



Report

# Rethinking power markets: capacity mechanisms and decarbonisation

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Cover photo: Michael Murphy (2010). Looking down from the 14th floor of the London Transport HQ at their recently installed solar power panels on the 10th floor.

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## Glossary

**Ancillary services:** A range of services that System Operators (SOs) procure to respond to unexpected shocks, such as the sudden shutdown of a power plant, to guarantee system security in real-time. These include black-start capability (the ability to restart a grid following a blackout); frequency response (to maintain system frequency with automatic and very fast responses); fast reserve (which can provide additional energy when needed); the provision of reactive power and various other services (ENTSO-E, 2016).

**Balancing markets:** These operate after trading in the wholesale electricity market ends (after gate closure). In the balancing market, system operators manage a number of ancillary services to balance supply and demand in and near-real time (ENSTO-E, 2016).

**Baseload, mid-merit, and peak-load generation:** Different operation modes of generating plants based on a combination of technical and commercial factors (e.g., how economically the plant can run at different load factors). A power plant that runs all or most hours to meet minimum electricity needs is referred to as 'baseload'. An operation that runs for short periods during times of high demand or resource scarcity is referred to as 'peak load', and an operation between baseload and peak that is adjusted to respond to fluctuating demand throughout the day is referred to as 'mid-merit' (Gottstein and Skillings, 2012).

**Capacity:** The maximum power that is available from the power sector or a power station at any point in time (NIC, 2016). Power stations do not operate at full capacity at all times, therefore generation is not the same as capacity.

**Capacity mechanisms (CM):** A mechanism that rewards market participants for available capacity, on top of revenues generated by selling electricity in the wholesale market. These payments are meant to ensure security of supply by incentivising sufficient investment in new capacity or preventing the retirement of existing capacity.

CMs take many forms and are sometimes referred to as capacity remuneration mechanisms (CRMs).

**Demand response aggregators:** Third party intermediaries or suppliers that reduce or shift demand on behalf of consumers in return for a compensatory payment, and that sell aggregated demand response products on the wholesale electricity market.

**Demand-side response (DSR):** The intentional modification of electricity usage during system imbalances or in response to market prices (Hurley et al., 2013). Currently, demand side response consists mostly of industrial users that withdraw, lower or shift their demand when there is limited supply, or that allow system operators or third-party aggregators to do so in return for a compensatory payment. In addition, new products are increasingly available that enable households to reduce or shift their electricity consumption in response to price signals (OECD, 2015).

**Dispatchable generation:** Sources of electricity that can increase or decrease output on command. These include hydroelectricity, gas-fired and biomass power and some coal-fired generation. Some types of base load generation, such as nuclear power, cannot easily adjust output, and wind and solar power are also less controllable because of their variability.

**Energy-only markets:** These have no explicit mechanism for procuring or paying for capacity. Revenues are earned primarily by selling electricity on the wholesale electricity market (Hogan, 2012).

**Flexibility:** The ability to modify supply and demand to the needs of the electricity system within a given timeframe.

**Gate closure:** The moment when trading on the wholesale electricity market ends and the system operator takes on the role of ensuring a balance between demand and supply near or in real time in the balancing market (Keay-Bright, 2013).

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**Interconnectors:** Electricity cables that facilitate the physical linking of electricity systems, allowing electricity to flow across borders and sub-national electricity markets. This enables the exporting of electricity when supply is abundant, and the importing of electricity in times of system stress (Ofgem, 2016).

**Load factor:** A measure of the average output of power stations relative to their installed capacity and, therefore, an indicator of capacity utilisation. It is expressed in the ratio of kilowatt-hours (kWh) produced in a given period, divided by the total possible kWh that could have been produced over the period.

**Loss of load expectation (LOLE):** LOLE represents the number of hours or days per year in which it is estimated that supply will not meet demand.

**Merit-order principle:** In wholesale electricity markets, bids for electricity generation are ranked (or ordered) from the lowest cost to the highest cost. Based on this ranking, electricity generation available at the lowest price is deployed first to meet demand needs.

**Missing money problem:** In energy-only markets, where market operators earn revenues primarily by selling electricity in the wholesale electricity market, government regulation or market failures may prevent prices from rising to sufficiently high levels (and frequently enough) for mid-merit and peaking plants to recover their fixed costs. Typically, this provides the rationale for the introduction of CMs.

**Mothballing:** The preservation of an electricity production facility, which remains idle. In other words, power plants are turned off but kept in working order so that production can be restored if needed.

**Non-dispatchable generation:** Energy sources that cannot or can only limitedly be controlled in response to demand fluctuations or supply interruptions. This includes nuclear, run-of-river hydroelectric plants, solar, wave and wind power.

**Operating reliability:** The ability of the electricity system to ensure short-term power system reliability and to withstand unanticipated disturbances or imbalances. Balancing and ancillary services contribute to operating reliability. A reliable power system requires both resource adequacy and operating reliability (Keay-Bright, 2013; NERC, 2013).

**Power system reliability:** A power system is reliable when it has both adequate resources to meet the highest levels of electricity consumption (resource adequacy) and is able to balance demand and supply in real-time, including in response to unexpected outages (operational quality).

**Providers of capacity:** Electricity market participants that either provide generating capacity or reduce electricity demand in response to supply shortages. Examples include owners of generation capacity, demand side response aggregators, consumers that actively manage their demand, interconnection, and storage.

**Ramping:** Ability of an energy resource (generation or demand) to change its power output or consumption up or down. The ramp rate is the speed of output/consumption change measured in MW per minute (Keay-Bright, 2013).

**Reliability standard:** In some countries the regulator or system operator sets a performance standard for the power system. Different metrics are used. Some European countries, for example, use a Loss of Load Expectation (LOLE) reliability standard, defined as the average number of hours a year for which it is estimated that supply will not meet demand (Keay-Bright, 2013).

**Resource adequacy:** The availability of sufficient generating and demand side capacity to ensure that forecasted electricity needs can be met.

**Scarcity prices:** High wholesale electricity prices that occur when electricity demand is high or when there is an imbalance between electricity demand and supply that leads to the deployment of higher-cost technologies. Scarcity prices allow providers of peaking capacity to recover their fixed costs and provide price signals for investments in new electricity generation or demand-side capacity when this is needed. In some countries, price caps prevent scarcity prices.

**Scarcity value:** The value of uninterrupted service to consumers often expressed as Value of Loss Load (VOLL) (Baker and Gottstein, 2013).

**Security of Electricity Supply:** the ability of the electrical power system to provide electricity to end-users with a specified level of continuity and quality in a sustainable manner (Eurelectric, 2006).

**Smart technologies:** Appliances and technology that automatically control the use of energy – often remotely (NIC, 2016).

**Storage:** A wide range of technologies that can store electricity and can act as sources of demand at times of low demand and sources of supply when demand increases or when other sources reduce output (World Bank, 2015). While some storage technologies will store energy for minutes or hours, others can store electricity from night to day or across seasons. Examples include hydroelectric pumped storage, compressed air, water heaters, flywheels, the transformation of excess electricity into hydrogen, storage in the form of molten salts in concentrated solar-power plants and different battery technologies (flow, lead-acid, lithium-ion, sodium and zinc batteries).

**Stranded assets:** Assets that lose value or turn into liabilities before the end of their economic life. This can be caused by a number of risks, including technological innovation and market developments, but also climate and energy policy and regulation (adapted from HSBC, 2015). Examples of potential risks to the value of conventional electricity generation assets include competition from new technologies (such as renewable energy technologies or storage), falling demand for electricity or emission reduction policies.

**Suppliers:** Suppliers buy electricity from generators or in the wholesale electricity market and then sell it to firms and households in the retail market (NIC, 2016).

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**System peak:** The highest level of total energy demand on the power system at a given time (e.g. daily peak, seasonal peak, annual peak) (Keay-Bright, 2013; NIC, 2016).

**Transmission network:** The high voltage network that is used to move electricity long distances (NIC, 2016).

**Transmission System Operators (TSOs):** These are responsible for balancing supply and demand in the electricity system on a second-by-second basis, which ensures grid stability. TSOs are tasked with the operation of the electricity system after gate closure by dispatching power plants and demand response on the basis of bids in the wholesale electricity market. They are also responsible for balancing capacity in the case of system stress caused by unexpected weather conditions, technical deficiencies or short-term changes in electricity demand (Grigorjeva, 2015). The TSO in the UK is National Grid, in France the TSO is Réseau de Transport d'Électricité (RTE), while Germany has multiple TSOs. In the US they are often called Independent System Operators or Regional System Operators.

**Value of lost load (VOLL):** The estimated maximum price that customers would be willing to pay to avoid a

loss of supply. The value of VOLL is often different for each class of consumer (industrial, commercial, domestic) and for individual consumers within those broad classes (Baker et al., 2015; IEA, 2016).

**Variable generation:** The term variable describes the fluctuating nature of wind and solar electricity generation in response to changing weather conditions, independently of changes in demand. This makes these sources less controllable for network operators than dispatchable resources (such as hydropower, gas-fired generation or demand side response), for which output can be increased or decreased in response to supply scarcity or fluctuations in demand (Hogan, 2012).

**Wholesale electricity market:** The market where trading takes place between generators, retailers and other financial intermediaries for delivery of electricity to meet forecasted demand before gate closure. After gate closure, system operators are responsible for balancing supply and demand in real-time (see balancing markets).

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# Acronyms

<b>ACER</b>	Agency for the Cooperation of Energy Regulators	<b>KWh</b>	Kilowatt hour
<b>CEER</b>	Council of European Energy Regulators	<b>LOLE</b>	Loss of Load Expectancy
<b>CCGT</b>	Combined Cycle Gas Turbine	<b>LOLP</b>	Loss of Load Probability
<b>CM</b>	Capacity mechanism	<b>MW</b>	Megawatt
<b>CRM</b>	Capacity Remuneration Mechanism	<b>MWh</b>	Megawatt hour
<b>DG</b>	Directorate General	<b>NEM</b>	National Electricity Market, wholesale electricity market for eastern Australia
<b>EC</b>	European Commission	<b>NERC</b>	North American Electric Reliability Corporation
<b>EDF</b>	Électricité de France S.A.	<b>NIC</b>	National Infrastructure Commission
<b>ENEL</b>	originally Italy's National Entity for Electricity (Ente nazionale per l'energia elettrica)	<b>NY-ISO</b>	New York Independent System Operator
<b>ENTSO-E</b>	European Network of Transmission System Operators for Electricity	<b>OCGT</b>	Open Cycle Gas Turbine
<b>E.ON</b>	European holding company based in Düsseldorf, Germany, running one of the world's largest investor-owned electric utility service providers	<b>OFGEM</b>	Office of Gas and Electricity Markets
<b>ERCOT</b>	Electric Reliability Council of Texas	<b>PJM</b>	Pennsylvania-New Jersey-Maryland Interconnection
<b>EU</b>	European Union	<b>RTE</b>	Réseau de Transport d'Électricité
<b>EU ETS</b>	European Union Emission Trading Scheme	<b>RWE</b>	until 1990: Rheinisch-Westfälisches Elektrizitätswerk AG
<b>Eurelectric</b>	Union of the Electricity Industry in Europe	<b>SO</b>	System operator
<b>GDF Suez</b>	Now ENGIE	<b>STOR</b>	Short Term Operating Reserve
<b>GHG</b>	Greenhouse gas emission	<b>SBR</b>	Supplemental Balancing Reserve
<b>IEA</b>	International Energy Agency	<b>TFEU</b>	Treaty on the Functioning of the European Union
<b>IEM</b>	Internal Energy Market	<b>TSO</b>	Transmission System Operator
		<b>VOLL</b>	Volume of Loss Load



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# Executive summary

## Context and aims

With variable wind and solar power generation accounting for a growing share of electricity generation, power systems are undergoing significant transformation. For governments, this raises new concerns about security of electricity supply when the sun does not shine or the wind does not blow, or, conversely, when there is high renewable electricity supply, but insufficient demand to match it.

At the same time, the growth in renewable electricity generation, combined with falling demand among other factors, has led to a loss of flexible power generation capacity (in particular gas). Accordingly, the power system is losing capacity that can be adjusted in response to fluctuations in supply at a time when increased flexibility is necessary to complement an increasing share of renewables.

This has raised concerns about security of supply and has re-ignited interest in capacity mechanisms (CMs) across the European Union (EU) and beyond. CMs come in many different forms, and are generally designed to offer payments to electricity market operators for their capacity to produce electricity or to reduce or shift electricity demand. By providing a stable stream of revenue, independently of actual electricity produced and sold, capacity mechanisms aim to prevent the shutdown of existing generation capacity or incentivise investment in new resources, with the primary objective of ensuring security of electricity supply.

With a particular focus on the EU, this report is directed at those who want to advance climate objectives, but who, until now, have had a limited understanding of power markets. It provides guidance on how governments could assess and ensure security of supply while meeting parallel objectives, including decarbonisation and the phase out of fossil fuel subsidies. As a number of EU member states are moving ahead with the design and implementation of domestic CMs the European Commission has launched an investigation into these developments. Its findings will feed into its electricity market redesign proposals for the end of 2016. This is therefore a key moment to influence this process, as well as the wide range of power market reforms planned at the national and sub-national level.

## Capacity mechanisms – risks to wider energy objectives

In a context of growing needs for flexibility to respond to fluctuations in wind and solar generation and to meet decarbonisation objectives, the traditional ‘generation adequacy’ approach to CM design is no longer suited to address today’s challenges. Traditional capacity mechanisms have failed to adequately value flexibility and carbon intensity.

Recent experiences with the development and implementation of CMs in France, Germany, the UK and the US have flagged these challenges, as well as options for improving capacity mechanisms:

- The UK’s capacity auction has led to large payments – estimated at £658 million (\$966 million) – to the most polluting forms of electricity generation, including diesel- and coal-fired power.
- Germany is making efforts to improve electricity market operations to promote flexibility and facilitate the uptake of variable renewables, but has also proposed a new capacity reserve that is made up entirely of high-carbon lignite-fired power plants. Our analysis suggests that this reserve, with an estimated cost to the government of €1.6 billion (\$1.7 billion), may be a political compromise around the closure of these old power stations, rather than a measure to support security of supply or reduce emissions.
- Although a proposed French CM has the stated objective of promoting demand response and flexibility, high levels of market concentration (by state-owned utility EDF) and scheme complexity may create barriers to new market entrants in the clean energy space. It remains to be seen whether the mechanism will be introduced as planned, as the European Commission has launched an in-depth investigation into its planned design.
- The limitations of CMs that remunerate generation capacity regardless of flexibility became apparent in a number of US power markets. In response, PJM (Pennsylvania-New Jersey-Maryland Interconnection) has gradually promoted the participation of demand side response in its capacity market. This, alongside other measures, has helped reduce the costs of ensuring the reliability of the power system by an estimated 10-20% in 2014/15, delivering estimated consumer cost savings of \$1.2 billion.

