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Assessment of electricity generation adequacy in European countries

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INFORMATION PAGE

Abstract

This document (C13-ESS-32-03) is a CEER report on the assessment of generation adequacy in European countries.

The European community is showing increasing interest in the ways generation adequacy is ensured in electricity markets, notably with increasing shares of variable generation. In July 2013, the CEER the Electricity Security of Supply Task Force (ESS TF) undertook an investigation of the ways assessments of generation adequacy are conducted in responsibility areas.

An internal questionnaire was launched among CEER member and observer countries in order to establish an in-depth stock of the current practices for assessing generation adequacy in the Internal Electricity Market.

This document provides an overview of responses to this questionnaire which includes some analysis and key findings in relation to the current national assessments of generation adequacy.

Target Audience

Entities responsible for generation adequacy assessment: European countries (incl. EU Member States), Transmission and Distribution System Operators, National Regulatory Authorities.
Interested stakeholders: energy suppliers, traders, gas/electricity customers, gas/electricity industry, consumer representative groups, academics, etc.

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Related Documents

CEER documents

CEER Call for Evidence on Generation Adequacy Treatment in Electricity (Evaluation of Responses); 8 November 2011

CEER Response to the European Commission Consultation Paper on generation adequacy, capacity mechanisms and the internal market in electricity; 7 February 2013

ACER documents

ACER Opinion on the Ten-year network development plan 2012; 5 September 2012

ACER Opinion on the ENTSO-E summer outlook report 2012 and winter review 2011/12; 8 October 2012

ACER Opinion on the ENTSO-E winter outlook report 2012/13 and summer review 2012; 25 March 2013

ACER Position on ENTSO-E Scenario Outlook and Adequacy Forecast 2013-2030; 18 July 2013

External documents

ENTSO-E Scenario Outlook & Adequacy Forecast (SO&AF) 2013-2013; April 2013

Related EU Directives and Regulations

Directive 2009/72/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC

Regulation (EC) No 714/2009 of the European Parliament and of the Council of 13 July 2009 on conditions for access to the network for cross-border exchanges in electricity and repealing Regulation (EC) No 1228/2003

Directive 2005/89/EC of the European Parliament and of the Council of 18 January 2006 concerning measures to safeguard security of electricity supply and infrastructure investment (Text with EEA relevance)

Table of Contents

EXECUTIVE SUMMARY

Security of supply is a high priority area for EU Member States and National Regulatory Authorities for energy (NRAs); more specifically, the issue of generation adequacy is a well discussed topic in many countries across Europe. Before any decision can be taken on how guidance on generation adequacy could be applied to realise the benefits of an integrated and competitive Internal Electricity Market (IEM), there are questions to be answered concerning integration of volatile generation, market structure, regulatory framework or grid reinforcement[1]. In particular, it is of upmost importance to consider ways to improve current and future generation adequacy and risk assessments at national, regional and European levels in order to ensure more transparency, address the need for flexible resources and consider the benefits of the IEM through interconnection capacity.

In this respect, CEER analysed current practices and methods used to assess Generation Adequacy across Europe, based on answers received from 20 CEER member and observer countries and covering the following topics: roles and responsibilities, general provisions, assumptions on load, generation and adequacy forecasts. The study was used to elaborate 45 findings, including:

Roles and responsibilities: In most countries, transmission system operators (TSOs) are the responsible bodies for monitoring and reporting on generation adequacy. Other responsible institutions are NRAs or governments. Answers show that there is a consensus on Reliability Standards even though they are used only indicatively in most cases. Compared to reporting, the responsibilities for setting standards (if there are any at all) vary widely between NRAs, Governments and TSOs. The underlying methodologies (notably, probabilistic vs deterministic assessment) also differ significantly.

General provisions: Regarding the scenarios used, the methodologies differ greatly depending on the targeted timeframe and the majority do not seem to be consistent throughout most of the national generation adequacy assessments and the ENTSO-E System Outlook & Adequacy Forecast. Even though in some countries expert or advisory groups support the developments of the reports, assessments are in most of the cases done without consultation of broader stakeholders.

Generation and load assessments: Regarding load forecast, the most exploited parameters are economic growth, temperature, policy, demography and energy efficiency. Some reports include detailed complementary sensitivity analyses on these parameters where relevant. The extent to which types of consumers and uses are grouped to appraise carefully different consumption patterns can be very different. Moreover, demand response is largely not included as a separate factor in load forecast methodologies, even though it may appear that it is indirectly included in the projections through the effects it has had on the historical load curves. Regarding generation forecast, all countries take projected investments into account, sometimes with very heterogeneous sources and assumptions. Decommissioning (and mothballing) of investments is not systematically taken into account. Most collected data comes from generators, partly directly via the TSOs. In addition, there are also various ways generation from variable output is modelled; from no consideration at all, to precise hourly estimations based on sophisticated data. It is commonly agreed that there is a need to improve methodologies to better address how variable output impacts adequacy.

[1] Those topics were already addressed in the CEER Call for Evidence in 2011.

Adequacy forecast methodologies: Despite on-going developments, some assessments are still considering isolated systems and/or developing ways to include interconnectors. Others use non-harmonised methodologies to consider cross-border capacity, with no cross-border coordination foreseen. The availability of interconnection capacity is mostly based on historical data and to lesser extent, on estimated data. Generation and load data correlations at supranational levels are rarely considered, and for country-wide modelling, the "copperplate approach" prevails. Adequacy methodologies still differ (deterministic vs stochastic) and system stress tests, which are not included in every report, are obviously based on various assumptions.

As a next step, CEER aims to consider the findings in this report in order to identify best practices across Europe and develop recommendations for a common framework for assessing generation adequacy.

1. Introduction

The aim of the on-going energy market integration process in Europe is to ensure an efficient cross-border use of existing generation, demand-side and storage resources, transmission infrastructure, and to incentivise an efficient system expansion.

With the objective to deliver sustainable and secure energy and a competitive internal market for energy (IEM), it is clear that security of supply is no longer exclusively a national consideration, but is to be addressed as a regional and pan-European issue. From this perspective, generation adequacy needs to be addressed and coordinated at regional and European level in order to maximise the benefit of the IEM.

On the one hand, the need for a coordinated approach in the design and implementation of policy instruments that are considered to ensure generation adequacy is being discussed. On the other hand, different countries use very heterogeneous approaches to generation adequacy assessments – including adequacy standards, metric, methodologies, responsibilities, etc. This also raises the concern whether a comprehensive analysis of European generation adequacy – and following that the needs for generation as well a grid infrastructure for the future – can be carried out without a harmonised approach on the assessment and calculation of generation adequacy. CEER does not intend to treat the former topic, but instead focus on the latter as the need for an in-depth analysis and further on e.g. the establishment of best practises and common methodologies seem inevitable in the light of the issues considered here above.

The European community is currently showing increasing interest in the ways generation adequacy is ensured in electricity markets with increasing shares of variable generation. In this context – and given that CEER has been working on these topics for several years[2] already –the CEER Electricity Security of Supply Task Force (ESS TF) members continue to work on:

- Establishing an in-depth stock of the current practices for assessing generation adequacy in the IEM;
- Elaborate key principles for a common metering and criteria for generation adequacy;
- Possibly determine the impact of having different national adequacy criteria within the IEM.

An internal set of Terms of Reference (ToR) was established for the ESS TF's work and describes the scope and substance of the task, as well as practical working arrangements in order to deliver the output.

As part of this ToR, an internal questionnaire was circulated to CEER members and observers in order to establish an in-depth stock of the current practices for assessing generation adequacy in the IEM. Responses to the 26 questions were provided by 20 NRAs in October 2013.

This document intends to analyse these responses and formulate a set of findings in relation to the assessment of generation adequacy.

[2] CEER Call for Evidence (2011) as well as CEERs Response to EC Public Consultation (2013)

2. Analysis of Responses

2.1. Roles and responsibilities with respect to generation adequacy

2.1.1. General remarks

Firstly, assessing generation adequacy is a complex activity that requires different tasks: defining key concepts (generation adequacy[3], adequacy criteria, system stress, etc.) and the procedures to be adopted for the monitoring of generation adequacy.

Secondly, the assessment of generation adequacy can be used as a reference tool for decision makers regarding the action(s) to be taken, if actual or perspective problems are encountered, and implementing those actions.

To begin with, the definition of roles and responsibilities specifies which body is ultimately responsible for ensuring generation adequacy, i.e. undertaking those measures which are considered as necessary to make sure that there will be a sufficient amount of resources to meet generation adequacy requirements in the electricity system.

The procedures that are employed to ensure generation adequacy can deliver a discretionary power to the responsible body on the action to be taken. Indeed, the consequences of monitoring generation adequacy for the decision maker responsible for ensuring generation adequacy can imply that optional actions can be taken, or that they can be automatic in the sense that there is a pre-defined set of actions to be taken in case threats are envisaged.

Assessing generation adequacy usually includes specification of the methodologies, rules and procedures that are employed for investigation, i.e. with the aim of estimating if possible threats to security of supply might arise and if so, under which circumstances this could happen. This is typically done on the basis of a specific report that describes the methodology and the findings about generation adequacy in a given responsibility area. Such a report can be made public to enhance knowledge and dissemination of information about generation adequacy.

2.1.2. Responsibility for ensuring generation adequacy

<u>Finding 1</u>: Responsibility for ensuring generation adequacy seems to be clearly defined across Europe. In almost all countries (15 responses out of 17) it is attributed to the national governments.

2.1.3. Responsibility for assessing generation adequacy

In the short term (daily operations), the transmissions system operator (TSO) is always the responsible party for balancing operations close and/or in real time (the only obvious exception being Malta that has no high-voltage transmission lines).

[3] The European Commission Electricity Coordination Group's subgroup on generation adequacy indicates in its report (November 2013) that "Generation Adequacy is a basic mechanism to measure whether there will be sufficient sources of electricity in a system to meet the expected requirements".

