Capacity reserves until 2025: declining, but sufficient

Trends from ENTSO-E's Scenario Outlook & Adequacy Forecast 2015

Once a year, ENTSO-E[1] publishes a Scenario Outlook & Adequacy Forecast (SO&AF). The purpose of the report is to provide *"stakeholders in the European electricity market with a Pan-European overview of generation adequacy with a five to ten year time frame".*

According to the terms of reference for the new Danish energy commission, Denmark will not maintain a local reserve capacity in power stations, but rely on electricity import and other measures. ENTSO-E's SO&AF 2015 seems to support that position.

One message from the SO&AF 2015 executive summary is:

> *The regional analysis shows that from a Pan-European system point of view, the level of imports necessary to maintain adequacy is **feasible** and **within** the level of forecast cross-border interconnectivity for the period 2016–2025. These results rely on the assumption that the forecast cross-border interconnectivity is in place in 2020 and 2025.*

It means that it is technically possible to maintain normal security of supply in all countries until 2025 if the planned new transmission facilities are commissioned in due time.

The following charts from the executive summary indicate a change from 2016 to 2025:

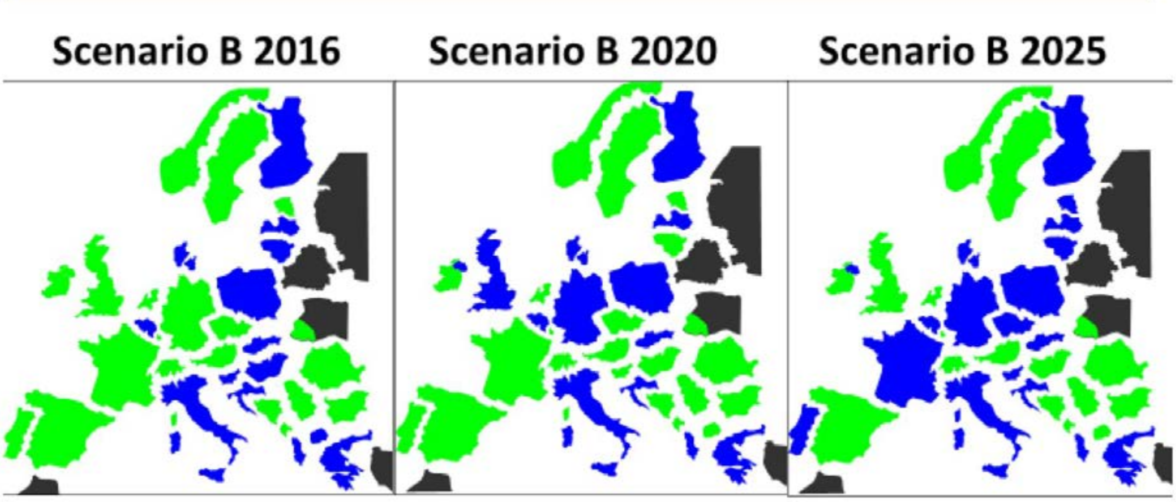

Fig. 1 - Blue countries must rely on import. Green countries have excess capacity.

By 2025, a band of large, central European countries from France to Finland seems to be dependent on imported reserve capacity. The same countries can have shortage of wind and solar power at the same time. This note presents results from SO&AF 2015 for selected countries.

Towards more volatility in the spot markets?

SO&AF 2015 includes 37 European countries. Denmark is the only country with a negative adequacy power balance every month in 2016, 2020 and 2025 and for both scenarios, but a few other countries have mainly negative balances.

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[1] ENTSO-E: the European Network of Transmission System Operators

Belgium has a strained power balance and on the top of that uncertainty about its future nuclear capacity. Finland had for many years an agreement on import of base load power from Russia. However, for most of the investigated months, the negative balance exceeds the import capacity from Russia. Greece has a mainly negative balance, particularly for 2025.

The total load for all 37 countries is expected to grow by 3% from 2016 to 2020 and by 5% from 2020 to 2025.

The growth of *net generating capacity* (NGC) depends on the scenario. For scenario B ("best estimate"), the growth is 6% from 2016 to 2020 and 7% from 2020 to 2025. However, ENTSO-E defines most of the new capacity as unavailable, for instance non-dispatchable wind and solar power (see definition in fig. 3).

Scenario B		2016	2020	2025
Available capacity	GW	602	612	611
Unavailable capacity	GW	419	474	556
Total	GW	1021	1086	1167

The available capacity is expected to grow less than 2% from 2016 to 2025, while the expected growth of the load is 13%. The report does not quantify an adequacy power balance, combined for all the countries, but for many countries including France, Germany, Great Britain, Italy, Poland and Sweden, the level of reserve capacity is expected to decline.