Overall, our review of current and planned CMs in the EU and US suggests that capacity mechanisms risk undermining parallel energy and climate objectives by locking in dependence on high-carbon power generation assets. The introduction of CMs is often politically motivated, instead of based on a rigorous analysis of their need. In addition, challenges with their design and implementation means that there is a serious risk that they undermine governments’ parallel objectives of ensuring system reliability and decarbonisation. Finally, the uncoordinated introduction of CMs risks undermining wider efforts to integrate energy markets, which,

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paradoxically, are meant to ensure a more efficient use of resources and improve security of supply.

### **Recommendations**

Given the urgent need to move towards zero-carbon power systems, governments must be held to account for meeting parallel objectives of decarbonisation when they seek to address issues around power system reliability. Instead of focusing narrowly on CMs as a near-term solution, governments

should take a system-wide approach that supports rather than undermines decarbonisation. This includes:

- establishing a clear understanding of the scale and the nature of the reliability challenges facing their power systems
- considering whether improvements in current market design can help to improve power system reliability
- recognising the potential of demand side response, interconnection and storage in providing economically competitive, low-carbon flexibility.

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# Introduction

With variable renewable energy capacity accounting for an increasing share of electricity generation, power systems are undergoing significant transformation. For governments, this raises new concerns about security of electricity supply when the sun does not shine or the wind does not blow, or, conversely, when there is high renewable electricity supply, but insufficient demand to match it.

This has re-ignited interest in capacity mechanisms (CMs) across the European Union (EU) and beyond. CMs take many different forms but are generally designed to offer payments to capacity providers to prevent the shutdown of existing generation capacity or incentivise investment in new resources, with the primary objective of ensuring security of electricity supply. These payments are meant to ensure that enough resources are kept available for matching demand and supply, in periods of both high and low levels of renewable electricity generation.

Although there is growing interest in CMs, they are not a new tool. Since the liberalisation of electricity markets began in the early 1980s, governments worldwide have used various approaches, including CMs, to enable generators that only operate at times of peak-demand to recover their fixed costs. Given this history, experiences with CMs and wider power market reforms, both within and beyond the EU, can provide lessons for those who aim to support the security of electricity supply in a way that is consistent with decarbonisation. At the same time, the fundamental transformations that are taking place in

electricity markets, linked in part to decarbonisation, make it essential to reconsider traditional approaches to security of supply and capacity mechanisms.

This report, with its particular focus on the EU, is directed at those who are seeking to advance climate objectives, but who, until now, have had a limited understanding of power markets. It provides guidance on how governments could assess and ensure security of supply while meeting the parallel objectives of decarbonisation and the phase out of fossil-fuel subsidies. It also highlights the role of both market redesign and the opportunities provided by new technologies and energy services in the development of secure, affordable, and efficient power systems.

The report is structured as follows. Section 1 outlines the rapid shifts in electricity markets and how these are creating new concerns about security of supply. Section 2 discusses why governments deploy CMs and their various types. Section 3 reviews the opportunities for market redesign and for additional flexibility to create low-carbon, secure power systems. Section 4 assesses the risks that CMs may pose to the achievement of wider government objectives (including decarbonisation). Finally, Section 5 provides an overview of lessons learned and implications for assessing and addressing security of supply concerns in a manner that is consistent with wider climate and energy objectives. This report is based on a review of recent literature and a number of interviews (see Annex 1).

# 1. Electricity markets in transition

Electricity markets across the European Union, as in other regions around the world, are going through significant transformation, leading to increased concerns about security of electricity supply. We are seeing a rapid increase in the share of renewable, often decentralised electricity production, driven by decarbonisation objectives and policies and a sharp reduction in the cost of renewable energy technologies (FS-UNEP, 2016). At the same time, there is a decline in conventional, centralised and often more flexible generation capacity. Another factor that is contributing to the shifting landscape of electricity markets is the availability of innovative, low-carbon solutions to balance demand and supply (discussed in section 3 of this report) (Figure 1 provides an illustration of the changing landscape of power systems).

## 1.1 Renewables on the rise

With the recent adoption of the Paris Agreement, world leaders reaffirmed their commitment to limit the increase in global average temperature to well below 2°C degrees, and agreed to pursue efforts to limit global temperature rise to an even more ambitious 1.5°C target (UNFCCC, 2015). The Agreement calls for a peak in greenhouse gas (GHG) emissions as soon as possible, followed by rapid reductions. As energy supply remains the biggest source of GHG emissions, an urgent shift from high- to low-carbon energy is imperative (IPCC, 2014). The power sector will play a central role in the transition to low-carbon energy systems as low-carbon electricity can substitute for fossil fuels in transport and heating (OECD, 2015).

The EU has adopted various policy packages since 1997 to promote the uptake of renewables with the objectives of reducing Europe's reliance on energy imports and its GHG emissions.

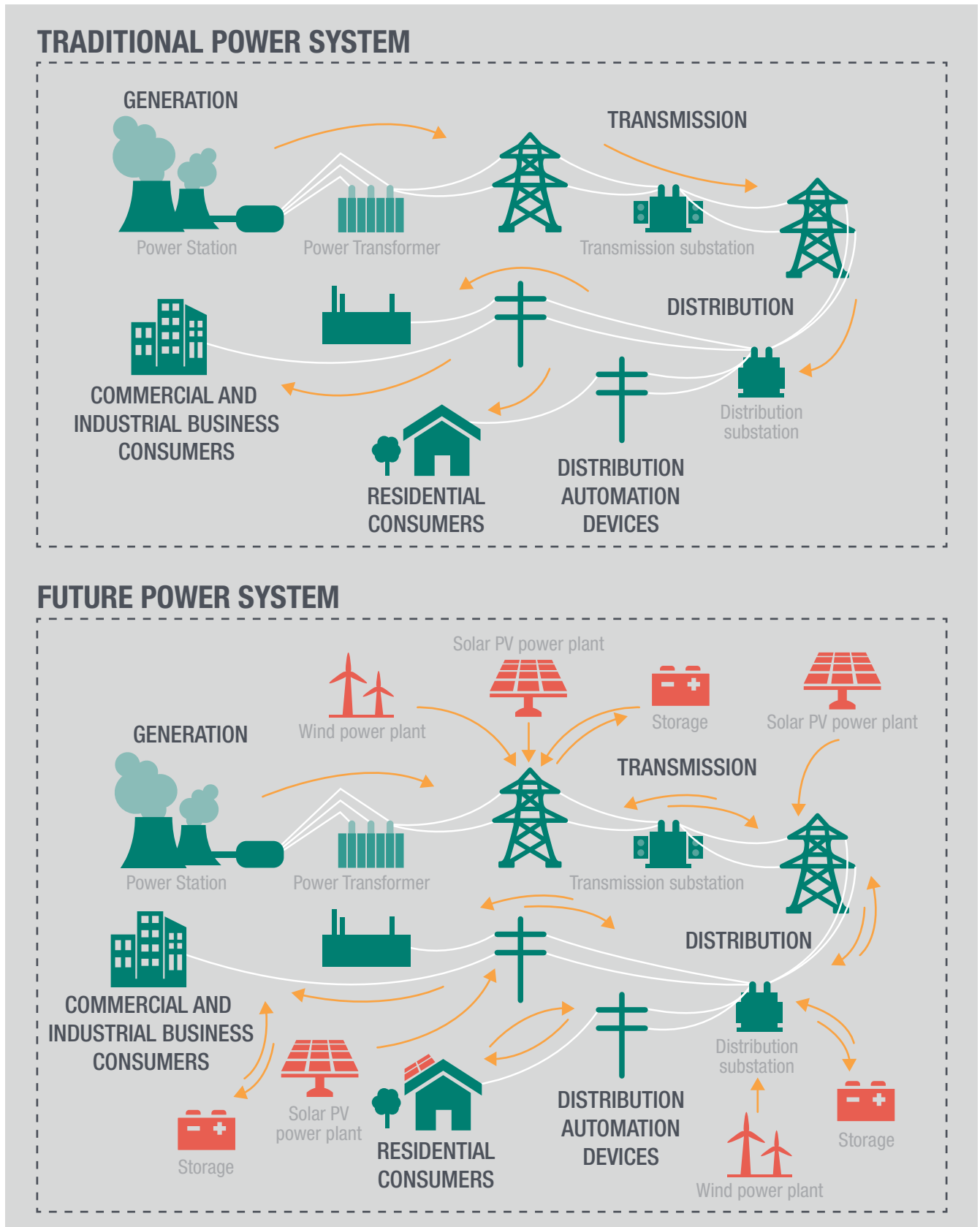
- The EU Emissions Trading Scheme (EU ETS), presented as the 'cornerstone' of EU climate change policy, was launched in 2005 (Directive 2003/87/EC). However, because of a surplus of emission allowances, it has created a very low carbon price that does not provide sufficient incentives for the reduction of emissions. Despite a number of initiatives to improve its functioning, prices are projected to remain low through 2030 (Buck et al., 2015).
- The EU's 2020 climate and energy package sets a binding region-wide target of 20% renewables in final energy consumption by 2020 and the objective of reducing energy consumption by 20% by 2020 (Directive 2009/28/EC; Directive 2012/27/EU).
- The longer-term 2030 Energy Strategy sets targets of a 40% reduction in GHG emissions on 1990 levels, a 27% share of renewables in energy consumption, and a 27% reduction in energy consumption by end-users by 2030 (European Council, 2014).
- As a member of the G20, the EU committed to phasing out 'inefficient fossil fuel subsidies' in 2009, recognising that these encourage wasteful consumption and undermine investments in clean energy (G20, 2009). The European Commission has repeatedly called upon Member States to phase out environmentally harmful subsidies by 2020, including those for fossil fuels (European Commission, 2011a).

As a result of policies adopted to achieve renewable energy targets and a rapid decline in the costs of renewable energy technologies, the EU has seen a significant increase in the share of renewables in the power mix (Figure 2), particularly in variable wind and solar electricity generation (FS-UNEP, 2016). In 2014, renewables accounted for one third of electricity production across the EU, up from 13% in 1990, with large variations between Member States (Eurostat, 2015a). While hydropower still accounts for the largest share of renewable electricity production, its share has declined sharply from 94% in 1990 to 45% in 2013 – a fall linked to the rapid growth in biomass and in variable wind and solar power (Eurostat, 2015b).

Between 2005 and 2014, wind power generation more than tripled and solar electricity generation grew by a factor of 40 (Eurostat, 2015b). Variable renewable energy sources already make up a significant share of electricity production in some Member States. In Spain, for example, renewables met 42% of electricity demand in 2014. On one day in July 2015, unusually high winds enabled Denmark to meet all of its electricity needs with wind, while exporting excess capacity to Norway, Germany and Sweden, with Norway storing a portion of this supply in its hydropower systems for later use (Neslen, 2015). For the EU to achieve its target of an 80-95% reduction in GHG emissions by 2050, the power sector will need



Figure 1: A traditional, centralised power system and a future, lower-carbon, decentralised power system



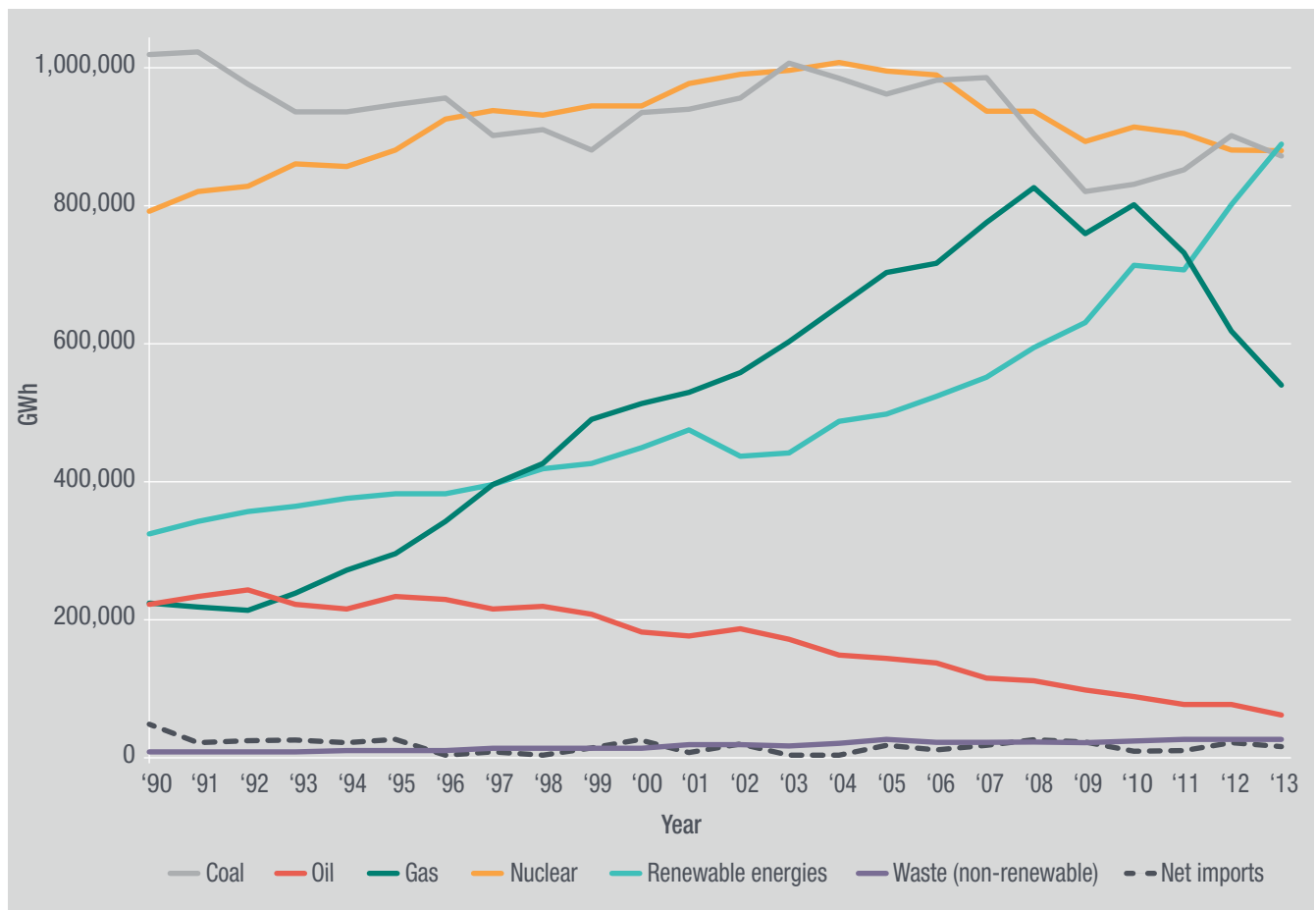
Source: NIC (2016).

to reach full decarbonisation (Hewicker et al., 2011; European Commission, 2011b). At the same time, electrification of road transport will be necessary to meet decarbonisation objectives, and this will increase electricity demand in the transport sector in the EU by a factor of eight compared to 2005 (ECFIN, 2015). Considering the current availability of renewable energy sources in the EU, this will require a significant further increase in variable wind and solar generation (Gottstein and Skillings, 2012).