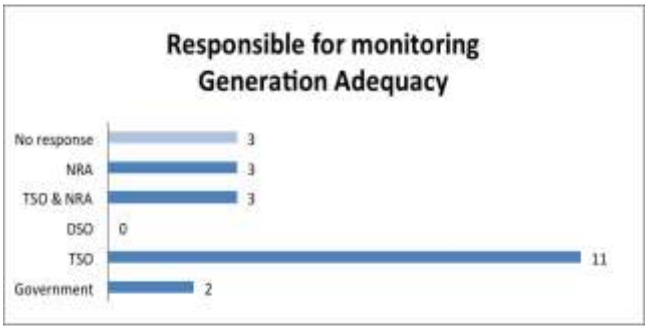
Monitoring responsibilities are shared among Institutional bodies (i.e. TSOs, NRAs and governments).

For the short term[4], the responsibility belongs to:

- the TSOs in 13 countries;
- to the government in Belgium and Luxembourg; and
- to NRAs in Finland, Malta, Lithuania and Spain (together with the TSO in the latter case).

In the medium and long terms[5], the share of responsibility remains similar to that in the short term, with the exception of:

- Great Britain, where the responsibility shifts from TSO to NRA and government respectively;
- Switzerland, where it shifts from TSO to NRA; and
- Estonia where the long term monitoring is managed by the government.



Finding 2: Most of the short and mid-term generation adequacy assessments are carried out by TSOs.

2.1.4. Responsibility for delivering a generation adequacy report

Today, a generation adequacy outlook is elaborated in almost all countries that responded to the questionnaire (with the exception of Denmark). However, it seems that it is not always elaborated by the entity that is responsible for monitoring generation adequacy, either in the short, medium or long term.

In 10 countries the TSO is the body that is both responsible for monitoring generation adequacy (alone or as a shared responsibility, such as in Spain) and elaborating adequacy reports (including France, the Netherlands, Norway, Estonia, Romania, Hungary, Spain, Ireland, Italy, Sweden). The TSOs usually also publish such a report, with the following countries excepted:

- Italy, (elaborated by the TSO and published by the government);

[4] Short-term monitoring refers to the process of evaluation of risks in the system in a short-time spell, that typically covers the coming months /season (e.g. winter and summer outlooks).

[5] This analysis assumes that report sections focusing on generation adequacy covering periods between 2 and 6 years can be considered as mid-term assessment. Beyond that, they are considered as long-term assessments.

- Malta (elaborated by the distributions system operators (DSO) and published by the NRA).
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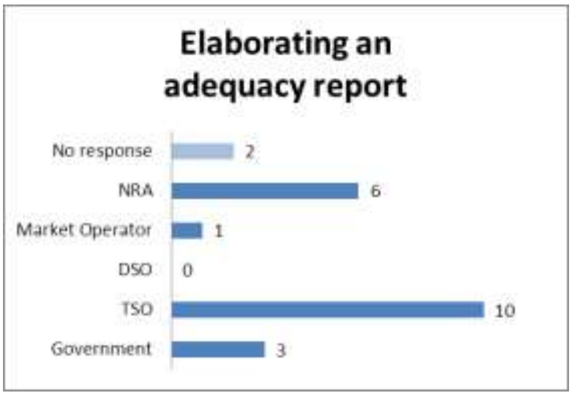
Among the countries where the NRA is responsible for monitoring generation adequacy, the latter is also the entity that elaborates the adequacy reports (with the exception of Lithuania, where the TSO elaborates and publishes the report).

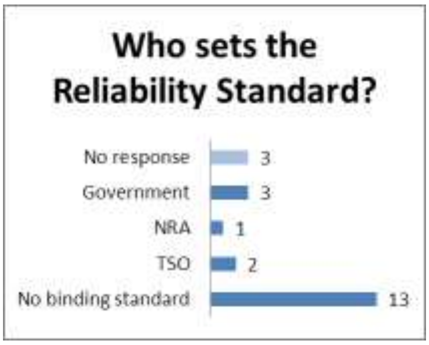
The adequacy report is elaborated and published by the government in Germany (where the responsibility of monitoring lies with TSOs), and by the market operator in the Czech Republic.

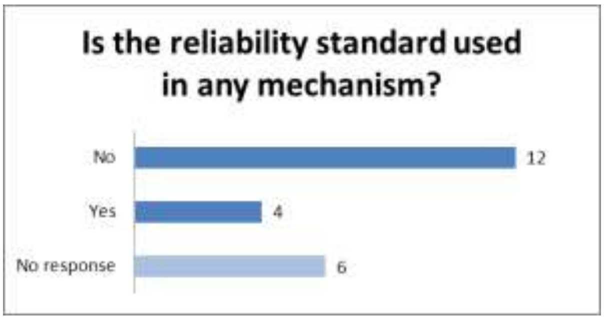


Finding 3: Responsibility for assessing generation adequacy seems to be coherent in most cases: the same body which is responsible for assessment is also responsible for delivering a report in 13 of the 20 countries who responded. The entity that elaborates this report is the TSO in a large majority of countries (11 responses), and to a lesser extent the NRAs (6 responses), the government (3 responses) and the market operator (1 response). The same body is usually responsible for publishing this report.

2.1.5. Reliability Standards for generation adequacy

Even though the definition of generation adequacy can be subject to considerable discussion, it is commonly accepted that an adequate level of generation adequacy can hardly be apprehended without specifying what an acceptable resource adequacy performance is. Performance targets (if any) can be different from one country to another. Generation adequacy reports can include specific metrics to track this adequacy performance and possibly identify reliability gaps at national level. The many assumptions generate different reserve margin requirements, but the differences in definitions are usually small compared to the gap between the formulation of the standards and the market design. Such metrics can be described as "Reliability Standards", which can take different forms; they can serve as pure informational metrics with the sole aim of identifying possible threats; or be used as binding parameters which can be used for automatic action (i.e. in specific actions / mechanisms addressing adequacy).





Standard parameters are used to assess generation adequacy in 9 countries; however, they are not always binding (e.g. in the Netherlands, Finland, Belgium and Hungary). Only in 6 cases do they represent binding thresholds beyond which actions are to be taken by the responsible bodies. In 8 countries (including Norway, Estonia, Austria, Romania, Malta, Czech Republic, Lithuania, and Germany) the assessment is not based on any Reliability Standard.

Based on the responses, it seems that binding Reliability Standards are or will soon be foreseen in at least 5 countries (including Great Britain, France, Ireland, Spain and Sweden).

Finding 4: The attribution of responsibilities to the body in charge of ensuring generation adequacy seems to leave room for the adoption of discretionary policies in most cases.

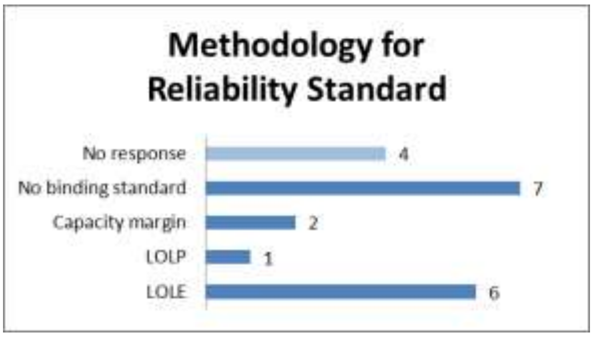
Finding 5: A significant number of countries seem not to use any binding Reliability Standard; it is however unclear whether this means there is no standard at all, or an indicative standard exists for the sole purpose of assessing generation adequacy without explicit consequences (e.g. automatic actions).

In some cases, Reliability Standards, when present, are set by the body that is responsible for ensuring generation adequacy: for example, the government in Great Britain, Spain, France, Hungary (except Ireland, where the NRA sets the standard), which refer to probabilistic standards (except the Spanish Government which uses a deterministic one). In some countries (e.g. Sweden where the standard is also based on deterministic risk-analysis studies e.g. reserve capacity margin) it is the TSO, that is responsible for monitoring generation adequacy, which sets the binding standard.

Finding 6: Where Reliability Standards exist, the entity responsible for setting them can be the body that assesses generation adequacy, the body that ensures generation adequacy (if different from the former) or by any other actor/stakeholder involved. Based on the responses, it can be the government, the TSOs or the NRA.

The methodology used to define the Reliability Standard differs throughout the respondents. In particular, in 7 cases (Great Britain, France, the Netherlands, Finland, Hungary, Belgium, and Ireland) the standard is based on a probabilistic assessment of generation adequacy (LOLE, LOLP, and EUE);[6] nevertheless the value differs (3 hours/year in Belgium, France and Great Britain; 4hours/year in the Netherlands; 8 hours/year in Ireland).

In Sweden and Spain, the Reliability Standard is a quantitative one (capacity margin).

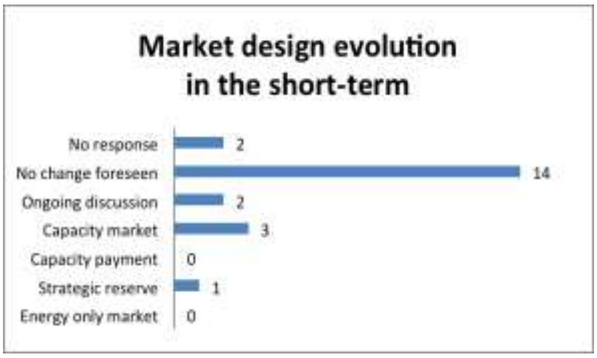


Finding 7: Where Reliability Standards exist, the underlying methodologies to define them can differ. Most of them are based on a probabilistic assessment (LOLE/LOLP/EUE), while a few of them consider a deterministic assessment (capacity margins).