A decreasing reserve capacity can have a positive effect on market prices, particularly in capacity markets, where increasing prices can encourage investments. In the spot markets, some conflicting forces make the outcome uncertain. On one hand, an increasing amount of subsidized energy will press prices downwards. On the other hand, shortage of backup capacity may cause increasing prices during calm and dark periods. The total effect could be more volatility in the spot markets.

Crucial grid reinforcements

The result of more fluctuating power and less dispatchable backup capacity must be more exchanges of power across Europe. SO&AF 2015 assumes "*that the forecast cross-border interconnectivity is in place in 2020 and 2025*". Not only cross-border interconnectivity is important. Exchanges are already now limited by internal bottlenecks, particularly in Germany.

There are large differences in European spot price levels (fig. 2). One of the reasons for the differences is the limited transmission capacity.

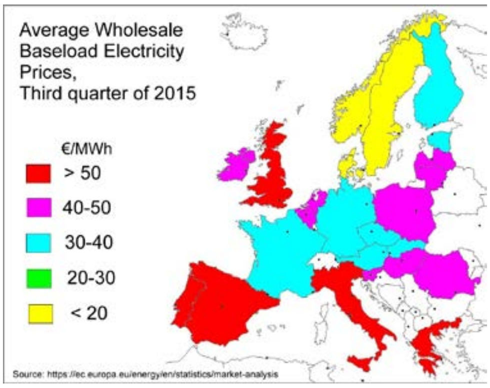


Fig. 2 – Bottlenecks are essential reasons for the different price levels in Europe

Congestion problems are frequent in Germany. Germany and Austria make one common zone in the electricity spot market. Therefore, overload must be avoided by other measures, the so-called "redispatch". Owners of wind turbines and

PV installations are paid for curtailing production, when needed. Even Danish market participants contribute to the relief of German grid problems through a “special regulation”, which is running parallel with the Nordic market for regulation, NOIS.

The present transmission capacity is far from satisfactory, and additional challenges will follow. The grid reinforcements will be in a delicate balance with increasing load, more fluctuating power and a decreasing share of dispatchable backup power. In the next few years, the differences in European spot price levels and the spot price volatility will be indicators showing either improvements or deterioration.

Method

The analyses include two scenarios, scenario A ‘Conservative’ and scenario B ‘Best Estimate’.

Scenario A includes approved commissions and decommissions of production units. Scenario B also includes probable, but not yet decided, commissions and decommissions. The total renewable capacity in 2025 is about 20% higher in scenario B than in scenario A.

The first part of the results is called “National upward generation adequacy assessment”. This section deals with the adequacy of supply capacity.

Two types of monthly power balances were estimated:

- Reference points: Remaining Capacity minus Spare Capacity (SC) on the 3rd Wednesday every month at 7 p.m.
- Peak load time: Remaining Capacity at national peak time minus Adequacy Reference Margin

Fig. 3 defines the data. See appendix 1 for the definition of Non Usable Capacity.