The term ‘variable’ describes the fluctuation of wind and solar electricity generation in response to changing weather conditions, independently of changes in demand (see Glossary). This fluctuation makes these energy sources less controllable than ‘dispatchable’ resources (such as hydropower, gas-fired generation or demand side response), for which output can be increased or decreased rapidly

in response to supply scarcity or fluctuations in demand (see Glossary) (Hogan, 2012). Solar and wind electricity generation technologies are, therefore, qualitatively different from the perspective of the system operator, and require a more flexible power system to respond quickly to fluctuations in supply (IEA, 2016). While small to medium shares of variable renewable generation (less than 40% of annual generation, according to IEA analysis)<sup>1</sup> have a negligible impact on traditional electricity market operations and costs, their high penetration introduces new challenges for balancing demand and supply in real-time (IEA, 2014). This calls for a transformation of power markets that have, for more than a century, been designed around centralised and predominantly thermal (fossil-fuel and nuclear based) electricity generation (IEA, 2016).

**Figure 2: Gross electricity generation by fuel in GWh**



Source: Eurostat (2015a).

1 Based on case studies of Brazil, ERCOT in Texas, Italy, Iberia, East Japan, and NWE in Australia, the IEA finds that a share of up to 40% of renewables in annual generation can be facilitated with current levels of flexibility.

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## 1.2 Loss of flexible capacity

Alongside, and linked to, the rise in renewables, a significant share of flexible power generation capacity in a number of EU Member States has been retired. This has been driven by four key factors across the region:

- success in support for renewable electricity production technologies and a fall in their costs
- a widespread drop in electricity demand<sup>2</sup>
- a significant number of coal- and gas-fired power plants in the region reaching the end of their operational lives
- environmental policies leading to the phase out of high-emitting plants.

In part, these developments have led to overcapacity and, in turn, exceptionally low wholesale electricity market prices across the EU (which dropped by up to 50% in France and Germany between 2008 and 2014) (OECD, 2015; European Commission 2014a; Genoese and Egenhofer, 2015).<sup>3</sup>

In addition to falling average electricity prices over the course a year, renewables (particularly solar) can also reduce the incidence of electricity price peaks over the course of a given day, as they can provide low-cost supply in times of high demand (Gray et al., 2015). High solar electricity generation, for example, often coincides with periods of high electricity demand at midday. In Germany, high wind and solar electricity production on sunny or windy days has even driven wholesale electricity prices down to negative levels<sup>4</sup> (European Commission, 2015b; Morris, 2015).

While the drop in wholesale prices is effective in signalling that there is a surplus of generation capacity and that hence disinvestment is needed, in the context of an increasing share of variable renewable electricity generation and decarbonisation targets, the type of capacity that retires is of relevance (Hogan, 2012; Buck et al., 2015). The retirement of capacity becomes problematic when the more flexible and lower carbon generation

units close, such as combined cycle gas turbines (CCGTs), rather than the higher carbon and less flexible generation units, such as old coal-fired capacity – a scenario that is beginning to play out in Europe.

Gas-fired power, typically the most flexible of generation technologies, has also been the most expensive in the context of low coal and carbon prices. As a result, it is most likely to be pushed out of the market when renewable generation is high (Caldecott and McDaniels, 2014). Increasing shares of renewable electricity production have, therefore, caused thermal plants, (and in particular flexible CCGTs) to run fewer hours and at lower load factors.

Between 2008 and 2013, the average utilisation rate of all thermal plants (coal, gas and nuclear) across the EU dropped from 50% to 37%. This has made it more difficult for these plants to recover their fixed and operational costs by selling their electricity on the wholesale electricity market (Coibion and Pickett, 2014).

Falling utilisation rates have major implications for power companies that have large conventional, often fossil fuel-based, generation assets. According to Carbon Tracker Initiative (CTI), the largest five power generators in Europe (EDF, GDF Suez, Enel, E.ON, and RWE) lost more than €100 billion (\$128 billion) collectively between 2008 and 2013 (representing 37% of their value) on a market capitalisation basis (Gray et al., 2015). As a result, the EU is seeing increasing mothballing (see Glossary) as well as increasing rates of premature closure of power plants (Caldecott and McDaniels, 2014). In 2012 and 2013, 10 EU utilities had plans to close or mothball over 20GW of CCGT capacity, almost half of which had been built or acquired within the past decade (Caldecott and McDaniels, 2014). European power markets are, therefore, losing flexible and, relatively lower-emission power plants (i.e. gas instead of coal) at a time when increased flexibility is necessary to complement an increasing share of variable renewable electricity generation. This is heightening emerging concerns about security of supply.

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2. Driven by economic slowdown, mild weather and improvements in energy efficiency demand for electricity in Europe dropped 3.3% between 2008 and 2013 (Gray et al., 2015). Forecasts for future electricity demand in the EU vary substantially. ENTSO-E forecasts demand to increase by 0.8% annually between 2016 and 2025, based on the highest electricity demand forecasts of the different System Operators (ENTSO-E, 2015). Carbon Tracker Initiative forecasts electricity demand to continue to decline by 0.3% from 2014 to 2030 (Gray et al., 2015).

3. This drop in wholesale electricity prices is not reflected in retail prices, which have increased on average over the same period. According to the European Commission, this might suggest that price competition in retail markets is weak, enabling suppliers not to pass on wholesale price reductions to their consumers (European Commission, 2014a). Regulated retail prices in some Member States, as well as taxes and levies, also play a role.

4. Negative prices occur because, for some market operators (i.e. nuclear plants), it is more expensive to reduce output than to keep operating at full capacity but at a loss (IEA, 2016; Morris, 2015).

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# 2. Capacity mechanisms: rationale, types and current demands

## 2.1 The historic rationale for introducing capacity mechanisms

Although new concerns about security of supply linked to the wider transformation of energy systems have reignited interest in capacity mechanisms (CMs), they are not a new instrument. They have been introduced in various power markets in the past, particularly in the US and Latin America, to address concerns about security of supply, which has been a persistent challenge for system operators and energy policy makers.

To understand the different approaches taken to maintain the reliability of the power system it is essential to understand the different elements that form part of the challenge of ensuring security of supply, and the rationale for government interventions through a CM.

To ensure power system reliability, electricity demand and supply must be balanced in real-time, or on a second-by-second basis. When supply exceeds demand or is insufficient to meet demand the balance in the electricity system is disrupted, in turn causing blackouts (NIC, 2016). The electricity system must, therefore, have sufficient resources to respond to unexpected power plant shut downs or fluctuations in demand. While fuel security is also important for security of electricity supply, this relates less directly to electricity market design, and is, therefore, not discussed in this paper.

To assess and address power system reliability (see Glossary) many countries across the world have performance standards, for which different metrics are used.<sup>5</sup> Not all European countries have such reliability standards in place,<sup>6</sup> but most that do express their standard in the number of hours per year or over a set period during which involuntary power system failures or blackouts may be expected. As outlined in section 3.1, these reliability

standards are often set to conservative levels, which may not reflect the value of uninterrupted supply to consumers and, therefore, increases the risk of expensive overcapacity (IEA, 2016).

The challenge to continuously balance electricity demand and supply to uphold reliability standards consists of two elements:

- resource adequacy (i.e. are there sufficient resources available – including generation capacity, demand side response and transmission capacity – to meet the needs of electricity consumers).
- operating reliability (i.e. the ability of the system to respond to sudden shocks such as unexpected shutdowns of generating plants and restore the balance between supply and demand) (IEA, 2016); Hogan, 2015a.

While the first question applies mainly to longer-term investment timescales, the second applies to operational timescales, or the short-term functioning of the electricity system (Hogan, 2012; IEA, 2016). Governments, system operators and national regulatory agencies (NRAs) take different approaches so that sufficient investments are made in power market resources to ensure security of supply in the short and long-term.

Traditionally, the question of security of electricity supply has been dealt with primarily on the supply side. Enough generation capacity was built and operated to meet forecasted peak demand; with fluctuating demand levels being perceived as given (or largely uncontrollable). Power system reliability was, therefore, perceived largely as an issue of generation adequacy (Keay-Bright, 2013). Under this model, baseload capacity delivers the supply that is needed at all times through inflexible or less flexible

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5 The IEA has surveyed 30 electricity systems in its Member Countries, of which 22 had reliability standards that were set explicitly by governments (IEA, 2016).

6 Despite EU efforts to integrate energy markets, ensuring security of supply remains in the hands of each Member State, which can take its own preferred approach.



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generation capacity (nuclear or coal-fired generation). More flexible mid-merit power plants (like CCGTs) adjust their output in response to fluctuating demand throughout the day and fill the gap between base- and peak-load. Flexible peaking capacity, including open cycle gas turbines (OCGTs), diesel engines, or hydro-power, delivers the highest or peak-demand levels (Keay-Bright, 2013).

Following power market liberalisation efforts,<sup>7</sup> governments have taken different approaches to ensure sufficient incentives for investment by market operators in the different resources that are necessary to meet maximum forecasted demand. Historically, many European power markets have opted for relatively little intervention and have operated so-called energy-only markets, with providers of capacity remunerated only for the electricity produced and sold in the wholesale electricity market. In theory, in a competitive market without subsidies, price caps or other regulatory interventions, wholesale electricity prices should be able to rise to high enough levels and do so often enough to also enable plants that only operate at times of high demand (mid-merit and peaking plants) to recover their fixed costs through scarcity prices (see Glossary) (Baker and Gottstein, 2013).

The historic rationale for CMs has been that existing government interventions,<sup>8</sup> including price caps to keep electricity affordable, lead to prices that do not enable providers of mid-merit or peaking capacity to recover their fixed costs (the so-called ‘missing money’ problem – see Glossary). This has led to the introduction of various types of CMs that introduce payments for capacity on top of revenue generated from selling electricity on the market. By introducing a source of revenue that is available irrespective of operating hours, CMs aim to incentivise investments in new capacity when this is deemed necessary to meet forecasted electricity needs, and to prevent the retirement of existing capacity that is required to meet a given reliability standard (Baker and Gottstein, 2013).<sup>9</sup>

These mechanisms come in various forms, reflecting country-specific security of supply challenges, resource portfolios and government preferences for different levels of – and tools for – intervention.

## 2.2 Types of capacity mechanisms

The European Agency for the Cooperation of Energy Regulators (ACER) uses the following classification of CMs, based on whether they are quantity- or price-based, targeted or market-wide and centralised (purchases by system

operators or governments) or decentralised (procured by electricity suppliers or consumers) (Figure 3) (ACER, 2013):

- **Strategic reserve:**

A strategic reserve consists of either existing generation capacity that would otherwise be mothballed or decommissioned, or new generation capacity that is kept outside the wholesale electricity market to remain available to ensure security of supply as a last resort in situations of system stress. A strategic reserve is typically quantity based (the system operator or regulator determines the amount of new or existing capacity needed for the reserve) and payments are typically determined through a tender. In Germany, new strategic reserves have been established in the context of an increasing share of variable renewables in the power mix (see Box 6 in section 4 on Germany’s electricity market reforms).

- **Capacity obligation scheme:**

Under a capacity obligation scheme, suppliers and large consumers must contract a certain amount of capacity, determined by the system operator or regulator based on forecasted demand. A linked market for trading capacity certificates may be established. France has plans for a capacity obligation scheme, which was supposed to become operational by 2016, but the European Commission launched an inquiry into the scheme as it believes that the proposed design is inconsistent with EU rules (see Box 2 in section 4 on the EU’s patchwork of CMs). This is likely to delay the planned implementation of France’s capacity obligation scheme (see Box 5 in section 4) (ICIS, 2016).

- **Capacity auction:**

A capacity auction is a centralised, quantity-based scheme in which system operators or regulators determine, typically a few years in advance, the level of capacity that will be required to meet forecasted levels of demand. This capacity is then procured through an auction that sets a price that is paid to all capacity providers that bid successfully in the auction. The UK has implemented a capacity auction scheme, with the first two auctions held in 2014 and 2015. The results exposed some significant flaws in the UK’s CM design, as it is failing to sufficiently promote flexibility in the system and is incentivising high carbon power generation (see Box 4 in section 4 on the UK’s capacity auction).