2.1.6. Changes in the rules/procedure to ensure generation adequacy

When a risk or threat is foreseen, the body that is responsible for ensuring generation adequacy can usually undertake some action to prevent or resolve the problem; the action can be taken on the basis of some analysis, possibly relying on the generation adequacy report.

In all cases, action could follow on the basis of the adequacy report that justifies a given decision. Among the possible actions, interventions to change the framework design in order to ensure (or improve) generation adequacy can be implemented, if they are perceived as needed. Upcoming changes in the legal regime are envisaged in Great Britain, the Netherlands, Hungary, Lithuania, Belgium, Ireland, Germany and Italy.



[6] *Typical probabilistic adequacy metrics are the Loss of Load Expectation (LOLE in %, usually defined as the expected number of hours per year for which available generating capacity is insufficient to serve the demand), the Loss of Load Probability (LOLP in % = LOLE / period), the Expected Unserved Energy (EUE in MWh, as an average amount of unserved energy per year) or the Value of Service (VoS).*

Finding 8: In most countries (14 out of 20) no changes are envisaged on the rules and/or methodologies to ensure generation adequacy. In 6 cases some changes in the framework to ensure generation adequacy are envisaged. In these cases (2 countries) modifications are currently under discussion; in 3 countries market based solutions (capacity markets) are foreseen; one additional country foresees to rely on strategic reserves.

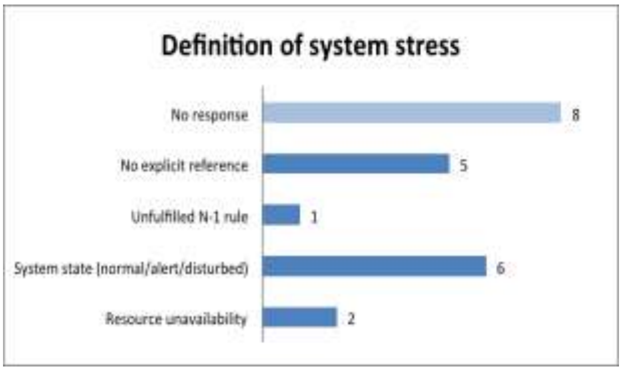
2.2. General provisions on the assessment of generation adequacy

2.2.1. Definition of System Stress and Peak Load

An explicit approach to generation adequacy that relies on pre-defined list of occurrences (e.g. on an explicit consideration of peak load) can help to assess generation adequacy by allowing comparison over time and performing forecasts. To do so, the assessment can benefit from:

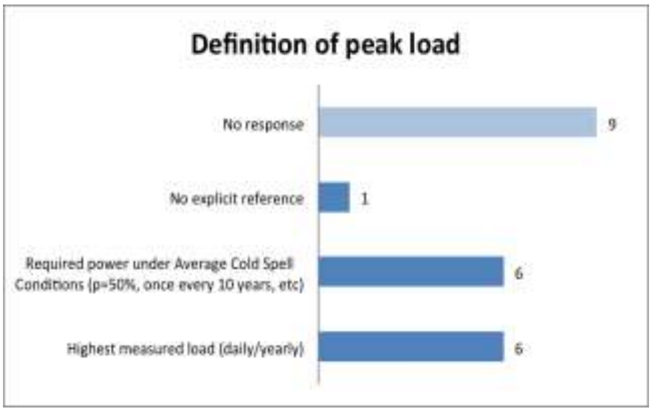
- explicit definition of System Stress, i.e. a pre-set list of events that determines a situation of risk; and
- explicit definition of Peak Load.

In 6 countries (Great Britain, France, Romania, Ireland, Sweden and Switzerland), the analysis is performed recurring to a pre-specified definition of system states, i.e., normal, alerted and disturbed system states. In Estonia and Lithuania, adequacy refers to a pre-defined specific condition of resource unavailability. In Great Britain, the Netherlands, Finland, Norway, Malta and Spain, there is no explicit reference to system stress in the methodology used to assess generation adequacy.



Finding 9: There seems to be no clear common definition of System Stress; 9 countries refer to this notion, with different approaches (no respect of N-1 rule, resource unavailability, different layers of system state, etc.).

A large majority of the 13 NRAs that responded affirms that there is an explicit reference to a definition of Peak Load in the assessment (no reference in the Netherlands). In 6 cases (Norway, Sweden, Switzerland, Estonia, Malta, Hungary), peak load is defined as the highest measured load (on a daily and yearly basis); In Great Britain, France, Finland, Lithuania, Belgium and Ireland peak load refers to the required power to cover load under average (pre-defined) cold-spell conditions.



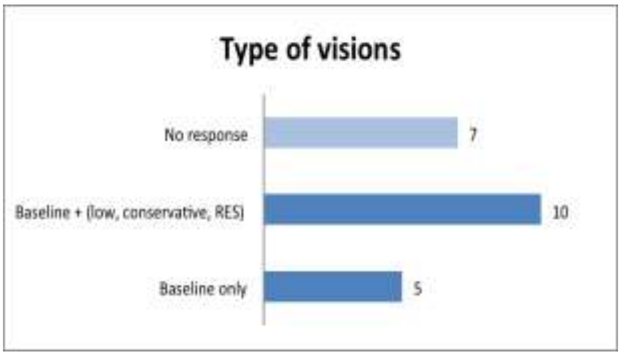
Finding 10: In almost all cases (12 countries out of 13 respondents) there is a pre-specified definition of Peak Load. There are two broad types of definitions of Peak Load with an explicit reference within the report: (i) statistical, i.e. the highest load in a pre-defined period of time (adopted in 6 countries) and (ii) modellistic, i.e. the highest load in a pre-defined set of events (employed in 6 countries).

2.2.2. Analysis of scenarios

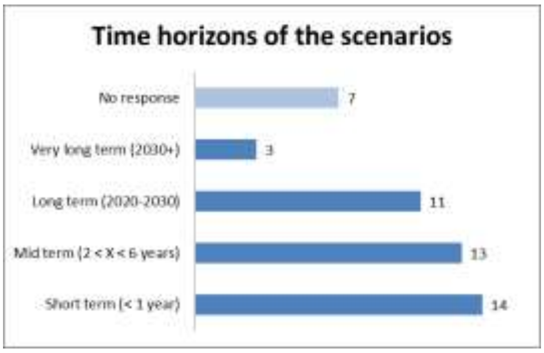
Assessing generation adequacy requires the definition of one or more scenarios that can affect generation and demand projections. They can differ with regard to the time spell, the characteristics of load, generation, uncertainties, etc. Moreover, the analysis undertaken can benefit from feedback either from past analysis or from confrontation with reality.

In at least six countries (including Sweden, Romania, Malta, Finland and Norway) generation adequacy is assessed against a single pre-defined baseline scenario. For the other cases (Great Britain, France, The Netherlands, Estonia, Hungary, Lithuania, Belgium, Spain, Ireland and Italy), several possible scenarios are considered on the basis of different assumptions about load and type and amount of future installed capacity, such as a conservative scenario, a baseline scenario, a RES penetration scenario, for examples.

Finding 11: Most reports rely on pre-defined scenarios under which generation adequacy is assessed. In 6 cases there is just one scenario considered; whereas in 10 cases several possible scenarios are taken into account.

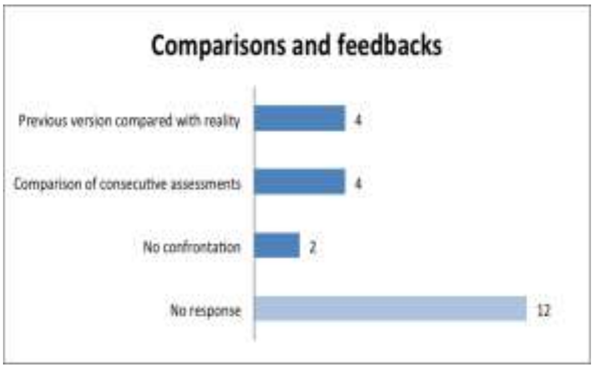


The scenarios can differ also on the basis of their time spell. In at least 9 countries (France, Estonia, Malta, Hungary, Lithuania, Belgium, Spain, Ireland and Italy) the scenarios are compounded taking as a reference the short, medium and long-term horizons (*see sections 2.1.3 for definitions*). In the Netherlands and Finland, the long term is not considered, while in Sweden and Norway only the short term is taken into account[7]. In Denmark only the long-term scenario is considered. In the Czech Republic and in Switzerland the only scenario considered is the very long term, while in Spain the latter scenario completes the short, medium and long-term analyses. Finally, in Romania, no short-term analysis is performed (only mid and long-term scenarios are considered). Most of the scenarios are updated every year, except in Romania and Finland (every 2 years or more).



Finding 12: Most of the respondents indicate that generation adequacy reports are mainly based on short and mid-term horizons. In a given report, the methodology and assumption principles can differ a lot depending on the time horizon considered.

The analysis undertaken in a given period can benefit from feedback on the previous analysis. This can be done explicitly, by comparing the forecast of past reports with actual events, or by comparing the scenarios to the ones elaborated before. Only 8 countries[8] declare that they undertake an explicit feedback analysis in their adequacy outlook. In Belgium, Great Britain, France and Romania, the outcome of the assessment of consecutive reports are compared. In Lithuania, Ireland, Hungary and Sweden, the forecasts and the real outcomes are compared.



[7] This can be justified by fact that these countries may only face a capacity issues during the wintertime, or that there is no serious concern about any lack of capacity in the mid/long term.

[8] It should be noted that half of the respondents have not provided a response to this question.

