	**-60**
Energy	Settlement$_{PX\ DA\ (B)}$	-45	-55	0	0	0
	Settlement$_{IMB\ (B)}$					
	Net revenue (with RO, excl. Fixed Fee)	-45	-55	-60	-60 +**Penalty**	-60
	Net revenue (w/o RO)	-45	-55	-65	-65	-75

ANNEX C – COMPARATIVE DESCRIPTION OF DIFFERENT END-TO-END CRM DESIGNS

In practice, the two different options under each main feature, type of the scheme and requirement setting and procurement, can be combined to produce an end-to-end CRM design. The different CRM options considered are:

- centralised capacity auctions (tickets and centralised);
- decentralised capacity obligations (tickets and decentralised);
- centralised reliability options (centralised and RO); and
- decentralised reliability options (decentralised and RO).

Table 18 provides a summary of the key design elements of the alternative CRM schemes. The designs are not specific to any country but rather exemplify the 'typical' design of that class of CRM.

Table 18 – Comparison of alternative capacity mechanisms

	Centralised Capacity Auctions	Decentralised Capacity Obligations	Centralised Reliability Options	Decentralised Reliability Options
Example Countries	GB[1]	France, Germany (BDEW), PJM	Italy, Ireland, New England	N/A
Product	Available Capacity[2]	Available Capacity[2]	Energy option and available capacity[2]	Energy option and available capacity[2]
Platform	Single, centralised auction	Decentralised, with centralised notification platform	Single, centralised auction	Decentralised with centralised notification platform
Counterparties	Central buyer, multiple sellers	Multiple buyers, multiple sellers	Central buyer, multiple sellers	Multiple buyers, multiple sellers
Timing of trading	Forward (up to 3-4 years)	Buyer and seller choice	Forward (up to 3-4 years)	Buyer and seller choice
Choice of total purchase volume	Central Agency	Supplier[3]	Central Agency	Supplier
Choice of sale volume per provider	TSO (derated capacity per unit)	Provider (own choice of firm volume)[4]	TSO (derated capacity per unit)[5]	Provider (own choice of firm volume)
Contract duration	Centrally standardised	Bilaterally agreed	Centrally standardised	Bilaterally agreed

Reference market/ expiry time	N/A	N/A	Day ahead (typically)	Day ahead, intraday (with specified expiry time/s) and balancing/ imbalance price
Strike price	N/A	N/A	Centrally standardised	Bilaterally agreed
Capacity fee	Auction clearing price	Bilaterally agreed	Auction clearing price	Bilaterally agreed
Commercial obligation	N/A	N/A	Financial settlement of energy option	Financial or physical settlement of energy option
Physical obligation	Availability	Availability	Availability	Availability
Penalty for failure	Administered (in event of shortage)	Administered (in event of shortage)	Unhedged exposure to option settlement and administered penalty (in event of shortage)	Unhedged exposure to option settlement, and administered penalty (in event of shortage)

Notes

1 This is a generic description of a centralised scheme, and the details are not specific to any particular scheme. In particular, the French scheme and BDEW's proposal for a German scheme are rather different.

2 Experience in the NE US markets suggests that "availability" is not the desirable definition, but that something more concrete is required (delivery of energy or reserve at critical periods). The GB scheme requires the sellers to deliver energy (or be de-loaded under TSO instruction) following a valid warning from the TSO (to be issued with a minimum warning of four hours).

3 The French (decentralised) scheme requires retailers to buy a volume including a TSO-determined temperature-dependent margin.

4 The French (decentralised) scheme permits wind and run-of-river hydro generators to sell a TSO-calculated capacity volume, without penalty in the event of wind/water unavailability.

5 The New England scheme allows sellers to negotiate de-rating factors with the TSO.

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