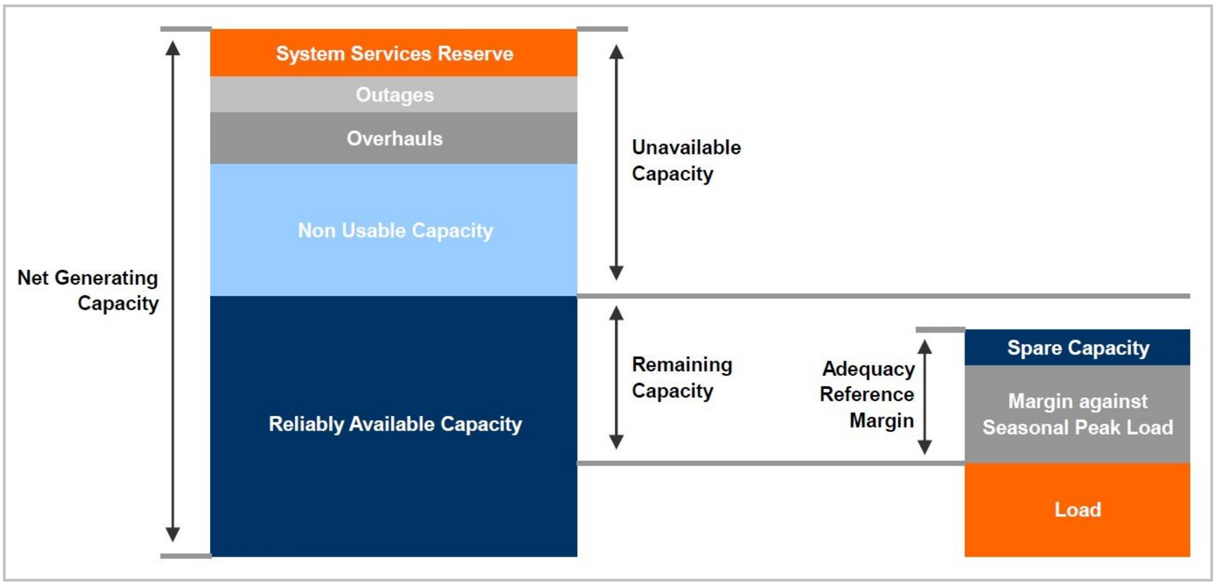


Fig. 3 - Adequacy methodology

The second part of the results is called “National Residual Load Analyses/Ramping–Need for flexibility”. This section quantifies the challenges caused by fluctuating and non-dispatchable generation.

The residual load is defined as the actual load minus production of wind, solar and must-run generation within the hourly time interval. The section evaluates two statistical distributions:

- RES (wind and solar) penetration of the load, including must-run generation
- hourly RES and residual load ramps (calculated as the difference between consecutive hours)

Adequacy results for selected countries

Germany:
Fig. 4 is a chart with adequacy monthly results for Germany. For each month, either the reference point or the peak load values are shown depending on adequacy level. In fig. 3, the reference point is used only for October 2025. There are only minor differences between scenario A (red) and scenario B (blue). The adequacy level is falling from 2016 to 2025. In 2025, it is negative during the winter season for both scenarios, but the import capacity (light green area) is sufficient for filling the gaps.

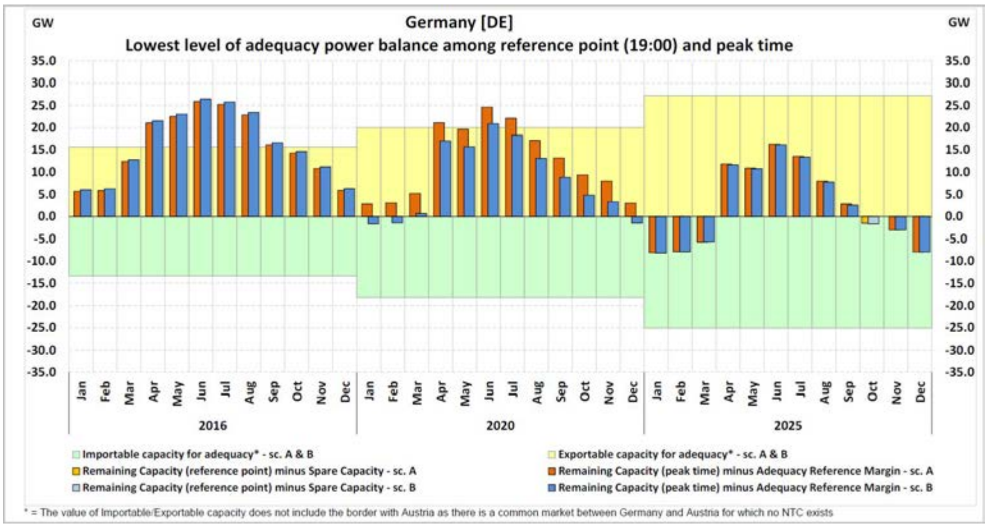


Fig. 4 - Germany: Monthly adequacy results for 2016, 2020 and 2025

According to fig. 4, Germany has access to sufficient reserves for maintaining the normal electricity supply. In 2025, Germany can import electricity from the following "green" countries (fig. 1): Norway, the Netherlands, Switzerland and Austria.

Germany has a considerable annual net export of electricity, but due to bottlenecks in internal German grids, it is not always possible to utilize or export all renewable energy.

Rapid progress of the large German transmission projects is vital, both for the electricity sector in Germany and for Germany's neighbouring countries.