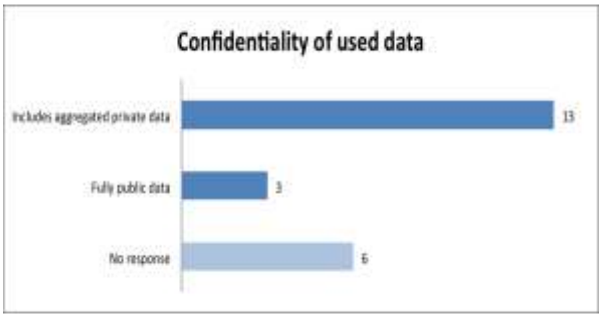
Finding 13: The extent to which national adequacy outlooks explicitly include comparison studies and feedbacks varies from one country to another. Some outlooks do not foresee any confrontation of results. Some describe the differences between consecutive assessments (change in methodologies, comparison of results) while 4 national reports intend to estimate the level of consistency of their estimations with real events that eventually occurred during the given period.

2.2.3. Stakeholder involvement, frequency and transparency of monitoring

Finally, when performing the analysis and elaborating the adequacy outlook (if any), the body responsible for monitoring generation adequacy can explicitly involve stakeholders and rely on either pure publicly available data or confidential and aggregated data.

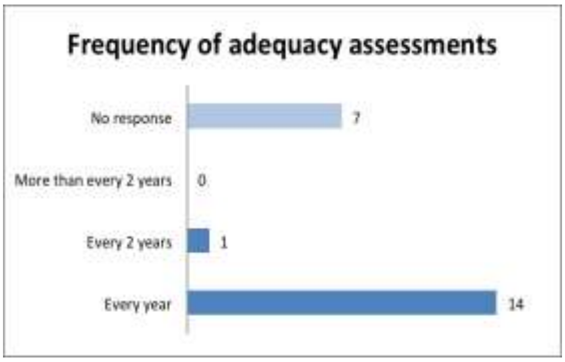
The issue of stakeholder involvement in the adequacy assessment process is tackled differently across Europe; 11 countries explicitly responded to this question[9]. In 7 cases (the Netherlands, Romania, Finland, Norway, Hungary, Ireland and Sweden), there is no consultation process. In Great Britain, France, Lithuania and Belgium, a public consultation phase is foreseen. In Great Britain and Belgium in particular, the stakeholder consultation implies also support from external experts.

The assessment is based on data fully publicly available in Finland, Norway and Sweden. In all other cases, (excluding Spain, Czech Republic, Malta, Portugal and Germany that have not responded to the specific question) data includes aggregated private data.



9 The responses do not allow for an overall understanding of whether the assessment methodology is also consulted on.

Finding 14: Stakeholders are not systematically consulted during the elaboration process of assessing generation adequacy. Only in 4 countries there is an explicit consultation process for the monitoring report. Moreover, the assessment reports usually rely on public and private aggregated data, except for 3 countries where it relies on publicly available data only.

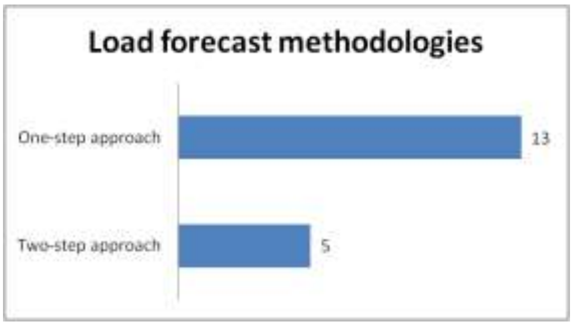


Finding 15: In most cases (14 countries) the adequacy assessment report is developed every year. Only in one case is it performed every 2 years.

2.3. Assumptions on Load

2.3.1. Principles for load forecast methodologies

All countries base their projections on historical load curves; 13 countries indicated that they apply a one-step approach, described as a methodology where historical load curves are adjusted with different parameters assumed to influence future load curves.



As examples, the Netherlands assumes annual growth in power usage is equal to the annual growth in Gross Domestic Product (GDP), underpinned by historical observations; while the Czech Republic includes several other factors influencing future load in their projections.

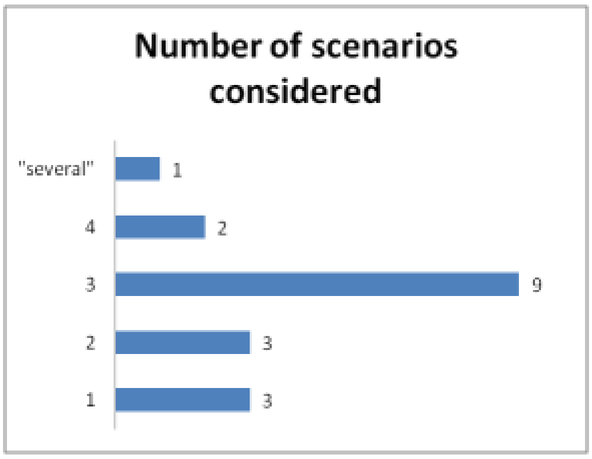
Finding 16: All reports include historical load curves in their methodology. The load curves are used as basis for projections on future peak load, with assumptions on the evolution of specific factors which influence future load (e.g. correlation with GDP growth, see **Error! Reference source not found.**).

The methodologies applied by France, Estonia, Romania, Italy and Austria were clearly described as a two-step approach by respondents. For instance, in the French report, there is first a projection on annual energy demand for each year covered in the assessment, which is then used to define a projection on power demand per hour. These steps include a retrospective analysis of past years. A similar approach is also used by Estonia, Romania, and to some extent Austria, where an econometric time series model is used in the first step.

Finding 17: Some responses highlight the use of a two-step modelling including a projection of annual energy demand which is used to set a projected demand power curve per modelling time unit.

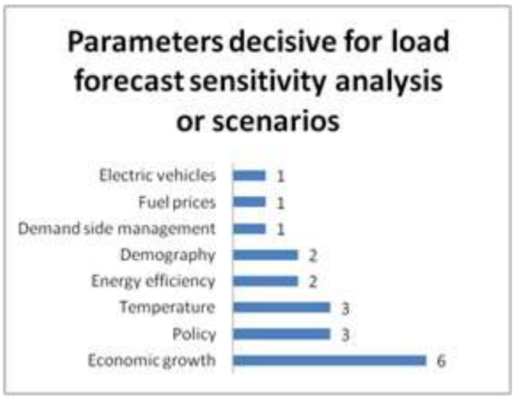
2.3.2. Load sensitivities and scenarios

As we can see from the graph below, all but 3 NRAs (the Netherlands, Finland and Austria) explain that more than one scenario is used for load projections; these other 3 NRAs report that two scenarios are used. This is typically a “high demand scenario” and a “low demand scenario”. 9 NRAs report that three scenarios are used. Typically, these scenarios are “low demand”, “reference demand” and “high demand”.



Finding 18: Most NRAs apply more than one scenario for load forecasts: typically a “low demand”, a “reference demand” and a “high demand” scenario are considered.

The parameters which are reported to influence the scenarios or are decisive to the sensitivity analysis are: fuel prices, inclusion of demand-side management, the influence of different level of energy efficiency, varying temperature levels, the influence of different policies, electric vehicles and economic growth. Some NRAs report that more than one of these parameters defines their scenarios.



The most commonly used parameter is economic growth; applied by 6 NRAs.

Some countries use more than one parameter to define their different scenarios. As an example, France reports that the load forecast is based on 4 scenarios ("low", "reference", "high" and "improved energy efficiency") with different levels of economic, policy and demographic drives.

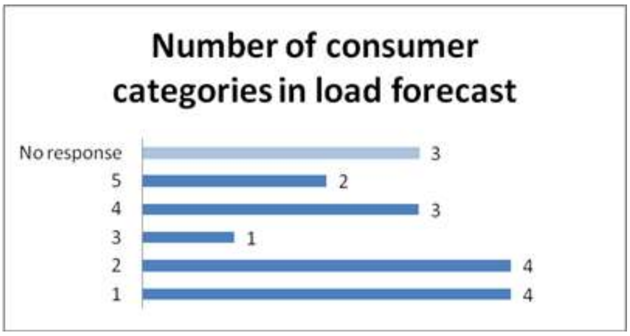
Malta considers 3 scenarios where the price of fuel is varying; while Italy reports that 2 scenarios are considered, where economic growth is the varying parameter.

3 NRAs report that varying temperature is used as input in the sensitivity analysis or in the scenarios. As an example, Norway and Sweden estimate expected peak load during the winter season at two different temperature levels, a normal winter and a so called "one in ten year winter" (extreme temperature level expected one out of ten years- 10 % probability of occurrence). These are based on historical load curves.

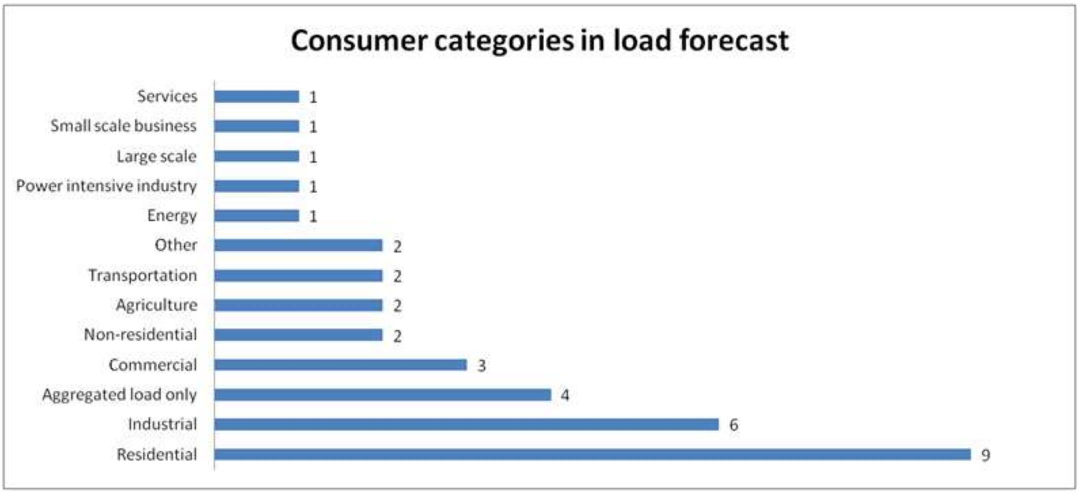
Finding 19: Several parameters are decisive for the scenarios; the most common ones are economic growth, temperature, policy, demography and energy efficiency. Some countries use more than one parameter to define their different scenarios.