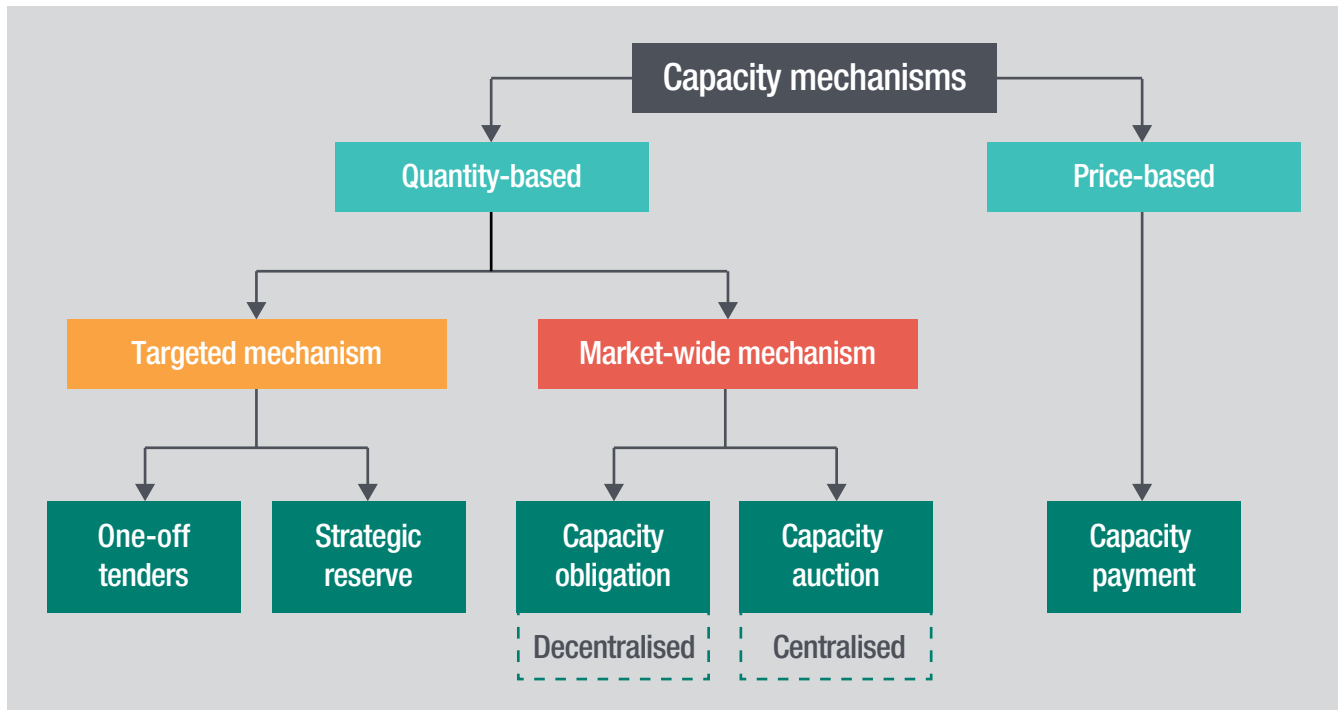
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7 Since the 1980s, market liberalisation efforts have sought to increase the role of the market in determining the level of investment in generation capacity. However, even in liberalised electricity markets, the sector remains heavily regulated and affected by government policies that have a very significant influence on the power mix (IEA, 2016).

8 Government interventions may aim, for example, to promote the deployment of renewable energy technologies, to increase competition or to ensure the affordability of electricity.

9 Sweden introduced a strategic reserve in 2003 after market liberalisation in response to concerns about security of supply following the shut-down of many diesel engines that could not compete in the liberalised market.

**Figure 3: Types of capacity mechanisms**



Source: Baker et al. (2015).

- **Capacity payments:**

Capacity payments provide a fixed price to providers of capacity for their contribution to security of supply. The price is determined by an independent body, while the providers of capacity determine the level of capacity they can provide on basis of those payments. Capacity payments have been in use in Spain since 1996 and in Greece since 2005.

- **Reliability options:**

Consumers, or an independent body acting on their behalf, buy reliability options from capacity providers for a fixed fee. The option is exercised when the wholesale electricity market price (spot price) is higher than a pre-set reference price. When this happens, providers of capacity are required to pay the difference between the wholesale electricity price and the fixed fee to consumers. Italy has recently implemented a capacity market with reliability options (Eurelectric, 2015).

There can be substantial variations in the design and implementation of the different types of CMs based on different methodologies for forecasting future demand and assessing security of supply; the different types of capacity that are allowed to participate in the scheme; different timescales; and different cost recovery methods (although charges tend to be applied to the suppliers who, in turn, typically pass the costs on to the end consumers). Addressing the general benefits and disadvantages of these various types of CMs falls outside the scope of this paper (for a more detailed discussion see ACER, 2013 or Hancher et al., 2015).

### 2.3 A new security of supply challenge

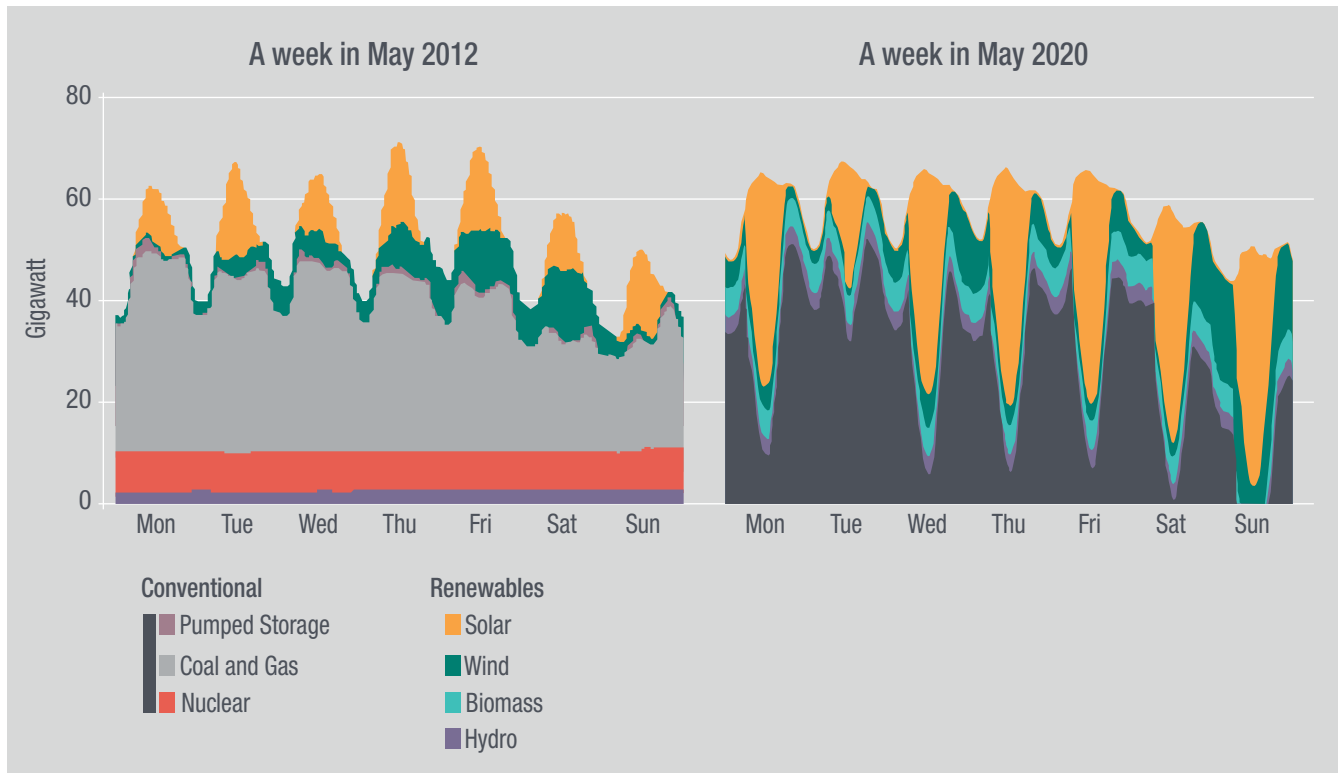
Although CMs are not a new tool, the increase in variable renewable electricity generation has fundamentally changed the nature of the security of supply challenge that CMs were traditionally designed to address.

As discussed in section 1.2, high shares of variable wind and solar electricity generation reduce the need for, and viability of, fossil fuel- and nuclear baseload and mid-merit generation (see Figure 4 on forecasts for Germany). When wind and solar outputs are high, mid-merit and peaking plants will either not run at all, or run at lower load factors. Indeed, the IEA forecasts that, in a scenario which it deems consistent with the goal of limiting global temperature rise to 2°C, gas-fired capacity in the EU installed by 2040 will only run, on average, at 12% of full capacity (IEA, 2016).

Acknowledging this, Steve Holliday, the outgoing CEO of National Grid, the company that operates gas and power transmission networks in the UK, has said that ‘the idea of large power stations for baseload is outdated’ (Beckman, 2015). Instead, there is an increasing need for power systems to respond to strong and frequent variations in wind and solar generation, and inflexible assets that cannot adjust their output in response to fluctuations in renewable generation will increasingly pose a threat to the reliability of power systems (Gottstein and Skillings, 2012).

The operational qualities of power system assets, particularly their ability to adjust generation output or demand quickly in response to variations in renewable electricity supply in the short-term, are therefore of

**Figure 4: Estimated power demand over a week in 2012 and 2020, Germany**



Source: Morris and Pebnt (2015)

increasing importance. In this context, it is evident that the traditional ‘generation adequacy’ approach to CM design that focussed on supply and fails to value operating capabilities (flexibility) is no longer suitable to ensure security of supply.

At the same time, rapid technological advances mean that governments, system operators and national

regulatory agencies (NRAs), have access to a growing number of low-carbon options to increase flexibility in the power system. The following section outlines options to build low-carbon and secure power systems.

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# 3. Beyond capacity mechanisms: options to integrate increasing shares of renewable electricity

An increasing number of options are available that, combined, can help to ensure the reliability of the power system in the context of an increasing share of variable renewable electricity production in a cost-effective manner. These can be divided into options to first, improve system and market operations, and second, add flexibility to the system.

Analysis by the International Energy Agency (IEA) has found that when variable renewables make up more than 45% of generation mix, shifting to a more flexible resource portfolio reduces system costs by two-thirds when compared to a situation where the resource portfolio remains unchanged<sup>10</sup> (IEA, 2014). Similarly, the Office of Gas and Electricity Markets (Ofgem) the UK Government regulator for gas and electricity markets, found that improved system flexibility in the UK power market not only improves reliability and reduces the need for new high-carbon peaking plants, it could also save consumers about \$11.74 billion (£8 billion) a year by 2030 in comparison to a less flexible system (NIC, 2016).

## 3.1 Improving system and market operations

Improving system and market operations can support the more efficient utilisation of existing assets, which can, in turn, reduce the need for back-up generation and additional flexibility in the system.

### 3.1.1 Reassessing reliability standards and assessments

With the intention to prevent blackouts as much as possible, governments tend to adopt conservative reliability standards that may not reflect the value of uninterrupted supply to consumers. This can lead to over-investment

relative to electricity system needs, and stranded generation assets (see Glossary) (IEA, 2016).

These standards need continuous reassessment to ensure that they reflect technological innovation and market developments and are not so demanding that they lead to investments in costly generation capacity that is rarely used. Ideally, reliability standards should also reflect the value of uninterrupted supply to consumers. However, as the value of uninterrupted supply varies across consumers, time of day and year, it is difficult to estimate the value of loss load (VOLL) in practice (IEA, 2016). As a result, we see very different standards across neighbouring countries. In the UK, for example, the reliability standard has been set at three hours expected loss of load per year (see Box 4 in section 4), compared to eight hours in Ireland (CEER, 2014; Keay-Bright, 2013; IEA, 2016).

### 3.1.2 Pricing

Removing price caps can help to improve the ability of the market to reflect scarcity value (see Glossary) and can, therefore, enable markets to better reward flexibility. Allowing wholesale electricity prices to rise in times of supply scarcity enables peaking and mid-merit plants that only operate in times of high demand or unexpected supply interruptions to recover their fixed costs. This also provides price signals that can incentivise investments in new capacity when this is needed (ECFIN, 2015). Another way for the market to better reflect scarcity value is by ensuring that the costs of reserves and ancillary services (see Glossary) that are required to balance demand and supply in real-time are reflected in the day-ahead and intra-day electricity market (Hogan, 2015a) (see Box 1 for background).

The introduction of locational pricing, as introduced successfully in wholesale electricity markets across the US,

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<sup>10</sup> This estimate assumes a strong decrease in the number of baseload power plants and an increase in mid-merit and peaking generation plants and demand side response, as well as improvements in grid infrastructure management.



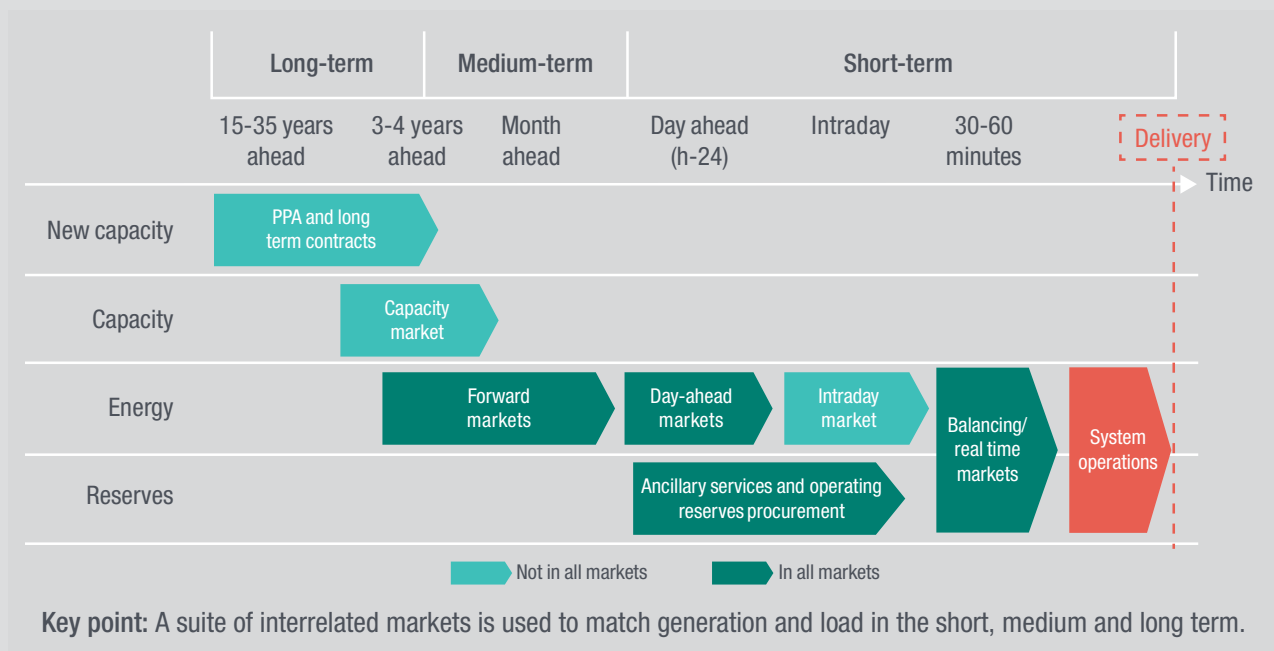
### Box 1: A brief introduction to electricity markets

To prevent blackouts, a balance between electricity demand and supply needs to be achieved on a second-by-second basis. To ensure that this balance can be reached from season to season, at different times of the day, and in the event of unexpected supply interruptions or demand peaks, system operators purchase contracts of different lengths.

