This paper compiles the requirements in the Guidelines on State aid for environmental protection and energy (EEAG) related to assessing the necessity of generation adequacy measures. It then outlines some ways of measuring generation adequacy, and describes developments in the approach to assessing generation adequacy at EU level.

1. **What do the guidelines require?**

The EEAG include the following requirements related to the assessment of generation adequacy:

(221) The precise objective, at which the measure is aimed, should be clearly defined, including when and where the generation adequacy problem is expected to arise. The identification of a generation adequacy problem should be consistent with the generation adequacy analysis carried out regularly by the European Network of Transmission System Operators for electricity in accordance with the internal energy market legislation.

(222) The nature and causes of the generation adequacy problem, and therefore the need for State aid to ensure generation adequacy, should be properly analysed and quantified, for example, in terms of lack of peak load or seasonal capacity or peak demand in case of failure of the short-term wholesale market to match demand and supply. The unit of measure for quantification should be described and its method of calculation should be provided.

(223) The Member States should clearly demonstrate the reasons why the market cannot be expected to deliver adequate capacity in the absence of intervention, by taking account of ongoing market and technology developments.

(224) In its assessment, the Commission will take account, among others and when applicable, of the following elements to be provided by the Member State:

(a) assessment of the impact of variable generation, including that originating from neighbouring systems;

(b) assessment of the impact of demand-side participation, including a description of measures to encourage demand side management;

(c) assessment of the actual or potential existence of interconnectors, including a description of projects under construction and planned;

(d) assessment of any other element which might cause or exacerbate the generation adequacy problem, such as regulatory or market failures, including for example price caps on wholesale prices.
Figure 1: Summary of EEAG requirements related to technology neutrality

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<th>Summary</th>
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<td><strong>EEAG requirement</strong></td>
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| (221) (222) | 1. The nature and cause of generation adequacy problem should be analysed and identified, and its extent quantified.  
2. National generation adequacy assessment should be consistent with ENTSO-E analysis. |
| (223) (224) | 3. The Member States should clearly demonstrate the reasons why the market cannot be expected to deliver adequate capacity in the absence of intervention. The potential impact on security of supply of alternative market improvements should be assessed, particularly the potential correction of market and regulatory failures, and an increase in DSR and interconnection. |

2. **The potential need for generation adequacy measures**

An effectively functioning market should result in generation capacity being constructed to meet the demands of consumers for electricity at all times based on expected future electricity prices and demand. However, some Member States fear there may be insufficient investment in generation to ensure security of electricity supplies and prevent blackouts. This is partly because of market failures unique to electricity markets.

The first market failure is that the reliability of electricity has some features of a public good. Although smart meters should help correct this, customers cannot currently choose their desired level of reliability, since system operators cannot selectively disconnect them and consumers do not respond to realtime changes in the wholesale price.

The second market failure is the ‘missing money’ problem. In a perfectly functioning ‘energy only market’ (ie. a market without a capacity mechanism), when there is a risk of blackouts electricity prices would rise to very high levels corresponding to the value consumers place on avoiding blackouts. However, prices are often regulated to prevent them from reaching high enough levels to attract sufficient investment, and even when prices are not regulated, investors fear that governments and regulators will take action to prevent high prices if a market becomes tight and prices begin reaching higher levels.

There may however be correctable regulatory failures that contribute to problems in the functioning of electricity markets. For example, price caps, inefficient rules for imbalance settlement, a lack of smart meters and opportunities for demand response, regulated prices for particular consumer groups, or insufficient investment in interconnection. Member States must look to correct regulatory problems and improve market functioning and the efficiency of their energy only markets before concluding that a capacity mechanism is required.
3. **MEASURING GENERATION ADEQUACY**

The Electricity Security of Supply Directive establishes measures aimed at safeguarding security of electricity supply so as to ensure the proper functioning of the internal energy market. In particular it requires public authorities to regularly undertake an objective, facts based, assessment of the generation adequacy situation in their Member State.

However, this Directive has to some extent been overtaken, not least as a result of the changes brought about with the Third Energy Package.\(^1\)

In the Communication *Delivering the internal electricity market and making the most of public intervention* the Commission addressed the need for public authorities to regularly undertake an objective, facts-based assessment of the generation adequacy situation.