2.3.3. Categorisation of consumers

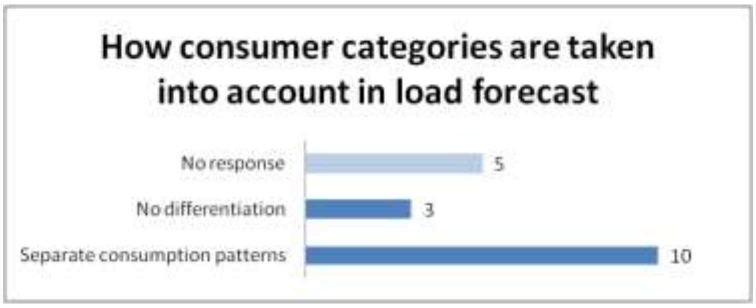
Generation adequacy outlooks do, to a (very) varying degree, take into account the different categories of consumers when establishing load forecasts. In 10 national generation adequacy reports (Great Britain, France, Norway, Malta, Czech Republic, Hungary, Lithuania, Ireland, Austria and Italy) more than one category of consumers serve as basis for the forecasts; while in 4 reports (the Netherlands, Estonia, Belgium and Sweden), load only forecasted at an aggregate level. 3 NRAs did not provide any information on how different consumer categories were accounted for.



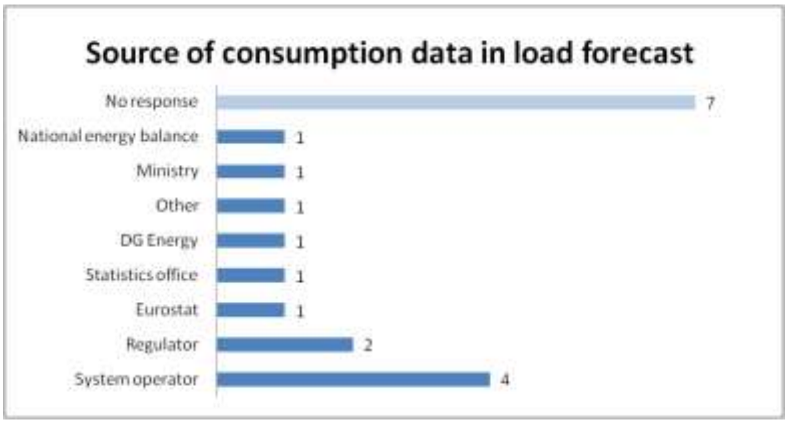
Looking deeper into the data, we can see from the figure below that a vast number of different categories exist. Austria, Ireland and Malta differentiate between residential and non-residential; while Norway makes a differentiation between power intensive industry and "other consumption". Great Britain and Hungary consider three different categories, namely residential, commercial and industrial consumption. The Czech Republic and Italy consider four types of consumer categories. The Czech Republic also differentiates between large and small-scale consumers (the latter being divided between small-scale business and residential), whereas Italy differentiates between residential, industrial, agricultural and services. Finally, France and Lithuania both consider 5 consumer categories each. France makes a differentiation between residential, industrial, agriculture, energy and transportation; while Lithuania considers residential, commercial, industrial, transportation, agriculture and "other consumption". Beyond the number of categories, however, it is difficult to compare the level of detail in the methodology that is used in the analyses (notably to track precisely the different functions and uses). We can see that residential and industrial are the most used categories.



Finding 20: Even if the national reports apply different and somewhat non-comparable classification of consumer categories – which may be a result of the need to reflect different local specificities – consumers groups are classified to account for the fact that different consumer categories have separate consumption patterns.



Finding 21: Looking at where the data of the consumer categories stems from, there seems to be no clear pattern. 4 NRAs responded that the data is provided by system operators, while the data in other countries is provided from Ministries, National Statistics Office, DG Energy, Eurostat or the NRAs themselves.

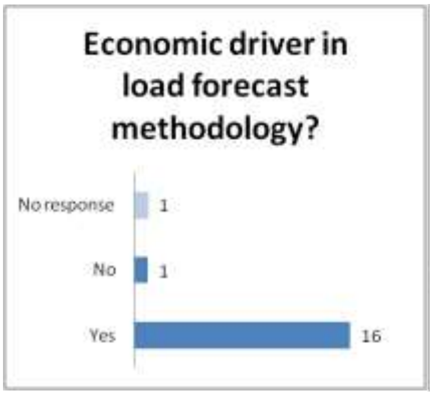


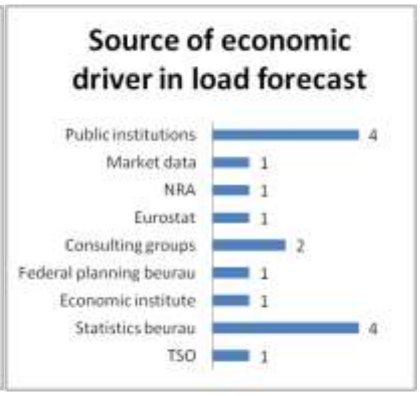
It should be noted that some of these sources may not be the final source of the data. As an example, some of the data provided by the regulators may have previously been collected from e.g. system operators.

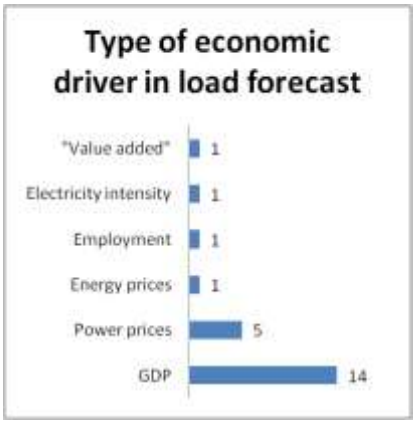
2.3.4. Drivers for the load forecast methodologies

When developing methodologies, national generation adequacy reports typically use one or more factors that are likely to impact load projections for different time horizons. These factors can take the form of macroeconomic, demographic, regulatory and/or policy drivers.

14 NRAs responded that the reports include GDP growth in their analysis. In addition to GDP, France, Belgium and Austria indicate that they also include power prices, while the Czech Republic also considers other energy prices than power prices only. Malta includes GDP growth and power prices in the load forecast methodology for industrial and commercial consumers; while they apply the employment rate as a proxy of income in the methodology for residential consumers, due to specificities of the Maltese economy. Norway does not include GDP growth, but accounts for the power price’s influence on power demand. Italy responded that they include GDP growth, electricity intensity and demand structure.



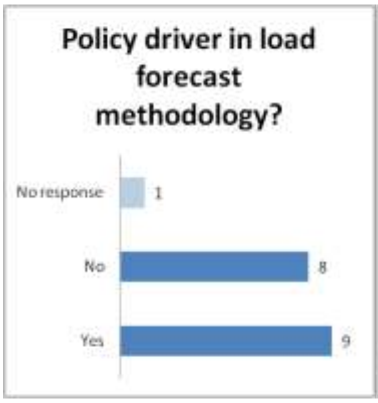


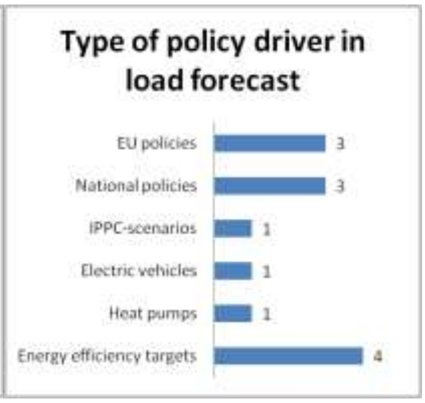


Finding 22: All but one NRA responded that the load forecast methodology includes one or more economic drivers. Most of them use the GDP growth as the key driver, while some other reports use energy prices and, to a lesser extent, factors such as electricity intensity, employment, value added. The sources of the economic drivers are a variety of different public institutions in addition to public available market data and data provided by the TSOs.

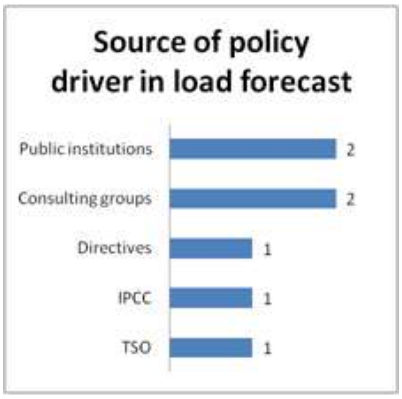
9 NRAs report that the national reports include policy drivers in their load forecast methodology: these are Great Britain, France, Estonia, the Czech Republic, Hungary, Lithuania, Belgium, Denmark and Ireland.

Great Britain responded that their capacity assessment methodology includes energy efficiency in addition to the impact of heat pumps and electric vehicles, which can be seen as policy drivers. France, Estonia and Ireland include energy efficiency targets. Without specifying the exact type of policies they consider, the Czech Republic respond that they consider both IPCC[10] and EU policies, Belgium considers both national and EU policies, whereas Hungary considers only national policies.