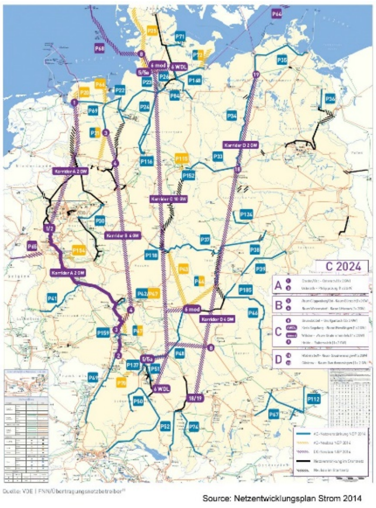


Fig. 5 - New electricity corridors in Germany

Denmark

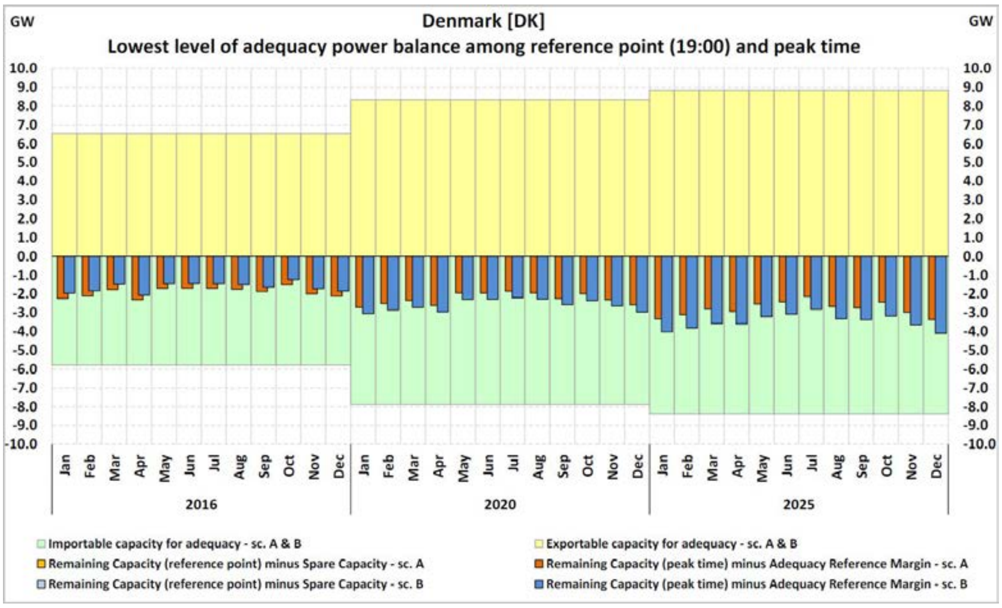


Fig. 6 - Adequacy results for Denmark

The Danish reserve capacity is negative for both scenarios and for all months. The import capacity is sufficient. Only peak load results have been used.

Fig. 6 seems to confirm that Denmark has a convenient situation regarding security of supply. SO&AF does not consider the difference between west and east in Denmark.

France:

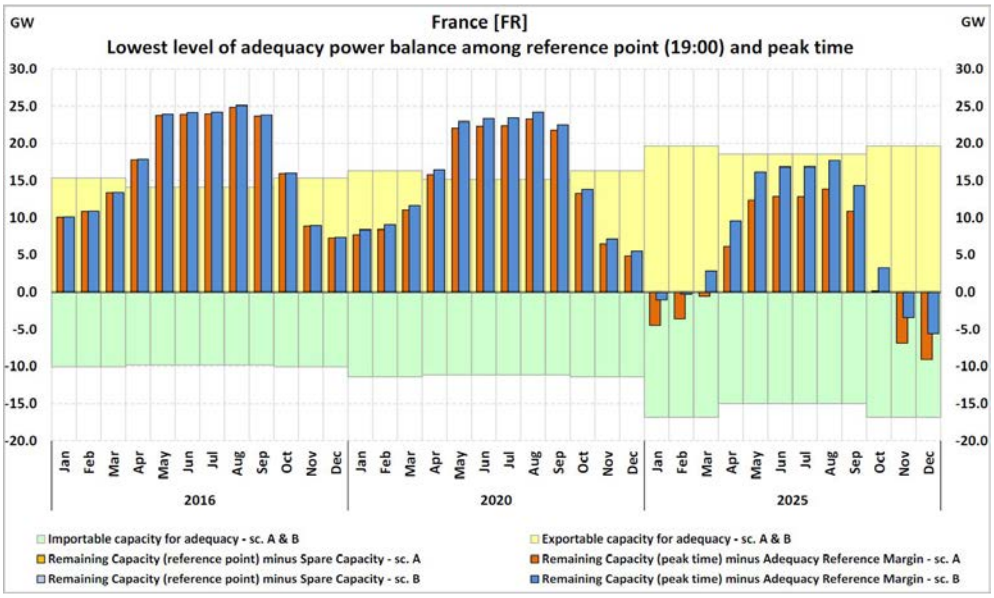


Fig. 7 - Adequacy results for France

The adequacy trend for France is similar to the German trend. Scenario A has a more significant difference between the scenarios for the winter season in 2025, but even her the import capacity is plentiful.