System operators purchase long-term contracts years ahead (including power purchase agreements (PPAs) and capacity contracts) and months ahead in the forward market (Figure 5). In the shorter term, electricity is traded in the day-ahead and intra-day markets (Keay-Bright, 2013; NIC, 2016). The bids in these markets are ranked in ascending order, together with the amount of energy that will either be generated or that, if demand-side response also participates in the market, can be reduced to create a merit-order (see Glossary). The forecasted levels of demand determine the marginal bid and, therefore, the wholesale electricity price, as well as which resources will be deployed to meet demand.

When the electricity system is imbalanced in real-time as a result of unexpected power plant outages or demand peaks, system operators are responsible for deploying balancing and ancillary services to prevent blackouts (see Glossary). This can be done by paying generators to increase or decrease their supply, paying consumers to adjust or shift their electricity consumption or by use of other ancillary services (Keay-Bright, 2013; IEA, 2016; NIC, 2016).

Figure 5: Different building blocks of electricity markets



Source: OECD.IEA 2016 *Repowering Markets*, IEA Publishing. Licence: [www.iea.org/t&c](http://www.iea.org/t&c)

can incentivise investments where they are most needed. This increases the business case for local-level storage and demand-side response (see section 3.2). In the EU, prices are mostly uniform over large areas that are, in many cases, defined by borders between countries (IEA, 2016). Shorter scheduling intervals for balancing markets (see Glossary) can also help pricing to better reflect scarcity close to real-time and increase the value of flexible assets in the electricity market. In addition, scarcity value can be better reflected in retail (consumer) prices, by offering customers time-of-use pricing (linking wholesale electricity prices that fluctuate

every hour to consumer prices) or smart metering technologies that give consumers information about their electricity consumption and costs. This can give electricity users an incentive to consume electricity at times when it is abundant and reduce consumption in times of system stress, through automatic systems or manually (see section 3.2). All EU Member States are now rolling out smart-metering (European Commission, 2016a).

These different pricing options can all help to achieve a more efficient utilisation of resources and, therefore, provide a cost-effective way to increase the reliability of the power system.

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### 3.1.3 Interconnection

Interconnection enables electricity to flow across countries and sub-national electricity markets through power lines, enabling the exporting of electricity in times of excessive supply and the importing of electricity in times of system stress. This, in turn, allows for a more efficient use of existing assets across countries, given that peaks of supply and demand do not always occur in neighbouring power markets at the same time (Pöyry, 2013). In addition, aggregating wind and solar capacity over larger geographical areas reduces variability in supply – i.e. when the wind does not blow in France, the sun might be shining in Spain. The possibility to import electricity from Spain in such cases reduces flexibility needs. According to a study by Booz & Company (2013) for the EU Commission's Directorate General (DG) for Energy, better connected electricity markets in the EU could offer wider benefits ranging from €12.5 billion to €40 billion (\$13 - \$43 billion) annually by 2030. The study found that expanding interconnector capacity could provide direct benefits of about €50-€150k/MW/yr (\$53-\$160k/MW/yr) (Booz & Company, 2013). The EU is accordingly aiming for a 10% interconnection level by 2020 and 15% by 2030 (European Commission, 2015c). National Grid, the system operator of the UK, estimates that the net value of doubling the UK's interconnector capacity to 8-9 GW would be £3 million (\$4.4 million) a day, because increased interconnection would reduce wholesale electricity prices (National Grid, 2014a; NIC, 2016).

### 3.1.4 Other options to improve market operations

In situations of over-capacity, it may be more efficient to enable the retirement of surplus inflexible generation assets than to postpone their exit through regulations or government interventions (Buck et al., 2015). This can help to increase the utilisation of existing flexible generation assets and incentivise investment in new more flexible assets (European Commission, 2013). Electricity saving measures can also reduce gross electricity consumption significantly (9% by 2050 compared to consumption levels in 2000), and therefore, the need for additional resource capacity (Boßmann et al., 2015). The addition of renewable electricity generation capacity can also be optimised from a power system perspective. This could include ensuring that capacity is developed close to demand centres or using less variable generation technologies, such as wind turbines with larger rotors that generate more electricity at lower wind speeds than wind turbines with smaller rotors (IEA, 2014). In addition, better weather forecasts can reduce uncertainty about real-time renewable electricity generation and, when combined with closer to real-time

market trading, this can help to achieve a better balance between demand and supply (IEA, 2014).

## 3.2 Adding flexibility to the system

In addition to options to improve market operations, an increasing number of resources are available that can add flexibility to the power system. These can make electricity systems better equipped to respond to fluctuating levels of wind and solar electricity generation<sup>11</sup> and include demand side management and storage solutions.

### 3.2.1 Demand side response

Demand response is the adjusting or shifting of electricity consumption in response to supply fluctuations in real-time, either on a contractual basis or in response to price signals. It can be undertaken by paying electricity consumers (business and households) to temporarily reduce or shift their consumption (i.e. turning-down air conditioning) in times of high electricity demand or to increase consumption during times of oversupply. Demand side response can, therefore, play a crucial role in responding to variable renewable electricity generation (ECFIN, 2015). The companies that intermediate this process at larger scale are known as demand-side response aggregators. Because demand-side response can reduce electricity consumption and help to better match demand and supply, it saves emissions and reduces system stress events that can lead to higher electricity prices.

In the US, demand-side response is already providing substantial benefits in terms of security of supply and cost savings for consumers.<sup>12</sup> One company in the US has found, for example, that sending text messages and emails to its customers during times of peak demand has helped to reduce these peaks by 3-5% (O Power, 2016). Across the EU, however, the potential of demand side response is still far from being tapped. While some Member States have adjusted regulations to facilitate the uptake of demand response (e.g. France and Ireland), in other countries (e.g. Spain, Italy, Germany, Poland, Netherlands) the development of demand side response is still hindered by regulatory barriers (for example, providers of demand side response may not be allowed to participate in the wholesale electricity market) (SEDC, 2015). According to Miguel Arias Cañete, EU Commissioner for Climate Action and Energy, deploying demand side response across the EU could generate savings of up to €100 billion (\$107 billion) a year, or almost €200 (\$213) per European citizen (European Commission, 2015d). Recent analysis finds that if 5% of peak demand in the UK were met by demand side

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11 As selling electricity has traditionally been the main source of revenue in electricity markets, and some of these options help to reduce electricity demand, there is a need to consider how these services can be rewarded within these markets.

12 Direct benefits to consumers were estimated at \$2.2 billion in 2014 (SEDC, 2015).

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response, electricity system costs could be reduced by £200 million (\$294 million) a year (NIC, 2016).<sup>13</sup>

### 3.2.2 Storage technologies

Storage technologies enable consumers and electricity suppliers to store electricity for use when it is most needed. This avoids the need to require (or pay) renewable electricity providers to stop generation at times of supply surplus, which can come at a high cost. In the UK, for example, wind farms are paid £90 million (\$132 million) a year to curtail electricity production during times of over-supply (NIC, 2016).

Storage solutions differ greatly in terms of costs and benefits, and technologies range from compressed air, pumped hydro, flywheel and battery storage (including in electric vehicles). They also differ in their application: while some technologies will store energy for minutes or hours, others store electricity across seasons (Lazard, 2015). In addition, while some storage technologies (such as pumped hydro and compressed air) already have a strong business case, other technologies are at earlier stages of commercialisation.

Over the past decade, however, a great deal of innovation has been achieved around battery technologies (such as Tesla's lithium ion 'Powerwall'), which are becoming increasingly commercially competitive, with costs falling from \$3,000/kWh in 1990 to below \$200/kWh in 2015 (NIC, 2016; FS-UNEP, 2016). Lazard (an asset management company) forecasts that within five years a number of battery technologies, such as lithium-ion and flow batteries, will be competitive against back-up gas-fired power generation as an option for complementing variable wind and solar renewable electricity generation (Lazard, 2015). Some case studies suggest that solar

electricity generation combined with utility-scale battery storage is already competitive with fossil fuel based electricity generation (FS-UNEP, 2016).

As with many technologies, cost-competitiveness, however, may not be sufficient to unlock the potential of storage options. In the UK, for example, the National Infrastructure Committee (NIC) has called for regulatory reforms to enable the participation of storage providers in electricity markets, and to prevent storage from being subject to double-charging for the use of the electricity network both when electricity is stored and when it is released for use (NIC, 2016).

The rising number of low-carbon options for enhancing the balancing of demand and supply, mean that it is possible for governments redesign power market design and regulatory frameworks to promote flexibility and facilitate the uptake of an increasing share of renewable electricity generation. This will, in turn, support the move away from centralised, mostly fossil-fuel fired generation to more decentralised electricity generation, an increasing number of market players, and a more proactive role for consumers.

Recognising that past approaches to capacity mechanisms have become outdated in the context of a changing reliability challenge, and that new opportunities exist to ensure the reliability of the power system, CMs in the US and the EU have been adapted, with varying degrees of success (See Boxes 2-6 in section 4). Building on a review of experiences with CMs and wider electricity market reforms in France, Germany, the UK and the US, the following section suggests that approaches to ensuring the reliability of the power system require a wider reconsideration of opportunities for a low-carbon transformation of the power system.

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# 4. Designing and implementing capacity mechanisms – risks to wider energy policy objectives

Whether the introduction of any type of CM is suited to address emerging concerns about security of supply depends on the power-mix,<sup>13</sup> market or mechanism design and the implementation process. These are all, in turn, functions of political context, wider electricity market design and integration with neighbouring and coupled<sup>14</sup> power markets (Caldecott and McDaniels, 2014).

Even without today's pressing decarbonisation needs and a rapidly transforming electricity market, the careful design and implementation of CMs has been a great challenge. Like all administrative solutions, CMs have practical constraints and their design and implementation introduce human and political factors that can result in unintended outcomes (Hogan, 2015b). They also create a new layer of regulatory complexity, while electricity markets undergo continuous transformation.

Our analysis of planned and existing CMs in France, Germany, the UK and the US highlights the existing and new challenges associated with their design and implementation. These can be categorised as political risks (section 4.1), technical risks (section 4.2) and institutional risks (section 4.3). This analysis also highlights how CMs can undermine parallel objectives of decarbonisation and

the phasing out of fossil fuel subsidies, as well as economic efficiency and electricity market integration (Box 2).

## 4.1 Political risks

An analysis of experiences with CMs in France, Germany and the UK suggests that designing and implementing capacity mechanisms involves political risks. These include risks of regulatory capture by vested interests and of concentrating benefits to incumbents.

### 4.1.1 Regulatory capture (by vested interests)

The consultation process for the design of CMs carries a risk of regulatory capture by incumbent market players that have better access to resources and information and are, therefore, better equipped to lobby. Incumbent market players – often power companies with fossil fuel or nuclear generation assets – can only be expected to aim to protect their own interests: the profitability of their existing assets and their investments. This creates the risk that CMs are implemented where they are not needed or designed in a way that 'suppresses innovation and new entry while privatizing profits for incumbents and socialising risks' (Hogan, 2015b).

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13. In Germany, for example, concerns about security of supply stem from the limited possibilities to transport electricity from areas in the North with an oversupply of wind-generated electricity to areas of high demand in the South (see Box 6). In France, the reliability challenge relates to a high usage of electric heating, which has created an intense peak-demand phenomenon (RTE, 2014). Since 1990, the peaks in consumption have increased faster than overall electricity consumption (Hubert, 2015), increasing the difference between average and peak demand for electricity (see Box 5).

14. Market coupling is the integration of two or more neighbouring electricity markets through an implicit cross-border allocation mechanism. Market coupling 'brings all bids and offers from different national power exchanges for cross-border trading into one 'basket' and allows matching them in an optimal manner across borders.' In Europe, market coupling has been used to integrate electricity markets across different areas (Glachant, 2010). The efficiency of markets over large geographic areas requires strong coordination and the consolidation of balancing areas. (IEA, 2016).

## Box 2: A patchwork of capacity mechanisms – undermining EU regional efforts on security of supply?

Recognising the significant benefits of integrating power markets across a larger geographical scale to enable more efficient utilisation of existing resources and improve the reliability of the power system, Europe has gradually moved towards increased power market integration since the introduction of the First Energy Package in 1996. While historically, European electricity networks were developed primarily to support national markets, electricity market design is accordingly increasingly becoming a cross-border issue.

Regulations, however, are still catching up with this new reality. Security of supply is still regulated at the Member State level, although some EU countries<sup>15</sup> are working together to develop a common, regional approach to setting reliability standards and to assessing reliability).

A proliferation of uncoordinated national capacity mechanisms (CMs) risks undermining internal market integration efforts, which, paradoxically, are supposed to enhance the reliability of the power system. The EU has, therefore, not been supportive of the introduction of uncoordinated CMs at national level. In addition, the EU Commission has recognised that CMs can create new State aid (EU terminology for subsidies) and conflict with decarbonisation efforts.

A 2013 communication of the EU Commission recognises that Member State-level public intervention may be required to ensure security of supply in some Member States in the near-term, but it clearly regards CMs as a last resort. It clarifies that Member States should only consider CMs when the potential offered by other options and wider market and regulatory reforms has been exhausted, including the removal of price caps, improving the effectiveness of intraday balancing markets (see Glossary), cross-border trade and demand side response.

The Commission is prepared to use its legal powers under the EU State aid<sup>16</sup> rules to scrutinise CMs where they have the potential to undermine the electricity market integration efforts. To this end, the Commission published a set of guidelines and assessment criteria for CM design in 2014 and, in 2015, as several Member States have started to implement planned CMs, it launched a sector-wide inquiry into these developments.

The 2014 guidelines clarify the application of State aid rules when CMs are introduced. Member States should:

- demonstrate why intervention in the market is required to ensure security of supply
- design CMs so they only remunerate availability of capacity and not electricity sold
- ensure that the measure is open to all possible providers of capacity and provide adequate incentives to all types of capacity, including generation, demand side response, cross-border trade and storage.

To ensure that aid is proportional and does not distort competition and trade, a competitive bidding process is recommended. Member States should also give preference to low-carbon generators ‘in case of equivalent technical and economic parameters.’

Although this guidance leaves a lot of room for interpretation, and more detailed guidance can be expected from the Commission’s investigation, a few observations can be made. First, the use of the term ‘generation adequacy’ rather than ‘resource adequacy’ is outdated in the context of the increasing importance of resource capabilities (flexibility and carbon intensity) and demand side response. Second, the requirement for the measure to be open to all providers of capacity to minimise market distortions might conflict with the EU’s decarbonisation objectives when payments prolong the lifetime of fossil fuel-fired generation assets. Third, if the requirement to provide adequate incentives to existing and future generators keeps less flexible assets in the power mix, this will undermine rather than support security of supply and innovation.