[10] Intergovernmental Panel on Climate Change



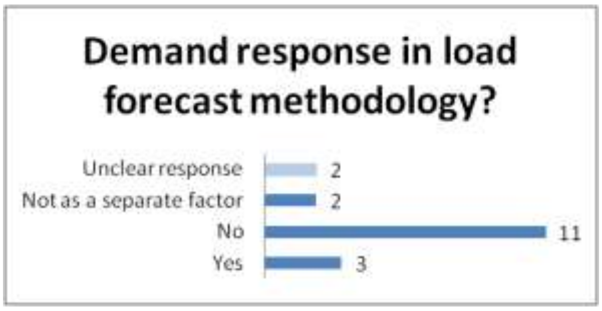
Finding 23: It appears that only a limited number of national generation adequacy reports include policy drivers. Some of them are based on energy efficiency targets, while very specific impacts can also be estimated (heat pumps, electric vehicles). While the policies used may have different scopes (national, EU, both), the sources of the policy drivers are mainly public institutions, consulting groups, directives, TSOs and the IPCC.

Finding 24: In addition to macroeconomic and policy drivers, there seems to be no common approach with respect to the impact of demographic drivers: 8 NRAs affirm that the national generation adequacy reports include estimations on the changing structure of human populations in their methodology (Great Britain, France, Estonia, Malta, the Czech Republic, Romania, Lithuania and Belgium), while 7 other reports do not (including the Netherlands, Norway, Hungary, Spain, Ireland, Italy and Sweden).

2.3.5. Treatment of Demand Response

Demand response can be defined as the ability of demand to respond to different signals (e.g. through price signals or by direct signals from system operators). As this influences the load curves, the inclusion of demand response can be an important element in projections on load.

Even though this is an important factor, only 3 NRAs reported that they include demand response as a separate factor in their methodology.



Finding 25: When it comes to demand response, only 3 NRAs respond that they include demand response as a separate factor in their load forecast methodology.

Great Britain reported that their methodology includes a contribution from demand-side response which refers to customers responding to a signal by changing the amount of energy they consume from the grid at a particular time. The historical demand data utilised to create demand distribution incorporates actual demand-side response levels (as it is transmission connected demand). Demand-side response levels are then projected based on assumptions around the potential available demand-side response for a given scenario, particularly during periods of high demand. Thus, the model treats demand-side response as a reduction in peak demand, which may vary year on year. The assessment also presents a demand-side response sensitivity recognising the effect of lower demand-side response participation due to high uncertainty around its potential future evolution.

France reported that demand response is defined as a generation asset, meaning that it includes implicit tariff option signals (around 3000 MW) and explicit resources available on the balancing market (less than 800 MW, data available for the TSO who operates the mechanism).

Finding 26: One way of including demand response in the analysis is to define demand response as a generation asset in the analysis.

In Spain, that interruptible demand is considered according to the contracted volume[11].

Norway and Finland responded that the contribution from demand response is not included as separate factor, but peak load estimation is based on actual load curves which include the effect of demand response.

Finding 27: Even if demand response is not included as a separate factor in the methodology, when basing load projections on historical load curves demand response may be indirectly included in the projections through the effects it has had on the historical load curves.

Sweden responded that the national adequacy report does not consider demand response, and that they do not assume that consumers respond to peak load in their analysis order to have a safety margin.

3 countries that consider demand response noted that the source of the data is the TSOs.

[11] *It should be noted that there may be a different understanding across Europe about what demand response actually covers. Some NRAs may not have considered e.g. interruptible demand as not being classified as demand response. In order to provide more clarity on this issue, more data or clarification from the respondents is needed.*

2.4. Assumptions on Generation

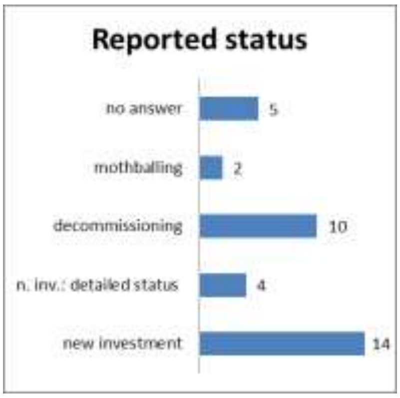
2.4.1. Principles for generation forecast methodologies

Generation forecasts are usually based on information on existing and new (to be built) units. The analyses are usually bottom-up, judging the probability of these investments because of their status of development for example. Therefore, the most important input is the information received by those intending to build new generation and rules on how to consider existing infrastructure (including interconnectors).

Generation forecasts are done by all countries that answered this part of the questionnaire. Therefore, scenarios are developed (or taken over) and information on generation projects is collected. Most outlooks are long term (> 5 years). Considered data varies from simply summed-up installed capacity, to detailed categories of generation technologies.

Finding 28: All countries take new (to be built) investments into account. Some also divide into different status of progress and some limit to confirmed investments only. Decommissioning (and mothballing) of investments is only taken into account by about half of the countries.

The Czech Republic gives self-sufficiency in production of electricity as a rationale for the generation adequacy assessment.

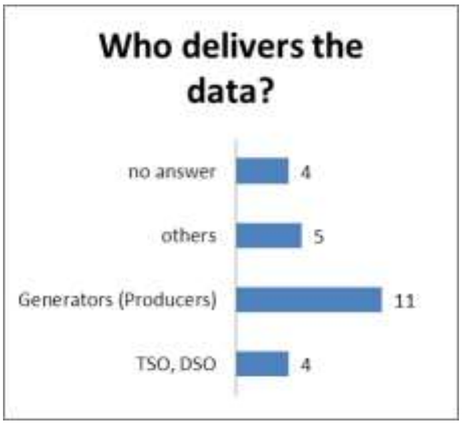


Mothballing is explicitly named in 2 countries (France, the Netherlands). Nevertheless, one could assume that mothballing is included in decommissioning, or is simply not needed right now in many other countries.

Some countries (e.g. Romania and Italy) give even more detail on the status than others; such as the status of progress for new investments, intended investments, and already received connection requests.

Lithuania and Spain also consider information on demand; while France additionally considers demand-response capacities.

The Czech Republic, Lithuania and Spain also collect information from other stakeholders like consulting groups or public institutions.



<u>Finding 29</u>: It can reasonably be assumed that in most reports, resources for the adequacy outlooks are based on pure generation capacity. Information on demand (-side response) capacity is not overly considered. In most countries, collected data comes from generators, partly directly via the TSO (if it is not the TSO who does the assessment anyway). Few countries also receive input from public institutions. Most data is analysed by categorising the different types of generation technologies.

Typical complementary sensitivity analyses covering generation assumptions are considered in some reports (e.g. in Great Britiain, France, the Czech Republic or Sweden) while some others do not consider such studies (including at least the Netherlands[12] and Hungary).

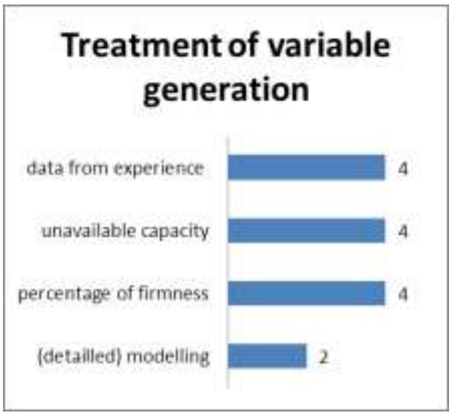
<u>Finding 30</u>: There are various ways uncertainties on generation output are modelled; probabilistic and statistic approaches were indicated here. Experience from previous years' respective assessments from historical data (e.g. failure rates, literature) gives a good picture of the behaviour of generation. Thus, derived reliability characters of different generation technologies are considered by most countries.

2.4.2. Treatment of generation from variable output and storage capacity

Different levels of development can be seen in the way to treat and consider variable generation[13]. Some countries (Estonia, Romania, Malta and Denmark) still go with the approach of unavailable capacity while there are also others like the Netherlands, Norway, Spain and Sweden, that take a certain percentage (5, 7, 20%) as available generation. On the contrary, France and Great Britain go up to detailed modelling based on climate data, hub heights (for offshore wind farms) and detailed coordinates for the generation sites.

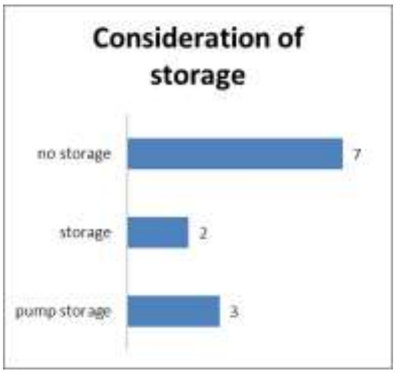
[12] This may be justified by the fact that the report estimates a significant excess of capacity in the system.

[13] Answers were mainly given for wind generation and not photovoltaic (PV); generally wind generation is treated grouped, but in some cases individually.



<u>Finding 31</u>: There are various ways generation from variable output is modelled. Depending on the level of penetration, this can vary from no consideration at all to a precise estimation of variable generation output per modelling time unit, based on sophisticated data. It is commonly agreed that there is a need to improve methodologies to better address how variable output impacts adequacy.

Less than half of the answers indicated that countries take storage into account while the others do not consider storage at all.

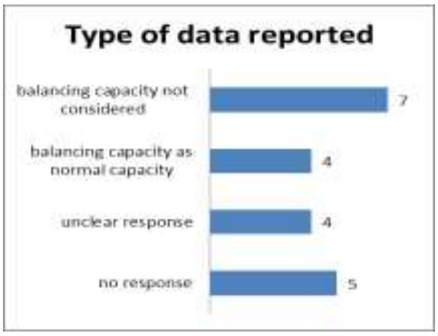


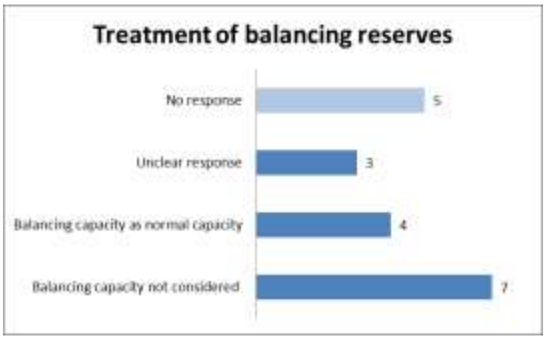
<u>Finding 32</u>: Apart from pumped storage hydroelectric power stations, it seems that a very large majority of national adequacy outlooks currently do not consider any other storage technology.