Assessments of generation adequacy are based on a judgement about future patterns of supply and demand, and the strength of the available electricity network (particularly for cross border flows). These must be based on:

- The general evolution of supply and demand as a result of social, economic and public policy developments.
- Projected generation (including new) capacity, taking account of mothballing and withdrawals.
- Projected Demand, including the impact of evolving public policy in relation to energy efficiency and smart grids.
- Expected periods of particularly high demand as a result of transient conditions, in particular weather conditions.
- The actual expected availability of generation capacity as a result of:
  - Weather conditions;
  - Operation decisions (including decisions by network operators);
  - The availability of primary fuels – in particular the potential impact of gas shortages; and
  - The voluntary response of demand to market conditions or instructions by network operators (in accordance with pre-existing agreements or contracts).

There are various ways in which generation adequacy can be measured and quantified. For example:

- **Capacity margins** can be analysed and measured. The capacity margin is the difference between peak demand for electricity in the system, and total available supply of

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electricity, and is usually expressed as a percentage (eg. a system with 11GW of capacity and 10GW of demand would have a 10% capacity margin).

An assessment of capacity margins will need to take account of the reliability of different supply sources, and include some kind of ‘de-rating’ to account for the difference between maximum potential supply in the system, and the level of supply that can be relied upon whenever needed.

The capacity margin measure provides a snapshot in time measure of generation adequacy e.g. at winter’s peak. However, it does not take into account variations in generation adequacy that might take place over the year due to e.g. climate variations or the likelihood of low output from wind generation. For that, a more probabilistic measure is needed.

- An alternative measure is a **loss of load probability (LOLP)**, which quantifies the probability of a given level of unmet demand at a particular point in time. This measure is expressed as a proportion of time in which demand will not be met (for example, 1 day in 10 years some customers would need to be disconnected). Sometimes this is expressed as a loss of load expectation (LOLE) which sets out the expected number of hours or days in a year in which we expect some customer disconnection. So if the LOLP was 1 day in 10 years then the LOLE would be 0.1 days or 2.4 hours. This probabilistic approach could take into account variations in demand over the years as a result of climate fluctuations.

LOLP/ LOLE make no measure of the total shortfall in capacity that occurs at the time when there are disconnections, and neither LOLP / LOLE nor capacity margins measure the amount of unmet demand.

- This would require a measurement of **expected energy unserved (EEU)** which would be expressed in MWh over a specific time period (eg. a year). This is also a probabilistic approach.

Whichever approach is taken to measuring generation adequacy, an acceptable benchmark may then need to be defined as a point for measuring whether generation adequacy has been achieved. This benchmark is often called a **reliability standard**. This could be expressed as a minimum acceptable capacity margin, a maximum acceptable LOLE, or a maximum acceptable level of unserved energy.

### 3.1. Developments at European level

In November 2013, the Electricity Coordination Group adopted a report on generation adequacy assessment calling for a harmonised European methodology for assessing generation adequacy, in particular with consistent treatment of variable RES generation and interconnectors.

ENTSO-E ran a public consultation on the Adequacy Methodology from 14 July-19 September 2014, asking all interested parties to comment on the package via the ENTSO-E consultation platform. Input from the consultation will be used by ENTSO-E to further improve the adequacy methodology.

In parallel, the Pentalateral Forum is committed to developing a regional level Adequacy Assessment.
3.2. DG Energy & Joint Research Centre (JRC) Cooperation

European generation adequacy assessments will likely form the basis of policy developments at national and European level. Therefore a process of oversight, assessment and approval of the inputs and methodology as well as the output of generation adequacy assessments will be needed to ensure that the approach taken is acceptable.

The JRC has been commissioned to assess the appropriateness of existing and proposed generation adequacy assessments at national and European level, and make recommendations on improving them.
4. **CASE STUDY: ASSESSMENT OF NECESSITY OF UK (GB) CAPACITY MARKET (SA.35980)**

Note: subheadings relate to summary EEAG requirements in Figure 1.

4.1. **The nature and cause of generation adequacy problem should be analysed and identified, and extent quantified**

The UK adopted a reliability standard of 3 hours LOLE for Great Britain’s (GB’s) electricity market, and presented modelling by the system operator (National Grid) showing that this was at risk of not being met from 2018/19. The Commission considered the aim of the capacity market to auction sufficient capacity to meet the reliability standard to be a clearly defined objective.