The EU’s efforts to establish an EU-wide approach to ensure the reliability of the power system and electricity market integration should be strengthened to make more efficient use of capacity across Europe and improve security of supply.

*Sources: European Commission (2015e; 2014b; 2013); IEA (2016).*

Indeed, many conventional power companies, including RWE and E.ON in Germany, the big six (British Gas, EDF, Npower, E.ON UK, Scottish Power and SEE) in the UK and EDF in France, and particularly those facing risks of stranded

coal generation assets, have put pressure on Member States to introduce CMs instead of alternative measures to support the reliability of the power system (Caldecott and McDaniel, 2014). This is unsurprising as these companies’ revenues

15 These Member States include Austria, Belgium, France, Germany, Denmark, the Czech Republic, Luxembourg, the Netherlands, Poland and Sweden.

16 State aid is defined as: 1) an intervention by the State or through State resources that can take a variety of forms (e.g. grants, tax reliefs, guarantees, government holdings of all or part of a company, or providing goods and services on preferential terms); 2) that gives the recipient an advantage on a selective basis; 3) may distort competition; 4) and is likely to affect trade between Member States (European Commission, 2013b).



from selling electricity are declining and CMs create an opportunity for a stable revenue stream, a reduction of losses or improved market performance.

This is demonstrated by the introduction of the lignite power stand-by security reserve in Germany, linked to the country dropping initial plans to introduce a climate levy that would penalise high-polluters. RWE had long lobbied against the climate levy and, following the announcement of the new plans to put lignite in a reserve, its share value rose by 6.4%. Under the new plans, the power companies will receive payments for shutting down their power plants, instead of needing to pay for the pollution caused by lignite power stations. E3G has estimated that the compensatory payments to RWE may amount to a significant 13% of its 2014 operating result from its entire conventional business (Schwartzkopff et al., 2015).

While the mechanism is framed as a tool to cut emissions in the power sector, it operates like a capacity reserve. Furthermore, while only those power stations not already listed in the closure notification list are eligible for the security stand-by (to ensure that the standby reserve cuts additional emissions), there are doubts as to whether the plants included in the reserves would not have shut down anyway, especially in the context of decreasing prices for gas. In addition, the Government's deliberate selection of power plants for the reserve may be at odds with EU competition rules that require these market interventions to be 'technology neutral'. All of this suggests that the security standby denotes a political compromise around the closure of old lignite-fired power stations, rather than a measure to support security of supply or reduce emissions.

In France, RTE, the TSO, has designed and would operate the country's proposed CM (see Box 5). As RTE is owned by EDF (the dominant publicly owned electricity provider) there is a possible conflict of interest in the design of the capacity obligation scheme. While the scheme is, allegedly, designed to incentivise demand response, the European Commission has raised concerns that it has a strong tendency to strengthen the dominant position of EDF instead (European Commission, 2016b).

Recognising the interest of utilities to protect the profitability of their assets, the EU Commission has clarified that CMs should not result in 'state support to compensate operators for lost income or bad investment decisions' (European Commission, 2013).

#### 4.1.2 Risk of concentrating benefits to incumbents

There is also a risk that the benefits of CMs accrue to the participants that dominate the market. EDF, for example, manages about 90% of installed capacity in France and dominates the retail electricity market. EDF will, therefore, be the biggest obligated party as well as the holder of the most capacity certificates in France's proposed capacity obligation scheme (see Box 5).

Regardless of the prioritisation of demand side response over generation in the design of the French

scheme, EDF is likely to be the price setter in the capacity market (Zgajewski, 2015). Although the mechanism was scheduled to first deliver capacity in 2017/18, the Commission has launched an in-depth investigation into the plans because it believes they are incompatible with EU rules, given the risks of market concentration and distortion (European Commission, 2016b).

When a large share of compensatory payments is secured by the incumbents, or when incumbents are the main players in a capacity market, CMs, as recognised by the Commission 'may have distortive effects by strengthening or maintaining substantial market power of the beneficiary' discouraging the entry of new competitors (European Commission, 2014b).

## 4.2 Technical risks

A review of experiences with CMs in the US, the more recent capacity market in the UK, and of the plans for a capacity obligation scheme in France and a capacity reserve in Germany suggest that the design and implementation of CMs also involve significant technical risks, including:

- overestimating future electricity needs, creating risks of stranded assets;
- locking in inflexible capacity, which in the context of an increasing share of wind and solar generation undermines the reliability of the power system;
- locking in high carbon generation, which undermines decarbonisation objectives;
- creating new fossil fuel subsidies that undermine fossil fuel subsidy phase-out objectives; and
- creating barriers to innovation.

### 4.2.1 Risk of overestimating future electricity demand

Quantity-based CMs carry the risk of overestimating future electricity needs, leading to the lock-in of unneeded capacity and, in turn, stranded assets (see Glossary). Forecasting the future needs of power systems is a particular challenge in the current context of rapid technological innovation and market transformation. One study that compared capacity mechanisms in the US with the energy-only National Electricity Market (NEM) in eastern Australia found that CMs were more likely to lead to over-procurement of capacity than markets that rely on scarcity prices and the pricing of ancillary services to attract investments (Hogan, 2015a).

In its assessment of the UK's plans for a capacity market, the European Commission warned that the planned scheme would overestimate capacity needs as a result of overly conservative assumptions, in particular for interconnector capacity (European Commission, 2014c) (see Box 4). Despite these warnings, the Commission approved the UK's capacity market, conditional on some improvement in its design. Nonetheless, the first UK auction was also based on conservative expectations of the contribution of demand

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side response, assuming that its deployment would not increase at all over the next four years (Baker et al., 2015). A 2014 study of EU Member States' generation adequacy assessments found that the UK is not alone, and that many countries fail to consider flexibility and the contribution of interconnection in these assessments (CEER, 2014).

To avoid the design of CMs based on overestimations of future electricity demand, the EU Commission requires Member States to demonstrate the need for intervention in the market. In assessing security of supply issues (commonly the responsibility of either the TSO, the NRA or the government), Member States should take into account 'on-going market and technology' developments, but how they should do so is not specified (European Commission, 2014b). The EU Energy Union Package further points out that frameworks for security of electricity supply in many EU Member States are out-dated and inconsistent. In line with its market integration objectives (see Box 2), the EU plans to work with Member States to establish acceptable risk levels for supply interruptions and an EU-wide security of supply assessment, taking into account cross-border flows of electricity, variable renewable energy generation, demand response and storage possibilities (European Commission, 2015f). A number of Member States,<sup>17 17</sup> together with Switzerland and Norway, are working together to develop a common, regional approach to setting reliability standards and to assessing reliability (IEA, 2016).

Despite these efforts, the IEA (2016) points out that a relative lack of attention to reliability regulations in the creation of the EU's Internal Energy Market may explain why countries still tend to take a national-level approach to the assessment of reliability, which can increase the cost of ensuring reliability and undermine market integration. Overestimating future system needs is a common risk when governments use incentives to promote investment in new capacity or infrastructure and even so when investment decisions are left to the market. Market participants may also fail to accurately forecast future demand or technological innovations (IEA, 2016).

#### **4.2.2 Risk of locking in inflexible capacity**

Historically, and as discussed more extensively in section 2.1, ensuring security of supply was approached largely as a matter of generation adequacy. Therefore, traditional CMs simply remunerated capacity, irrespective of operational qualities (like flexibility). Today, the increasing need for flexibility in the power system, given the growing share of variable renewable electricity generation, presents a paradox: fixed, undifferentiated payments for capacity may undermine, rather than boost, the reliability of the power system (Keay-Bright, 2013). This is particularly the case when capacity payments keep old, less flexible capacity in the market, which cannot adjust output in

response to fluctuating levels of renewable electricity generation. In addition, this can discourage investment in the more flexible resources required to facilitate the uptake of variable renewable electricity generation.

The limitations of CMs that remunerate generation capacity irrespective of operational characteristics became apparent in a number of US power markets, including PJM and ISO New England. In response to emerging issues like these the designs of a number of CMs in the US have been adapted continuously for more than a decade (see Box 3).

In Germany, the planned power market reforms include an additional back-up capacity reserve with largely inflexible, high-emitting plants. This security stand-by removes 2.7GW of lignite-fired power plants from the market, which, even though those power plants cannot respond quickly to system stress events, should provide a last back-up option to ensure supply security until they are decommissioned in 2021. This comes at an estimated cost of €1.6 billion (\$1.7 billion) to the German Government (Michel, 2015), which has agreed to reimburse the companies for lost revenues from the electricity market during these years of security stand-by.

The European Commission has emphasised that in situations of overcapacity – an issue in a number of European power markets – security of supply concerns will not be addressed by keeping generation capacity on the system. Instead, 'Member States may consider ... allowing for the retirement of environmentally inefficient plants, for example through the implementation of environmental legislation or by removing subsidies' and that 'creating market wide capacity remuneration schemes may under such circumstances be counter-productive as it may (depending on the design) postpone the exit of inefficient capacity from the market'. This is, for example, the effect of continued support for coal in Spain on revenues for newer and more flexible gas power stations (European Commission, 2013).

#### **4.2.3 Risk of locking in high carbon generation**

By providing a new source of revenue for providers of capacity, including fossil fuel generators, CMs can extend the lifetime of generation assets and undermine decarbonisation efforts.

The UK provides an example (see Box 4). In its first capacity auction, more than 70% of the capacity payments were secured by high-carbon assets, including coal and gas plants and diesel generators (National grid, 2014b). Existing coal-fired power secured 9.5% of capacity units, representing \$430 million (£293 million) in payments for 2019-2020 (Jones, 2014). Providers of coal-fired power were able to secure one-year contracts and, in the case of refurbishment plans, three-year contracts. By offering these longer contracts for refurbishment, the capacity auction encourages coal generators to extend the lifetime of their high-carbon

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17 These Member States include Austria, Belgium, France, Germany, Denmark, the Czech Republic, Luxembourg, the Netherlands, Poland and Sweden.

### Box 3: United States: adapting to new market realities

Parts of the US have a long history of using capacity mechanisms (CMs), which have been introduced since power market liberalisations, starting in the mid-1990s. Some lessons can be learned from the way in which these mechanisms have been adapted, often in combination with wider electricity market reforms, in response to electricity market developments.

The limitations of CMs that remunerate generation capacity irrespective of flexibility became apparent in a number of US power markets, including PJM<sup>18</sup> and ISO-New England.<sup>19</sup> Despite their success in incentivising investments in new capacity,<sup>20</sup> and these markets having ample capacity relative to the reference reserve margins, they experienced increasing stress events (Genoese and Egenhofer, 2015). The CMs had the effect of extending the lifetimes of existing inflexible capacity, and this, in turn, lowered electricity prices. This entrenched the existing mix of capacity, at a time when this mix was becoming less fit to ensure reliability in the context of a growing need for flexibility.

In response, PJM first proposed to differentiate payments for capacity based on capabilities, so that flexibility could be prioritised. This was, however, opposed by stakeholders and PJM decided to take a similar approach to that of ISO-New England, which introduced a bonus-penalty scheme linked to performance during system stress events. Rather than rewarding flexibility directly, this approach awards all capacity when it is available during stress events. By doing so, it does promote flexibility indirectly as the more flexible assets are more likely to be deployed to meet capacity needs during stress events.

In addition, PJM has promoted the participation of demand side response in its capacity market in three ways. First, by enabling its participation in the wholesale electricity market and the capacity market. Second, by introducing different categories for demand response resources to the capacity market on the basis of when they can be deployed. Third, by adopting a differentiated auction process. Demand side response has helped to reduce the costs of meeting the reliability standard by an estimated 10-20% in 2014/15, delivering estimated consumer cost savings of \$1.2 billion (Keay-Bright, 2013). More recent reforms also allow demand side response resources to submit aggregated capacity market offers together with other resource types (such as storage and energy efficiency).

In addition to these reforms to the capacity mechanism, PJM and NY-ISO<sup>21</sup> also ensured that market prices can better reflect the cost of balancing supply and demand in real-time (after gate closure). They did so by ensuring that day-ahead and intra-day electricity market prices also reflect the value of the reserves or other balancing services needed to ensure power system reliability.

Finally, US wholesale electricity markets (including those with CMs in place) have moved to more location-based pricing (nodal pricing). This has helped to create stronger price signals that reflect local imbalances in supply and demand and, therefore, incentivise investments where these are most needed (geographically), including in transmission and distribution.

*Sources: Hogan (2015a); Gottstein and Skillings (2012); Hurley et al. (2013).*

and less flexible fleet. This is at odds with a recent UK Government decision to phase out coal-fired power by 2025.

Diesel generators, the dirtiest form of electricity generation, secured capacity contracts worth (£109 million in the first capacity auction, and won 15-year contracts worth \$258 million (£176 million) in the second auction (Aldridge, 2015; Jones, 2015b). These highly polluting generation units, which have a higher carbon intensity than coal and emit other air pollutants that pose a threat

to human health, are exempted from environmental regulations because of their small size (Jones, 2014). What is more, they already receive large payments for their contribution to balancing services (including through the Short Term Operating Reserve) (Orme, 2016).

Recognising the risks posed by CMs to decarbonisation objectives, the European Commission has warned that they should not increase carbon intensity and must avoid locking-in high carbon generation (European Commission, 2013).<sup>22</sup>

18 PJM is the regional transmission operator in the US that coordinates the movement of wholesale electricity in 13 states and the District of Columbia in eastern US.

19 ISO-New England is the Independent regional transmission organisation operator overseeing the operation of New England's power system.

20 Existing resources still receive the largest share of capacity market revenues in PJM. In the 2017/2018 delivery year, existing resources will receive \$6 billion in revenues, compared to \$1 billion for new resources (IEA, 2016).

21 The Independent System Operator that manages the markets in New York State.

22 It must be noted that CMs are no decarbonisation tools. Wider decarbonisation of the energy sector requires carbon pricing and other policy tools that should not be undermined by CMs (where they are deemed necessary) – see section 5.