2.4.3. Treatment of balancing reserves

In national adequacy assessments, volumes procured by TSOs in terms of ancillary services and balancing reserves may or may not be taken into account as “normal” capacity when elaborating the adequacy calculation.

The answers given lead to the interpretation that there is no common approach regarding balancing reserves. In at least 7 countries (Finland, Norway, Estonia, Romania, Belgium, Ireland and Austria) the volume of reserve capacity is subtracted from the calculation of the available capacity. On the contrary, 4 responses (France, Sweden, Italy and Hungary) indicate that reserve capacity is treated as normal capacity in the adequacy assessment.





<u>Finding 33</u>: There seems to be no common approach taking into account balancing reserves in national adequacy outlooks. Surprisingly, methodologies appear to be conflicting, but it seems that there are more responses indicating that the reserve capacity is not included as part of generation assets.

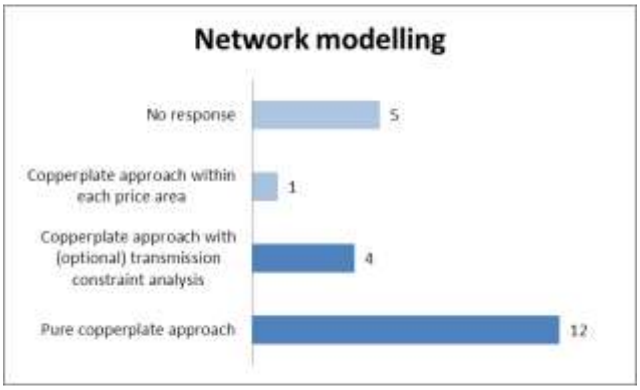
2.5. Adequacy Forecast

2.5.1. Modelling of network constraints

In the process of assessing generation adequacy, transmission and distribution networks can be modelled in a very different manner, from a highly realistic description of the technical parameters which constrain the power flows in the system, to a simplified modelling where these networks are considered as a copperplate grid. Some systems are said not to be subject to structural internal congestions (including Finland and Romania). Some systems may perform a specific analysis on a case-by-case basis:

- With a model analysing a system with possibly more than one area to estimate the impact of the most constrained transmission network link on the risk measures (including Great Britain and the Czech Republic);

- With (optional) specific regional adequacy analyses that can be foreseen in case of structural transmission constraints (e.g. France, Italy).



Finding 34: The responses show that a large majority of the national generation adequacy assessments are based on a copperplate approach, hence abstracting from network technical constraints.

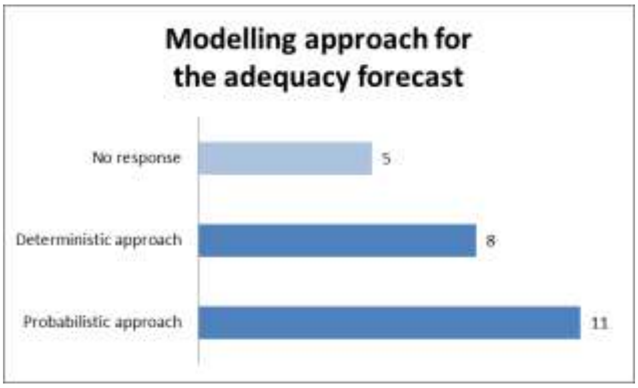
2.5.2. General methods to assess generation adequacy

In most risk assessments, methodologies are used to estimate whether there is or will be sufficient electricity resources to meet the expected energy demand (possibly under certain adequacy requirements).

Such methodologies can be based on a probabilistic approach (or stochastic reliability methodology), that usually intends to estimate the probability of a reliability metric (e.g. LOLE) in a given time period, based on an assignment of several ranges of parameter values to reflect different events that can affect the electricity system (e.g. temperatures, unforeseen unavailability of plants, variable generation, etc.).

They can also be based on a deterministic approach (or reliability margin methodology), that usually attempts to estimate a pre-defined amount of excess power and/or energy at all times.

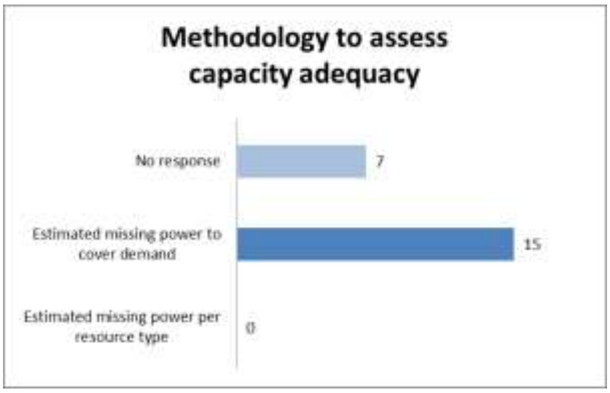
The internal questionnaire responses showed that half of the national studies are based on a probabilistic approach (Great Britain, France, the Netherlands, Finland, Romania and the Czech Republic, Lithuania, Belgium, Ireland, Italy) while 6 of them are based on a deterministic approach (Estonia, Malta, Hungary, Belgium, Spain and Sweden). Denmark uses a deterministic approach, but takes into account an outage percentage of power plants which is based on both historical observations and Monte Carlo simulations.

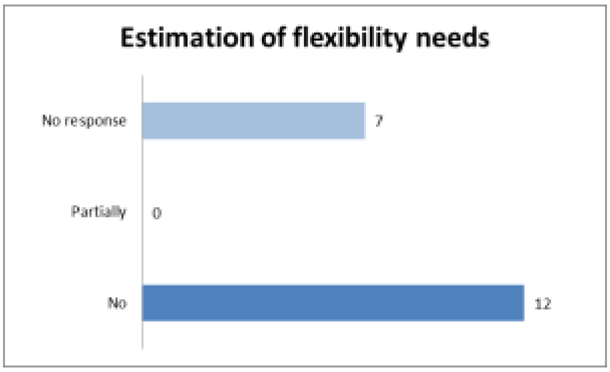


Finding 35: Both probabilistic and deterministic approaches are currently used in national assessment methodologies, but the former seems to be more favoured and/or envisaged.

In addtion, the results show that even though most of the described generation adequacy analyses under certain adequacy requirements attempt to evaluate the amount of missing energy or capacity in the responsibility area, i.e. the risk to security of supply, the type of adequacy outputs can differ a lot: expected energy unserved, missing power, frequency and duration of outages, etc.

Finding 36: Beyond the lack of a common structure to feed in to the national generation adequacy reports, there are no clear common indicators which reflect the extent to which adequacy is fulfilled.

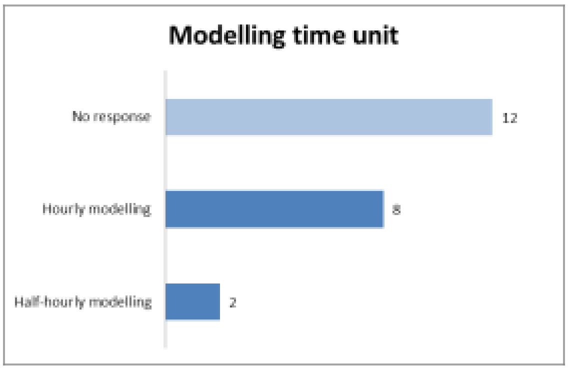




Finding 37: One observation is that none of these reports foresee a split of the adequacy needs per type of technology or given resource characteristics that would be required to cover the demand in the given period (e.g. to highlight the potential future need for flexibility). In other words, the current generation adequacy assessments concentrate on the potential capacity that would be needed in different time horizons, but do not consider flexibility and balancing mechanism issues to ensure operational reliability.

2.5.3. Modelling time unit

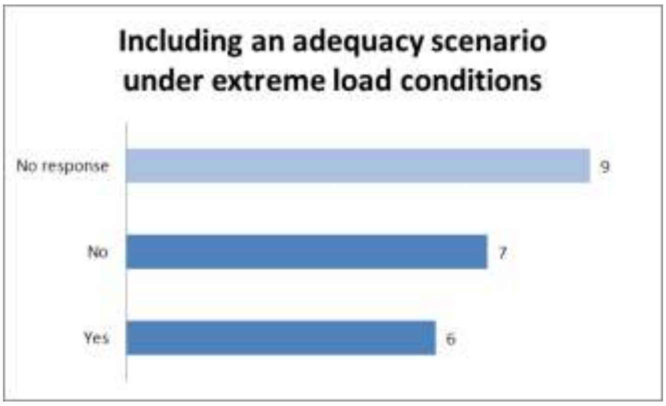
National generation adequacy reports often use typical or randomly chosen time periods defined as reference points to illustrate the modelling results.



Finding 38: It seems that most of the adequacy assessment models use a time unit of one hour, with very few reports considering a shorter time unit of 30 minutes.

2.5.4. System stress scenarios

Several national generation adequacy reports include a specific study that can be described as an electricity system "stress test", i.e. assessing the ability of the resource fleet to supply electricity demand under severe conditions. Such conditions can affect the generation output (both conventional and variable electricity sources) as well as the demand profile; typically, where the key uncertainty driver is the load curve, such an analysis can consist in providing adequacy responses to very rare temperature chronicles.