Great Britain

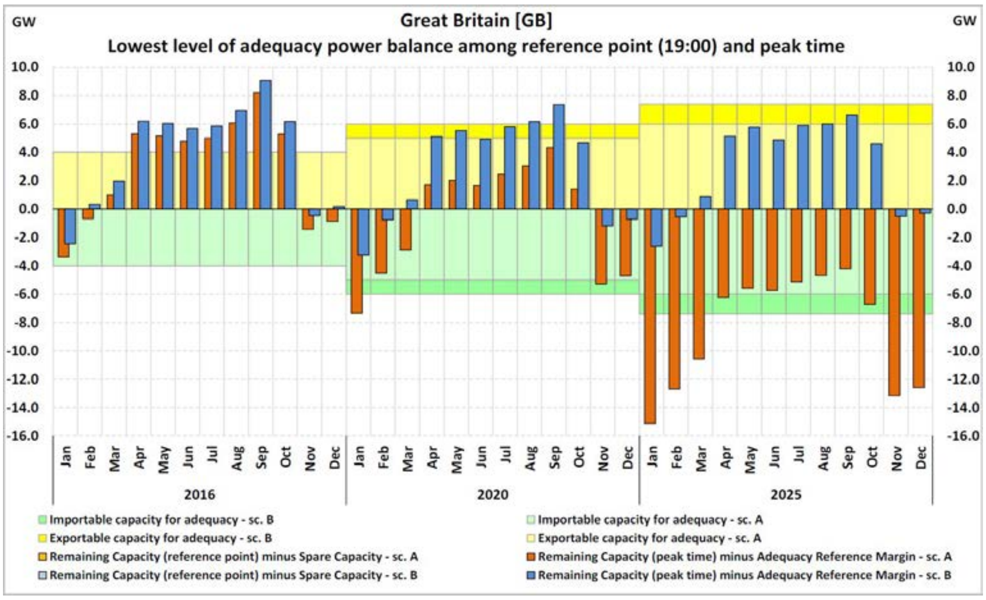


Fig. 8 - Adequacy results for Great Britain

The two scenarios for Great Britain are different from the previous cases in two ways:

- The adequacy is significantly lower in scenario A, particularly for 2025.
- The exchange capacity is extended in scenario B (darker yellow and green bands).

The scenarios for Great Britain are based on National Grid scenarios from 2014:

ENTSO-E	National Grid
Scenario A “Conservative”	“No Progression”
Scenario B “Best estimate”	“Gone Green”

National Grid publishes new scenarios every year. There were four scenarios in the 2014 edition (see appendix 2). The difference between the two selected scenarios is more fundamental than required by the ENTSO-E scenario definitions. However, the National Grid scenarios stretch a wider space of possible futures, which might be interesting for further studies.

Italy

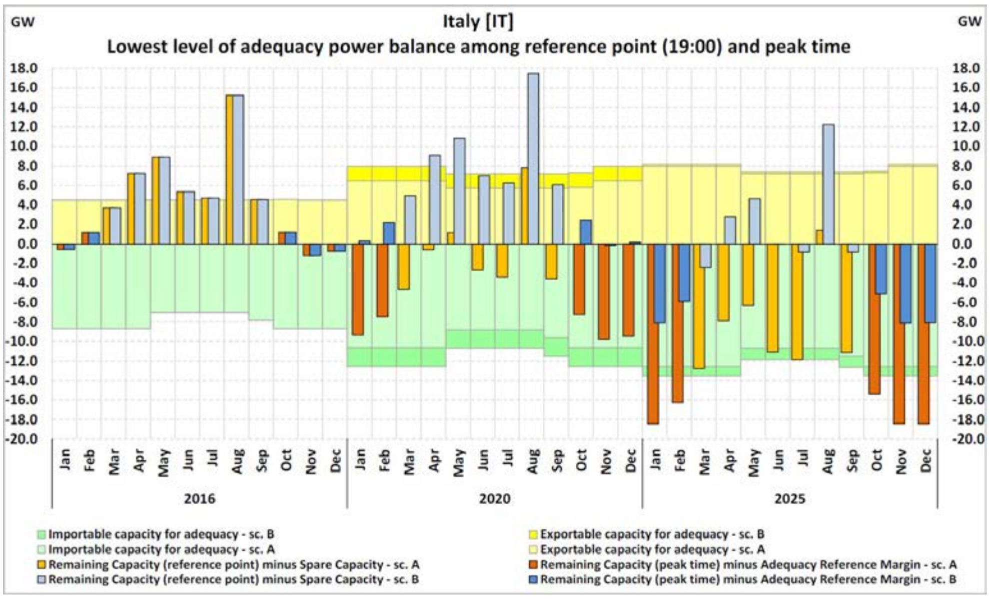


Fig. 9 - Adequacy results for Italy

The reference points seem to be the most critical during the summer season, while peak load has the lowest adequacy during the winter season. In scenario A, the estimated need for import of reserve capacity in 2025 exceeds the import capacity.