#### **Box 4: The UK capacity auctions – subsidising new dirty power generation and undermining flexibility**

The retirement of two-thirds of existing power stations by 2030, combined with a rise in variable renewable capacity, underpins concerns about security of supply in the UK (NIC, 2016).<sup>23</sup> In 2013, to address these concerns, Ofgem (the regulator for gas and electricity markets), the Department for Energy and Climate Change (DECC), and National Grid (the UK's TSO) introduced two new strategic reserves on top of the existing Short Term Operating Reserve (STOR). These new strategic reserves include a demand-side balancing reserve (DSBR) and a supplemental balancing reserve (SBR), that are kept outside the wholesale electricity market, and are activated to address short-term security of supply issues.<sup>24</sup> In addition, the UK Government has introduced a capacity auction scheme – operational since 2014 – to address more long-term security of supply issues.

The UK's annual capacity auctions procure capacity either in the form of existing or new generation, demand side response (DSR), storage or interconnection, to ensure that future demand (forecasted four years ahead) can be met.<sup>25</sup> National Grid is responsible for forecasting the capacity required to satisfy the reliability standard, which requires that Loss of Load Expectation (LOLE) not to exceed three hours per year. All but 2.5GW of required capacity is procured four years before the delivery year in a capacity auction (T-4 auction) and the remaining 2.5GW is reserved provisionally for a one-year ahead capacity auction (T-1). Existing and new capacity, including providers of nuclear power and DSR, are eligible to participate, while renewables that benefit from existing support schemes are not. DSR providers can participate in the T-4 auction or the T-1 auction, but are not permitted to participate in both. They are encouraged to participate in the T-1 auction, but when they do so they might be prevented from contributing to security of supply if too much capacity has already been procured in the T-4 auction. Those that bid successfully receive annual payments for the capacity auctioned and they are penalised if they fail to deliver contracted capacity during a stress event. Capacity payments are funded by consumers through charges by electricity suppliers, and are estimated to cost \$20 (£14) per UK household per year.

A number of concerns can be raised regarding the design and implementation of the UK's capacity auction. Firstly, it can be questioned whether the capacity market is needed in the first place. Ofgem has stated that the market is likely to be able to respond effectively to scarcity from 2017/18 as the result of falling demand, and the return to the market of a number of previously 'mothballed'<sup>26</sup> plants.

As currently designed, the UK capacity auction could also result in overcapacity and stranded assets. Demand forecasts, which determined the capacity needs for 2018/19, were based on conservative expectations of the potential contributions of interconnection and demand side response,<sup>27</sup> as well as of the availability of both coal and gas fired generation.<sup>28</sup>

Furthermore, although the UK's capacity auction is designed to be technology neutral, the Government hopes that it will incentivise investments in new gas. However, only one new gas-fired plant – Trafford Power – succeeded in the first auction and, so far, this plant has failed to attract the finance needed to start construction. In the second auction, only one new gas Combined Cycle Gas Turbine plant (Carrington) managed to win a one-year contract. To date, the largest share of capacity payments (more than 70%) has been secured by existing generation capacity, a portion of which is already profitable without these payments.

As well as subsidising existing profitable generation and undermining decarbonisation objectives, the scheme's provision of undifferentiated payments that disregard operational capabilities fails to promote flexibility.<sup>29</sup> For example, the UK's capacity auction has resulted in payments worth \$277 million (£189 million) to nuclear power plants, although these are inflexible assets that would have operated anyway. One UK-based energy consultancy predicts that the auctions will even undermine near-term security of supply as those market participants that do not succeed in the auction are more likely to exit the market as a result of decreased competitiveness.

Furthermore, low-carbon flexibility options cannot compete on an equal footing in the capacity auction. While new generation capacity is able to access 15-year contracts, DSR and interconnection can only access one-year contracts. This is because of a spending threshold that only allows market operators to access longer contracts when they are making investments in new capacity or in refurbishing capacity above a set amount. As demand reduction measures are often a cheaper option (allowing savings of \$44/MWh (£30/MWh) in contrast to the costs of new generation capacity from \$111/MWh (£76/MWh)), this may make the capacity auction more expensive (Green Alliance, 2015). This and other aspects of the UK's capacity auction are now the subject of a legal challenge by Tempus Energy, a demand side response firm, in the European General Court (Case T-739/14, OJ C18/21).

Finally, it appears that some capacity that has succeeded in the auctions will not be delivered. For example, operator SSE announced that the coal generation units at Fiddler's Ferry will be shut down on 1 April 2016, despite having secured capacity payments for delivering capacity in 2018/19. Although SSE will have to pay penalties for not delivering on its capacity contract, these penalties are likely to be lower than the costs of continuing to run at a loss (Orme, 2016).

*Sources: Ofgem (2015); Littlecott (2014); Harvey (2016); Cornwall Energy (2015a; 2015b); DECC (2015a; 2015b); Baker et al. (2015); Jones (2015a; 2015b; 2014), Stacey (2015a; 2015b); Aldridge (2015); Green Alliance (2015); Energy UK (2015).*



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The State aid guidelines require Member States to ensure that CMs give preference to low-carbon generators ‘in case of equivalent technical and economic parameters’ (European Commission, 2014b). At the same time, however, the guidelines require Member States to design their CMs to be open for participation by all possible providers of capacity to ensure that they do not distort competition and trade. Without further clarification on how governments can prioritise low-carbon generators, it is unclear how Member States can meet these potentially conflicting requirements (European Commission, 2014b).

#### 4.2.4 Risk of creating new fossil fuel subsidies

When capacity mechanisms create new payments for fossil fuel based generation, they not only undermine decarbonisation objectives, but are also at odds with the EU’s longstanding commitment to phase out environmentally harmful subsidies, including fossil fuel subsidies. Most recently, in the Roadmap to a Resource Efficient Europe, the European Commission called for a complete phase out by 2020. At the international level, as part of the G20, the EU has reiterated its commitment to ‘phase out inefficient fossil fuel subsidies’ every year since 2009.

There is a risk that CMs result in new subsidies for fossil fuel generation that will be hard to remove once they have been introduced.<sup>18</sup> In the US PJM capacity market, for example, 67% of capacity payments provided in auctions between 2014 and 2018 went to existing and new oil, gas and coal-fired generation, with only 33% going to demand side response, energy efficiency, imports, solar, wind and solid waste (across a total of \$46 billion) (Monitoring Analytics, 2015). The limited capacity payments for wind

and solar are, in part, explained by their variability, which means they can only participate for 13% and 38% of their installed capacity, respectively (PJM, 2014; IEA, 2016).

The UK capacity market has also led to subsidies for coal and diesel of \$548 million (£373 million) and \$418 million (£285 million) respectively. Capacity contracts of 15 years mean that the subsidies to diesel will be in place for the longer-term, while consumers simultaneously pay a carbon price for diesel and coal fired generation (Aldridge, 2015).<sup>30</sup> Perversely, solar-power companies (whose direct subsidies have been cut) are now installing diesel generators on their sites to increase returns through capacity payments for diesel (Stacey, 2015a).

Recognising the risk that CMs can introduce new fossil fuel subsidies, the EU State aid guidelines require Member States to: ‘consider alternative ways of achieving generation adequacy which do not have a negative impact on the objective of phasing out environmentally or economically harmful subsidies, such as facilitating demand side management and increasing interconnection capacity;’ (European Commission, 2014b). If Member States do choose to introduce CMs, they ‘should take into account the objective of phasing out fossil fuel generation subsidies by 2020’ (European Commission, 2013). The payments provided under the UK capacity auction to coal and diesel-fired generation appear to be directly at odds with this wider EU guidance and the commitments to phase out subsidies. The UK Government, however, maintains that the payments provided under the mechanism are not subsidies because they ‘provide missing money in the energy market’ (UK Parliament, 2016).

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23 Two-thirds of existing power stations are expected to close down by 2030 because of coal, nuclear and gas plant retirement cycles (NIC, 2016), emission control regulations and financial constraints faced by utilities (Caldecott and McDaniels, 2014). Between 2010 and 2014, the UK’s generation capacity reduced by 5.5MW, while wind capacity, when de-rated for intermittency, more than doubled, and electricity demand declined by 6.5% (DECC, 2015a).

24 The demand-side balancing reserve (DSBR) was first enacted in November 2015 to prevent a blackout in a period of system stress, while the final safety net – the supplemental balancing reserve (SBR) consisting of mothballed power stations – would have taken several hours to activate (Davies, 2015).

25 Interconnection has been included since the second auction.

26 Mothballing is when a power plant is not used to generate power, but is preserved (kept in working order) so that production can be resumed when needed.

27 In the first auction, interconnection was even excluded from the assessment of the capacity required to meet the reliability standard, despite analysis by Ofgem that found that interconnections can contribute about 60% of installed capacity to meeting winter peak demand.

28 Forecasted availability was estimated on the basis of average availability, rather than actual availability at times of peak demand.

29 Increased flexibility would not only reduce the need for new high-carbon peaking plants, but would also bring down the cost of decarbonisation, according to NIC (2016), by about £8 billion a year by 2030 relative to a less flexible system.

30 The carbon price floor was introduced to create a minimum carbon price. If the carbon price in the EU Emission Trading Scheme (ETS) drops below a certain level, the carbon price floor requires companies to pay the difference to the UK treasury. The floor was designed to increase every year, but in 2014 a decision was taken to freeze it at 2015/16 levels (HM Revenue & Customs, 2014)



### Box 5: France: incentivising demand side response?

Significant hydro and nuclear generation capacity has enabled France to ensure energy independence and to decarbonise its energy sector. This has also led to the promotion and uptake of electric heating in households, resulting in an intense peak demand phenomenon. Since 1990, the peaks in consumption have increased faster than overall increases in electricity consumption. Meanwhile, following market liberalisation, demand side response capacity declined from 6GW in the 1990s to 3GW in 2015. High levels of peak demand have also coincided with an increase in the share of variable renewable electricity generation<sup>31</sup> and the closure of coal and oil-fired plants to comply with EU environmental regulations. As a result, the French Government has become increasingly concerned with security of supply, particularly in times of peak demand for electric heating.

To address these concerns, a law was adopted in 2010 that called for the creation of a capacity obligation scheme. If introduced as planned, this scheme would require all suppliers to buy a set amount of capacity certificates, determined by the French TSO on the basis of consumption levels during peak times. The certificates would be issued by the TSOs or DSOs to operators of demand response or generation capacity based on their projected contributions during peak periods. Once the certificates are issued, suppliers and operators would be allowed to trade them.

This market-based approach is supposed to ensure that the prices of certificates will reflect the costs of ensuring security of supply. By giving a bonus payment to those who exceed their obligations in times of system stress, financed by penalties paid by suppliers that fail to meet their capacity obligation, the scheme rewards operators for their contribution to the grid in times of short supply.

The French capacity obligation scheme is also meant to promote the use of demand response as part of a wider four-year government programme to open all markets to demand side response providers. To that end, it will grant priority to demand side response over generation capacity by allowing the former to request certificates over a longer timeframe (up to a year prior to delivery, compared to three years for existing generation capacity). The system is also designed to promote flexibility by remunerating generation or demand side response capacity on the basis of their contribution to the grid when the system is tight. Although the market is designed to reward all capacity available at peak-times, including less flexible assets, and thus does not directly reward flexibility as such, it is likely that more flexible assets will be of greater value to obligated parties under the scheme, as these provide greater security for meeting capacity certificate obligations in periods of system stress.

In spite of the promise that the French scheme would promote demand response and flexibility, high levels of market concentration (by EDF) raise concerns as to whether the mechanism, if implemented, would realise the potential of demand side response. The complexity of the system might also create a barrier to new market entrants. More fundamentally, it remains to be seen whether the mechanism will be introduced as planned, as the European Commission has launched an in-depth investigation into its planned design. The Commission has raised doubts as to whether the mechanism is currently necessary, and asserts that it would be likely to strengthen the dominant position of EDF. The Commission holds that, in its current form, the mechanism is not compatible with the Guidelines on State aid for environmental protection and energy.

*Sources: RTE (2016; 2015; 2014); Hubert (2015); Veyrenc (2015); European Commission (2016b; 2015g); NOME Law (2010)*

### 4.2.5 Creating barriers to innovation

If a CM is not flexible enough to enable the participation of providers of innovative, emerging services and technologies, or if it entrenches the existing mix of capacity, it can also create an obstacle to innovation (Grigorjeva, 2015). The UK provides an example. While its capacity auction is supposed to be technology neutral, new low-carbon distributed electricity technologies are unable to compete on an equal footing with fossil fuel generators

(see Box 4) (Platt et al., 2014). New gas and diesel capacity can access 15-year contracts in the capacity auction, but demand side response and storage can access only 1-year contracts. Highly complex CM design or rules may also create a barrier to new market entrants with limited resources to allocate to understanding and participating in the mechanism, which is a concern with the creation of a new market for capacity certificates in France (Box 5).

31 France targets a share of renewable energy (including hydro) in total final energy consumption of 32% by 2030 and a reduction in fossil fuel consumption of 30% by the same year (Energy Transition Law, 2015).<sup>32</sup> One of the 15 action points of the Energy Union reads: 'Creating a seamless internal energy market that benefits citizens, ensuring security of supply, integrating renewables in the market and remedying the currently uncoordinated development of capacity mechanisms in Member States call for a review of the current market design.'

## Box 6: Germany's proposed system-wide approach

At the national level, Germany has surplus capacity, which it exports to neighbouring countries (BMWi, 2014). However, its geographical variations in generation, combined with a relative lack of transmission infrastructure, leaves some regions in Germany's electricity market oversupplied,<sup>32</sup> while others, particularly the demand centres in Southern and Western Germany, may face issues with power system reliability over the next few years. Variable renewable generation already accounts for a significant share (25%) of electricity production in the country, and this share will continue to grow as Germany has a target for 80% of its power supply to come from renewables by 2050. This has required a broad national strategy to facilitate the large-scale uptake of variable renewable electricity generation.

Despite strong lobbying for the introduction of a market-wide capacity mechanism (CM) by incumbents, including RWE and E.ON, the German Government decided to take an alternative approach. The Electricity Market 2.0 strategy, sets out plans to improve the country's energy-only market by fostering competition between generation and other flexibility options to 'make the electricity market fit for the 21st century'. The German Government favours this approach over a market-wide CM as, in the words of Sigmar Gabriel, Germany's Energy Minister, these involve risks of 'costs spiralling out of control, government-imposed false incentives and of disruptions on the electricity market.' An earlier government white paper acknowledges that CMs can increase carbon emissions and 'preserve existing structures' and could, therefore, 'delay the transition and the renewal of the power plant fleet.' In addition, this white paper highlighted that incomplete information and uncertainties about capacity needs mean that a capacity market would require continuous fine-tuning which would, in turn, cause regulatory uncertainty.