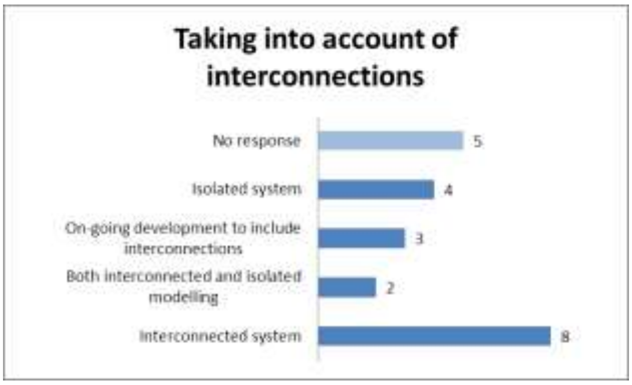
Finding 39: A quarter of the responses to the questionnaire indicate that the national generation adequacy reports foresee a specific scenario to address extreme load conditions (France, Norway, Estonia, Ireland, Sweden and Denmark). Nevertheless, it is not clear whether the impact of severe conditions on conventional generation is considered in the studies and it seems that none of these reports cover the impact of significant changes in intermittent generation output.

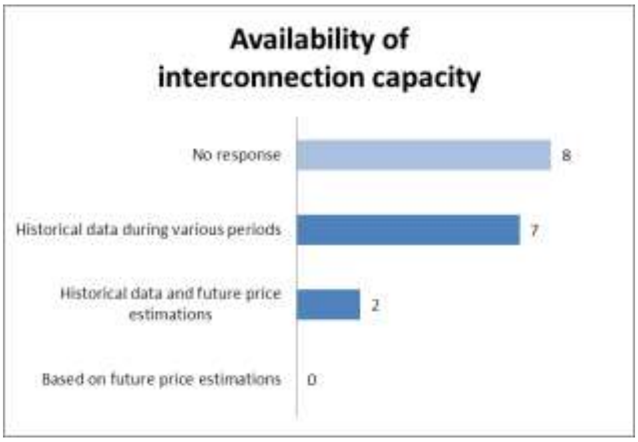
2.5.5. Interconnection and generation adequacy

In a pan-European electricity market, interconnectors play an essential role in ensuring security of supply as they can enable an efficient utilisation of electricity resources across Europe, in particular in times of electricity system stress.

The extent to which current generation adequacy reports take their benefits into account varies a lot. At least:

- 4 reports still model an isolated system (Norway, Estonia, Romania and Sweden);
- 2 reports use both methods (France and Belgium);
- 3 report methodologies are being modified to include an interconnection modelling;
- 9 reports simulate an interconnected system (Great Britain, the Netherlands, the Czech Republic, Lithuania, Finland, Belgium and Ireland; while France and Italy use both methods).





Finding 40: It appears that some national generation adequacy outlooks still do not consider the potential benefit of importing electricity for the securing of supply in their electricity systems.

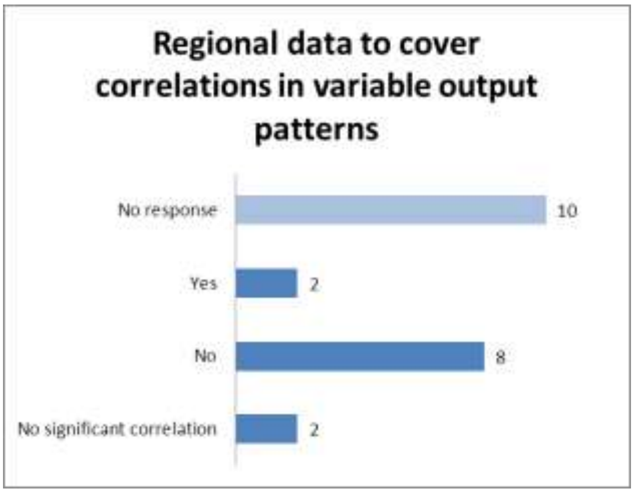
Finding 41: Where interconnections are considered, there does not seem to be a common modelling methodology. The availability of interconnection capacity is mostly based on historical data (export and import flows during various periods of time), while estimated data is more rarely considered in the analyses (e.g. market component such as future prices estimations). It also seems that no cross-border coordination is foreseen to ensure consistency between the different methodologies used.

It should be noted that least one national report draws its own estimation of the availability of capacity across their borders (through a simulation of the generation-demand balance, based on public data).

2.5.6. Correlations

Uncertainties around generation (conventional plants, variable energy sources) or load forecasts in different countries can be subject to a certain level of correlation: cold spell, large wind profiles, etc. Interdependence between generation and load profiles can also be investigated (e.g. as foreseen for wind-demand relationship in Great Britain's report).

Finding 42: It is not obvious that national generation adequacy reports generally take interactions between generation and demand profiles into account. Moreover, it seems that most of the reports do not consider correlated data, which could be done (for example) with the use of a common correlated (climate) database at regional level, or a common methodology for load sensitivity to temperatures. One direct consequence is that most reports do not intend to identify the impact (on security of supply) of potential simultaneous severe conditions in different electricity systems.



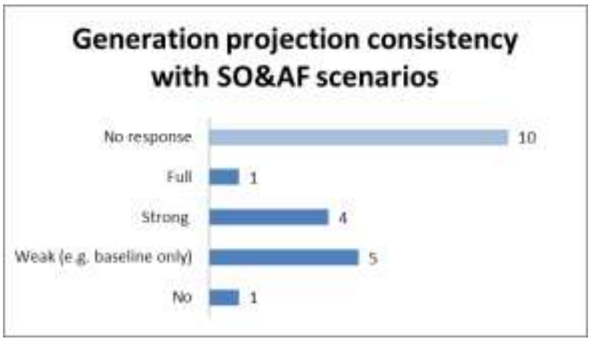
2.5.7. Consistency with ENTSO-E's System Outlook & Adequacy Forecast

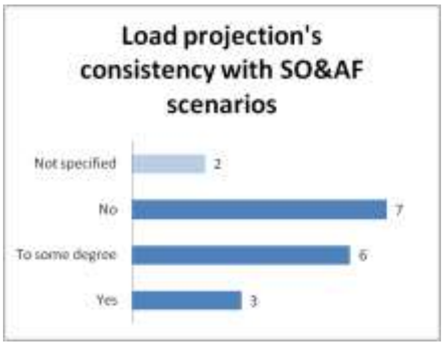
The European Network of Transmission System Operators for Electricity's (ENTSO-E) Scenario Outlook and Adequacy Forecast (SO&AF) analyses the adequacy of the pan-European power system by providing an overview of generation adequacy for all ENTSO-E members, for regions and for individual countries at a mid and long-term time horizons. In the adequacy forecast part, this annually published report presents and analyses the bottom-up scenarios A and B (conservative and best estimate, respectively) and a top-down scenario (EU 2020).

The analysis shows that reports reflect, if any, only scenarios A ("conservative") or B ("best estimate") of the SO&AF. Those are the two bottom-up scenarios that only consider information on generation capacities brought in by ENTSO-E's member TSOs.

Finding 43: All reported scenarios are indicated to be based on a bottom-up approach. They mostly reflect general principles from either scenario A or B (or both) of the SO&AF.

Regarding the Generation Forecast Scenarios, about one third of respondent countries indicate a partial consistency with the SO&AF (e.g. principles are quite similar but assumption details can significantly differ). Others answered this question with "No" or did not answer at all. Regarding Load Forecast Scenarios, 3 NRAs (the Czech Republic, Denmark and Spain) responded that the load forecasts are consistent with ENTSO-E's SO&AF. 6 NRAs (Great Britain, Romania, Hungary, Lithuania, Ireland and Italy) responded that the scenarios for load forecast are in line "to some degree" with the SO&AF. 7 NRAs (France, Finland, Norway, Estonia, Belgium, Austria and Sweden) responded that the load forecasts are currently not consistent with the ones used in the SO&AF.





Finding 44: There does not seem to be too strong a connection between the national scenarios for Generation and Load Forecast, and those which are developed in the European SO&AF analysis by ENTSO-E.

The national data used for assessing generation adequacy are typically collected by ENTSO-E for establishing the SO&AF. Conversely:

- Some national reports include a comparative study (including Finland and Austria);
- 4 responses suggested that the SO&AF results are partially used as inputs for the national reports (Denmark, Switzerland, Hungary and Lithuania).

Finding 45: A large majority of responses (11 out of 22) affirms that none of the SO&AF outputs are considered at national level. In particular, it is indicated that there is a timing inconsistency which makes it difficult to (i) reflect the most current adequacy status as the data used in SO&AF is forwarded well in advance before publication, and (ii) include results from the SO&AF in national generation adequacy reports.

Annex 1 – CEER

The Council of European Energy Regulators (CEER) is the voice of Europe's national regulators of electricity and gas at EU and international level. Through CEER, a not-for-profit association, the national regulators cooperate and exchange best practice. A key objective of CEER is to facilitate the creation of a single, competitive, efficient and sustainable EU internal energy market that works in the public interest.

CEER works closely with (and supports) the Agency for the Cooperation of Energy Regulators (ACER). ACER, which has its seat in Ljubljana, is an EU Agency with its own staff and resources. CEER, based in Brussels, deals with many complementary (and not overlapping) issues to ACER's work such as international issues, smart grids, sustainability and customer issues.

The work of CEER is structured according to a number of working groups and task forces, composed of staff members of the national energy regulatory authorities, and supported by the CEER Secretariat.

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Annex 2 - List of abbreviations

Term	Definition
GA	The Generation Adequacy
ACER	EU Agency for the Cooperation of Energy Regulators
CEER	The Council of European Energy Regulators
DSO	Distribution system operator
ENTSO-E	European Network of Transmission System Operators for Electricity
ESS TF	The Electricity Security of Supply Task Force
EU	European Union
GDP	Gross Domestic Product
IEM	The Internal Energy Market
IPCC	Intergovernmental Panel on Climate Change
NRA	National Regulatory Authority (for energy)
SO&AF	The ENTSO-E's System Outlook & Adequacy Forecast
TSO	Transmission system operator