Poland

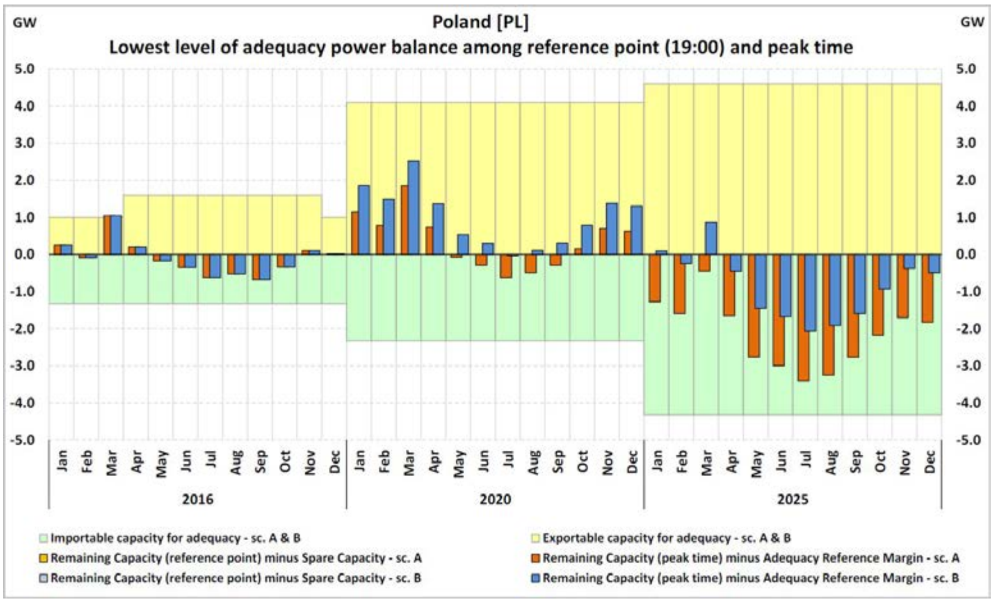


Fig. 10 - Adequacy results for Poland

Poland seems to have rather limited international options in 2016, for instance compared with ±6 GW for Denmark (fig. 6).

Sweden

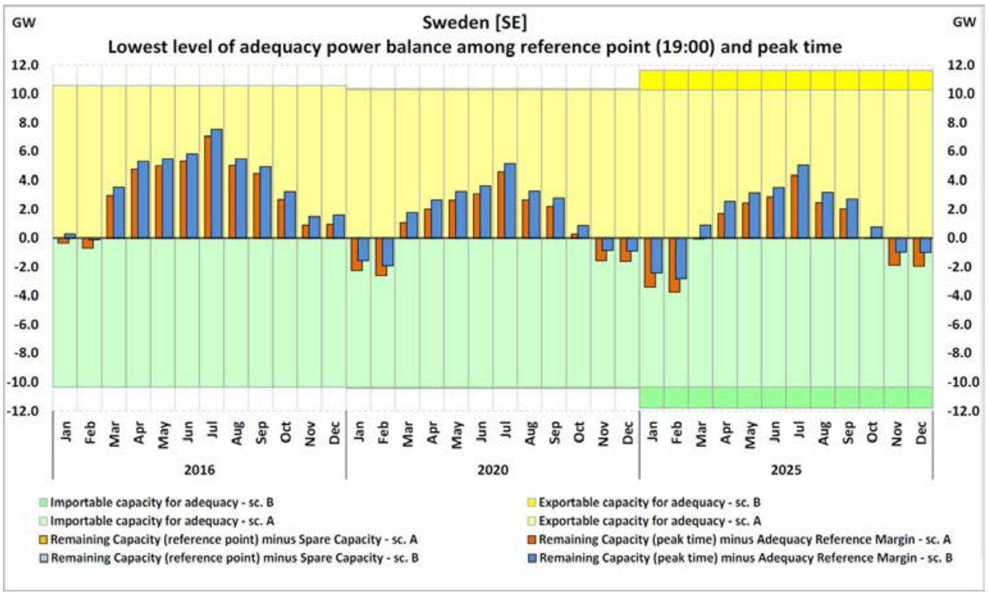


Fig. 11 - Adequacy results for Sweden

Even Sweden expects insufficient reserve capacity during future winter seasons.

Flexibility

The growth of non-dispatchable power sources leaves a highly fluctuating **residual load** for the remaining dispatchable power or backup power. The residual load can be negative. Its load factor is low, and the business volume is correspondingly low for the necessary backup power.