The proposed Electricity Market reforms<sup>33</sup> would be the most significant since the German energy markets were liberalised in the 1990s. The reforms are meant to enable the electricity markets to reflect scarcity value, and incentivise capacity providers and consumers to match demand and supply in the most efficient ways possible. In all, 20 specific measures have been proposed, which include the following key elements.

- Free price formation:<sup>34</sup> so that scarcity value can be reflected in the market. This should incentivise market players to invest in more flexible assets, including demand side management and storage.
- Greater accountability of electricity providers and traders: parties that buy insufficient capacity to balance demand and supply would face the costs of covering the shortfall.
- Greater competition between flexibility options: measures would be undertaken to enable demand side operators, providers of storage capacity and, in the medium to long-term, electric cars, to access the market and increase competition between these flexibility options.
- Redistributing the cost of grid network expansion: charges for transmission costs would be distributed equitably across Germany.
- An EU approach to ensuring security of supply: greater consideration would be given to security provided through the European internal market, as this is more cost-efficient.
- Increasing market transparency and the availability of real-time market information: with the aim of facilitating a more efficient balancing of supply and demand.

In addition, Germany has been running a funding initiative for energy storage since 2012 and introduced a new fund to support PV battery storage systems in 2016.

The proposals outlined above to improve Germany's energy-only market would be backed up by an extended network reserve beyond 2017 (first introduced in 2013), a new capacity reserve, and a security standby of lignite plants. These strategic reserves are kept out of the electricity market and will only be activated when the market is unable to meet demand. While the wider system reforms can be applauded, the lignite security standby can be criticised as it does not contribute to flexibility and results in targeted payments to highly polluting old coal-fired power plants. Although the CM is framed as a tool to reduce emissions and ensure security of supply, this suggests it may have been a political compromise to get agreement around the closure of lignite power plants by 2021.

*Sources: Paulos (2015); BMWi, (2015a; 2015b; 2014); Amelang and Appunn (2015); Schwartzkopff et al. (2015).*

32 This is particularly true in the north, because of significant offshore wind capacity.

33 The Electricity Market Act is due to be approved by the Cabinet in October 2016.

34 Free price formation enables prices to rise and fall i.e. through the removal price caps.

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## 4.3 Institutional risks

An analysis of experiences with CMs suggests that their design and implementation involves significant additional institutional risks. These include risks of delaying wider market and regulatory reforms and the undermining of regional solutions.

### 4.3.1 Risk of delaying wider market and regulatory reforms

In September 2015, Margrethe Vestager, the European Commissioner for Competition, warned that the first findings in the Commission's inquiry into CMs (see Box 2) suggests that these 'are sometimes seen as quick-fix solutions – as alternatives to real market and regulatory reforms. If...consumers were given a stronger incentive to respond to price increases and demand peaks, they would reduce their consumption and there would be less need to introduce a mechanism to support peak power plants.' (European Commission, 2015h).

While some EU Member States are introducing various tools (sometimes in an uncoordinated manner) to address security of supply concerns (such as the UK, which introduced two strategic reserves and a capacity auction simultaneously – see Box 4), others are taking a whole systems approach. Germany, for example, has undertaken whole-market reforms alongside the introduction of its more targeted strategic reserves (see Box 6), which can be criticised on various grounds (see section 4.1.1.).

### 4.3.2 Risk of undermining regional solutions

The proliferation of national CMs across the EU risks undermining wider EU energy market integration efforts,<sup>35</sup> designed to improve security of supply (see Box 2). In the context of these efforts, the uncoordinated implementation of national level CMs undermines a regional approach to security of supply and creates an increasingly complex regulatory environment for electricity. According to the European Agency for the Cooperation of Energy Regulators (ACER), EU Member States often give little attention in the design and implementation of CMS to their impact on the internal energy market and cross-border trade (Pototschnig and Godfried, 2013). Because of electricity market integration, however, the impacts of these mechanisms are not limited to national borders (for a more extensive discussion on this issue, see Baker and Gottstein, 2013).

The planned French capacity obligation scheme, for example, is likely to have cross-border impacts. Because of the energy-only market model in Germany

(complemented by capacity reserves), those suppliers that receive compensation for meeting their capacity obligation in France might receive double compensation through scarcity prices when selling electricity in the German market in times of German supply shortages. Furthermore, because the costs for the capacity scheme will be borne in France and the capacity obligation scheme would prevent price spikes there, German consumers can benefit from limited power price increases when electricity demand is high in both countries. The benefits of the scheme are, therefore, likely to accrue to French power companies when they sell electricity in the German market with high prices and to German consumers when electricity is bought from France, where prices do not reflect scarcity value. At the same time, German capacity providers will have a reduced opportunity to benefit from high electricity prices in times of supply scarcity in France (DNV GL, 2015).

In addition to the technical, institutional and political risks associated with the design and implementation of CMs discussed in the previous sections, there are challenges that are common to the design of any support mechanism (or subsidy). These include the risk of the subsidy creating windfall profits for some market participants, and the difficulties of removing support mechanisms once they have achieved their objectives.

Any support mechanism risks benefiting actors that do not contribute to the achievement of its original objectives, or of providing premiums to actors that do not need it to remain competitive in the market. The UK's capacity auction provides an example in the specific case of CMs. While clearing prices in the first two auctions were low, they were well above the 'exit bids'<sup>36</sup> of the majority of existing plants (Cornwall Energy, 2015b). These capacity payments, therefore, provide additional revenues for plants that are already economic and would have continued to operate also without capacity payments.

Finally, one common issue with the design of any support mechanism (including CMs) is that once they have been implemented, beneficiaries are likely to try to keep them in place. In the case of CMs, the expectations of additional revenues created by these mechanisms might lead to reduced investments by market players when the mechanism is withdrawn – which could have negative implications for security of supply (Hogan, 2015a). Given the uncertainties about rapid technological and wider market developments, the development of an exit strategy is an essential element of the design of any support mechanism. Such an exit strategy should take into account

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35 One of the 15 action points of the Energy Union reads: 'Creating a seamless internal energy market that benefits citizens, ensuring security of supply, integrating renewables in the market and remedying the currently uncoordinated development of capacity mechanisms in Member States call for a review of the current market design.'

36 The exit bid is the price at which a capacity provider leaves the auction – where the price is too low for the capacity provider to guarantee contributions to future capacity.

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the potential adverse effects of the removal of support, and include plans for a just transition to ensure that, when power plants are shut down and people lose their jobs, those affected are supported (Whitley and van der Burg, 2015). Our review shows that CMs tend to support existing high-carbon generation assets, in many cases without sufficiently promoting much-needed flexibility. Instead of payment schemes that entrench the status quo, measures are necessary to facilitate the transition away from generation assets that do not contribute to security of

supply or decarbonisation. In designing such programmes, consideration should also be given to the responsibilities of the power sector for supporting employees (i.e. through early-retirement schemes and retraining programmes)

Building on wide-ranging experiences with the CMs discussed in this section, the final section provides lessons learned for governments that want to ensure security of supply while meeting objectives for decarbonisation, fossil fuel subsidy phase-out, economic efficiency and electricity market integration.

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# 5 Recommendations for supporting power market reforms and climate and clean energy objectives

In the face of rapidly transforming power markets, linked to the rapid uptake of renewables, there has been renewed interest in capacity mechanisms as a tool to ensure reliability. However, our review of current and planned CMs in the EU and US suggests that these mechanisms risk undermining parallel energy and climate objectives by locking in dependence on high-carbon power generation assets.

A number of EU member states are moving ahead with the design and implementation of domestic CMs, a process that has been driven in part by lobbying from incumbents in the power markets (who primarily own and operate conventional, often fossil fuel-based thermal generation assets). This is not surprising as these schemes can provide a new source of stable revenues for assets that are no longer competitive in the context of wider energy system transformations.

This suggests that the introduction of CMs is often politically motivated, while the significant challenges with their design and implementation means that there is a serious risk that they undermine governments' parallel objectives of ensuring system reliability and decarbonisation. The uncoordinated introduction of CMs also risks undermining wider efforts to integrate energy markets, which, paradoxically, are meant to ensure a more efficient use of resources and improve security of supply.

The rapid shift towards variable renewables (wind and solar) requires governments to reassess their approaches to assessing and ensuring the reliability of power systems. We find that supporting the development of secure low-carbon and power system requires a system-wide approach that considers continuous market developments and technological innovations. These efforts should recognise the potential of demand side response, interconnection and storage in providing economically competitive, low-carbon flexibility. They should also include the removal of barriers to the uptake of these technologies and consider how to promote their deployment.

The European Commission has launched a sector-wide investigation into the development of national CMs, which will feed into its proposals for electricity market redesign for the end of 2016. The interim report of this investigation, which is open for public consultation, finds that CMs have significant shortcomings because of inadequate assessments of whether they are needed at all, and exclusion of some potential providers of capacity (such as demand side response or storage). Nonetheless, the Commission concludes that CMs may be necessary in specific cases.

Building on these findings, and previous research (Baker et al., 2015; EU Commission, 2014b and 2013; Hogan and Weston, 2014; Keay-Bright, 2013; Gottstein and Skillings, 2012), the following section provides a number of considerations that should be taken into account to promote power sector reforms that support not only security of electricity supply, but also decarbonisation objectives. These guidelines include approaches to:

- assess and understand specific security of supply issues;
- identify possible alternatives to capacity mechanisms; and
- enable the careful design of capacity mechanisms if governments choose to implement them.

A number of these recommendations build on general frameworks for good policy instrument design, and good subsidy design in particular.

## 5.1 Assessing and understanding security of supply issues

When countries face issues with security of supply, it is important that they start with a clear understanding of the scale and the nature of the reliability challenges facing their power systems. This will allow governments and regulators to better evaluate their options for market reform.



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We make six recommendations as follows.

- In their reassessment of power system reliability issues, governments, system operators or NRAs should consider the value of interrupted electricity supply to consumers, and avoid setting overly conservative reliability standards.
- The reliability assessment should consider not only the capacity available on the system and the capacity that will be needed to meet forecasted demand, but also system and operational adequacy, including flexibility, carbon intensity, transmission and distribution infrastructure.
- Forecasts of future demand and supply should take into account on-going technological developments, including improvements in energy efficiency, opportunities for more accurate weather forecasting, demand side response and storage technologies.
- In addition, reliability assessments should consider the impact of projected economic trends (such as fluctuations in international fuel prices, or demand trends) and the potential impact of the retirement of existing generating capacity.
- The impact of planned projects and policies (sub-national, national and regional) on power system reliability should be considered. In the EU, for example, energy market integration efforts are designed to contribute to the reliability of power systems across the region. In line with this, countries should consider the contribution of interconnector capacity in their reliability assessments.
- When issues with power system reliability are identified, and intervention is deemed necessary, there is a need to set clear objectives to address the specific reliability issues (which may not require additional capacity).

## 5.2 Identifying options to improve existing market design

When an assessment of country-specific reliability issues raises legitimate concerns, governments should consider whether improvements in current market design can help to improve power system reliability, and reduce the need for CMs.

We make five recommendations:

- In power markets where there are caps on electricity prices, the removal of these caps would make it possible for the market to provide the price signals to incentivise investments in the resources needed to balance demand and supply.
- Use of time-of-use pricing in the retail market and smart meter technologies can incentivise consumers to adjust or shift their electricity demand in response to supply fluctuations. This can also help to improve the reliability of the power system, reduce the need for back-up generation and reduce electricity bills.

- Barriers that prevent the retirement of existing, inflexible capacity can delay the much-needed renewal of the power fleet. Countries should therefore, for example, consider the impact of existing support schemes for fossil, nuclear and renewable electricity generation. These may entrench the existing power mix and, therefore, slow the transformation to a low-carbon, more flexible power system.
- Efforts should also be undertaken to remove regulatory barriers that withhold the participation of demand-side response providers and aggregators, storage (including through electric vehicles) and interconnection. For example, demand-side response or storage providers are not always allowed to participate in the wholesale electricity market.
- Flexibility for some power generation assets can be improved through refurbishment. Flexibility can also be enhanced by expanding interconnection and by coupling balancing markets (see Glossary) that can help to achieve a more efficient utilisation of existing assets.

## 5.3 The careful design and implementation of capacity mechanisms

After taking into account the broader actions that can help to improve reliability, governments may still determine that a CM is necessary to ensure security of supply. In this case, governments should ensure that the design and implementation of the mechanism is consistent with objectives of decarbonisation, fossil-fuel subsidy phase out, efficiency and affordability.

We make six recommendations, as follow:

- When a CM is implemented it should reward flexible rather than inflexible assets to support the uptake of variable renewable electricity generation.
- Given current decarbonisation objectives, consideration should also be given as to how the CM could prioritise low-carbon options to enhance the reliability of the power system (including demand response, interconnection, efficiency and storage) over higher-carbon options (coal-fired power plants and diesel generation). Similarly, consideration should be given to how the mechanism can avoid locking in high-carbon generation assets and support wider objectives of fossil fuel subsidy phase out.
- Plans to introduce CMs should always take into account their potential impact on wider market reforms, while market reforms should also consider their potential impact on CMs.
- In the context of regional electricity market integration, consideration should also be given to the potential impact of the mechanism on neighbouring power markets and how it can ensure the participation (or at least consideration) of cross-border capacity.

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- Governments must make significant efforts to avoid regulatory capture in the development and design of CMs. Consultations must inform and engage a wide range of stakeholders, so that their respective interests and agendas can be taken into account. The timeframe should be long enough to ensure sufficient regulatory certainty, allowing for long-term planning, while having sufficient flexibility for adaptation to new market realities and technology developments. Incorporating flexibility into the design of an intervention, through a variety of instruments or milestones for adjustment should also help to avoid path dependency on a particular set of technologies or approaches.
  - An exit strategy should also be developed so that the CM can be phased out when it is no longer needed.

Considering the urgent need to move towards zero-carbon power systems, governments must be held to account for meeting parallel objectives of decarbonisation when they seek to address power system reliability issues. Instead of focusing narrowly on CMs as a near-term solution, governments should take a system-wide approach that supports, rather than undermines, decarbonisation. Regulators should use the opportunities provided by market redesign and new technologies that can add flexibility, which will be crucial for building low-carbon, secure power systems. As the European Commission prepares its electricity market redesign proposals for the end of 2016, this is a key moment to influence this process, as well as the wide range of power market reforms planned at the national and sub-national level.

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# Annex 1: Interviewees

Dave Jones (Sandbag)  
Anne-Sophie Chamoy (Energy Pool)  
Michael Hogan (RAP Online)

Sara Bell (Tempus Energy)  
Mike Hemsley (Climate Change Committee)

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