Much attention was given to the assumptions regarding expected imports of electricity to GB at times of GB scarcity over interconnectors between GB and Ireland, France and the Netherlands. National Grid’s modelling showed 0.75GW of exports from GB to Ireland, and 0.75GW of imports (out of a maximum possible 3GW) from France and the Netherlands.

These assumptions were criticised as being overly cautious by an independent panel of experts appointed by the UK to scrutinise National Grid’s analysis. The Commission, however, noted the UK’s claim that historical flows into GB from the continent have not been as high as the panel of experts advised, and that there was not yet sufficient evidence for how interconnector flows will operate under new market coupling rules. The Commission therefore accepted the UK’s methodology for calculating the amount of capacity needed subject to the following commitments:

- The UK must reassess the contribution of interconnectors during stress events and review the methodology as of 2015;
- If the ex-post assessment shows that the assumed contribution of interconnectors in 2018 under the 2014 auction was an under-estimate, the amount of capacity reserved for procurement through the year-ahead auction in 2017 must be reduced correspondingly\(^2\);
- The assessment of capacity to auction must continue to be based on the expected availability of conventional generation during high demand situations and not on annual or seasonal averages. These averages do not seem to be adequate proxies; they may underestimate the contribution that a generating plant can make in an incentivised market;
- The UK must work with the Commission to develop standards for generation adequacy assessment and European best practice.

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\(^2\) The GB capacity market involves 2 auctions for each delivery year – one 4 years ahead, in which the majority of required capacity is auctioned, and another 1 year ahead, in which the remaining required capacity is auctioned. The intention with this design was to ensure most capacity was auctioned far enough in advance to allow time for new construction, but reserve some flexibility to fine-tune the amount of capacity required when more accurate forecasts of demand were available closer to real time. The 1 year ahead auction was also considered an important feature for providing a route to market for demand response.
4.2. National generation adequacy assessment should be consistent with ENTSO-E analysis.

The assessment noted that the findings presented in the UK’s national generation adequacy analysis were broadly consistent with the conclusions of ENTSO-E’s 2014 generation adequacy forecast, though again the assumptions on imports were critical. Notably, the ENTSO-E methodology was and is still under development and could therefore not serve as an exclusive benchmark.

4.3. The Member States should clearly demonstrate the reasons why the market cannot be expected to deliver adequate capacity in the absence of intervention. The potential impact on security of supply of alternative market improvements should be assessed, particularly the potential correction of market and regulatory failures, and an increase in DSR and interconnection.

The UK explained that the capacity market addressed 2 market failures in the GB electricity market. Table 1 from the decision records the ways in which the measure addresses these market failures:

<table>
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<th>Market Failure</th>
<th>How the Capacity Market addresses the market failure</th>
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<tr>
<td>Reliability is a public good</td>
<td>Rather than depending on the energy market to derive the optimal level of capacity (which is sensitive to how the value of lost load is determined in the market), the UK has set an enduring reliability standard (a loss of load expectation of 3 hours/year). The annual capacity auctions will procure the level of capacity that delivers that standard. The Capacity Market also promotes a more active voluntary demand side response – with parties receiving capacity payments for reducing energy use at times of scarcity – to reduce the need for involuntary disconnections. The Commission accepts that as long as individual real time metering is not available, that reliability displays many of the characteristics of a public good. However, in the future with the roll out of smart technology this will become less important as consumers will be able to manage their consumption in response to scarcity signals from the markets.</td>
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<tr>
<td>Missing money</td>
<td>The Capacity Market addresses the ‘missing money’ problem by giving capacity providers certainty on a part of their revenues. In effect, they exchange the possibility of part of their scarcity rents for a capacity payment. In return, they guarantee to provide capacity when needed, or face penalties. This mimics the action of a perfectly functioning electricity market. However, the Commission reiterates that the implementation of a capacity market cannot come at the expense of well-functioning short run markets. The Commission notes in particular the potential for a robust reference market for options trading developing under the cash out reform reported in recitals (89) to (91).</td>
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The Commission noted that the UK was pursuing a variety of other actions to improve market functioning and help address these market failures (see 3.1), and that the UK’s national generation adequacy assessment took into account the potential of capacity to be provided from all sources including interconnection and DSR.