It is not easy to quantify the additional need for flexibility. This section will be limited to a comparison of a couple of charts for Germany and Denmark. See the SO&AF 2015 for more results.

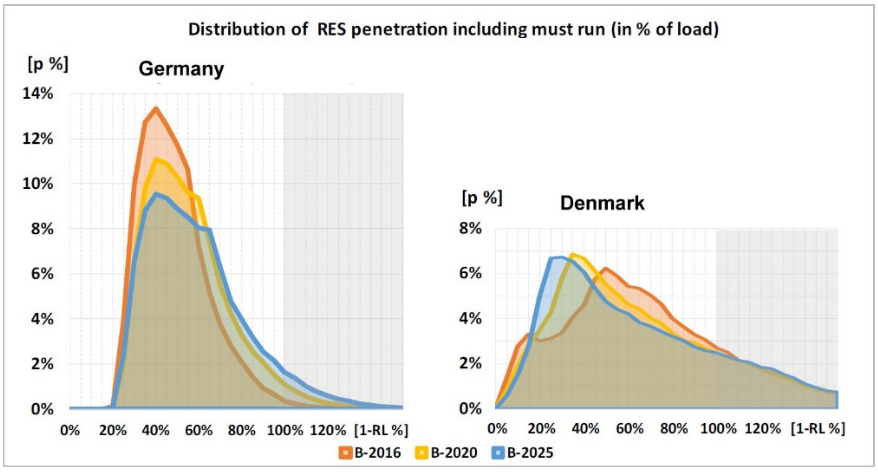


Fig. 12 - RES distribution in Germany and Denmark

“Must run” can be any type of constrained production such as nuclear minimum production and waste incineration. In 2016, nearly all German RES and must run production is between 20% and 100% of the load. The “tail” will grow to the right, so up to 150% of the load can be RES and must run in 2025.

The Danish distribution is different. Already in 2016, the range is from 0% to more than 150%.

The illustration of the need for flexibility is rather indirect and may be difficult to interpret.

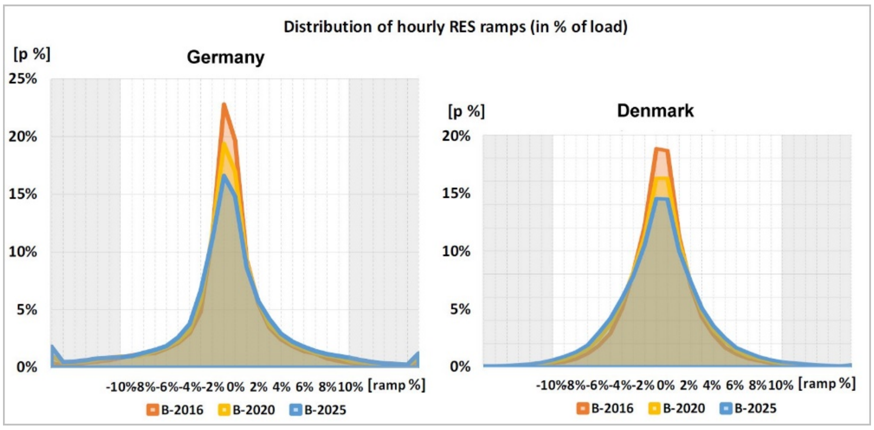


Fig. 13 - Distribution of hourly RES ramps for Germany and Denmark

The speed of production change is called ramping. It is another concern that RES production can change so fast that the dispatchable units cannot counterbalance it. In fig. 13, the “tails” outside the ±10% white range seem to indicate that Denmark is slightly better off than Germany. The reason could be the higher Danish share of offshore wind.

Charts with distribution of ramps for the residual load would have been more useful than the RES ramps, because it would show the necessary ramping for the backup production.

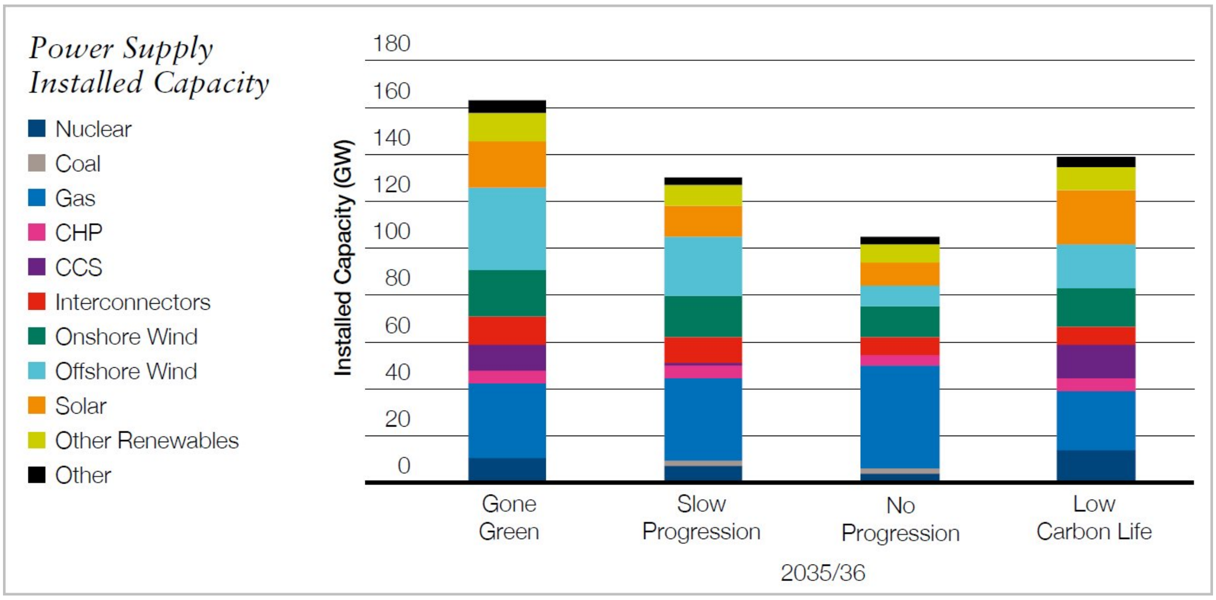
Appendix 1. Non-Usable Capacity (definition):

Aggregated reduction of the net generating capacities because of various causes, including, but not limited to

- Limitation because of intentional decision by the power plant operators
    - Power stations in mothballs that may be recommissioned if necessary
    - Power stations bound by local authorities that are not available for interconnected operation
    - Power stations under construction whose commissioning is scheduled for a certain date, but capacity is not firmly available because of delays or retrofitting
    - Power stations that are converted to other fuels or that are equipped subsequently with desulphurization and denitrification plants
    - Power stations in test operation
- Unintentional temporary limitation
    - Power stations whose output power cannot be fully injected because of transmission constraints
    - Power stations in multiple purpose installations where the electrical generating capacity is reduced in favour of other purposes, such as heat extraction in combined heat and power plants for example
- Temporary limitation because of constraints, such as power stations in mothballs or test operations, heat extraction for CHPs
- Limitation because of fuel constraints management
    - Nuclear power stations in stretch-out operation
    - Fossil fuel power stations
        - Power stations with interruptible fuel supply
        - Power stations with poor quality fuel, such as unfit coal
- Limitation reflecting the average availability of the primary energy source
    - Hydro power stations
        - Run-of-river power stations with usual seasonal low upstream water flow
        - Tidal power stations
        - Storage power stations subject to usual limitation such as limited reservoir capacity, power losses because of high water, loss of head height or limitation of the downstream water flow
    - Wind power stations
    - Photovoltaic power stations
    - Geothermal power stations
- Power stations with output power limitation because of environmental and ambient constraints
- limitation because of other external constraints
    - Hydro power stations with water flow regulation for irrigation, navigation, tourism
    - Power stations with output power limitation because of environmental constraints
    - Power stations with output power limitation because of external thermal conditions

Appendix 2. National Grid scenarios 2014

- **Low Carbon Life** (LCL) is a world of high affordability and low sustainability. More money is available due to higher economic growth and society has more disposable income. There is short-term volatility regarding energy policy and no additional targets are introduced. Government policy is focused on the long term with consensus around decarbonisation, which is delivered through purchasing power and macro policy.
- **Gone Green** (GG) is a world of high affordability and high sustainability. The economy is growing, with strong policy and regulation and new environmental targets, all of which are met on time. Sustainability is not restrained by financial limitations, as more money is available at both an investment level for energy infrastructure and at a domestic level via disposable income.
- **No Progression** (NP) is a world of low affordability and low sustainability. There is slow economic recovery in this scenario, meaning less money is available at both a government and consumer level. There is less emphasis on policy and regulation, which remains the same as today, and no new targets are introduced. Financial pressures result in political volatility, and government policy that is focused on short-term affordability measures.
- **Slow Progression** (SP) is a world of low affordability and high sustainability. Less money is available compared to Gone Green, but with similar strong focus on policy and regulation and new targets. Economic recovery is slower, resulting in some uncertainty, and financial constraints lead to difficult political decisions. Although there is political will and market intervention, slower economic recovery delays delivery against environmental targets.



Source: National Grid: UK Future Energy Scenarios 2014, July 2014