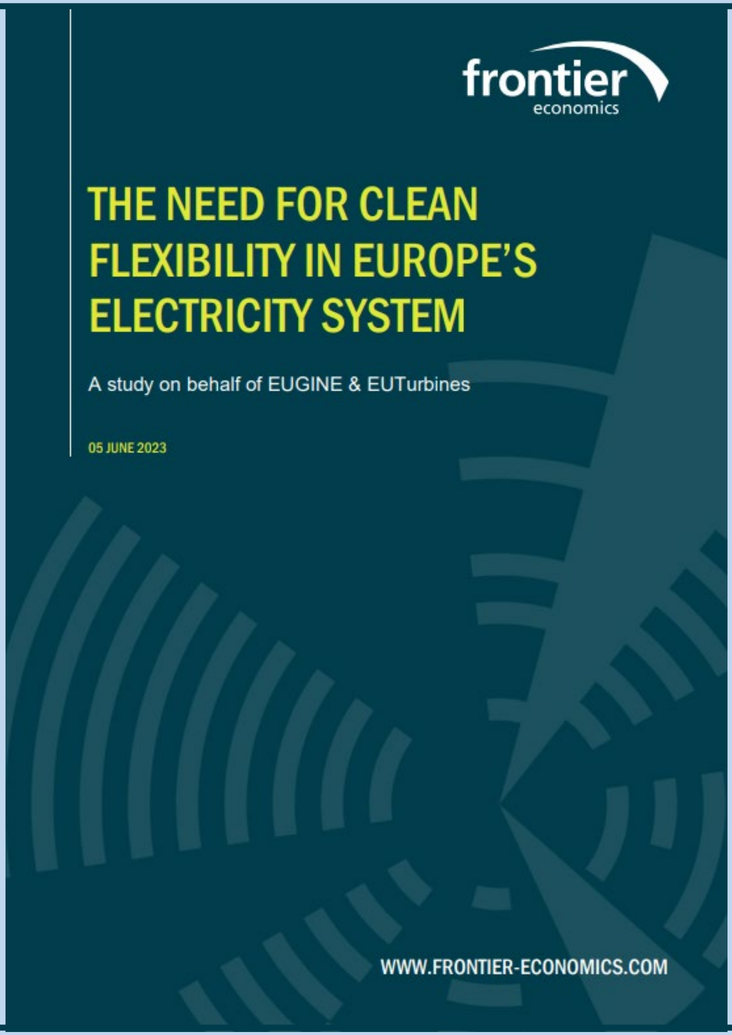
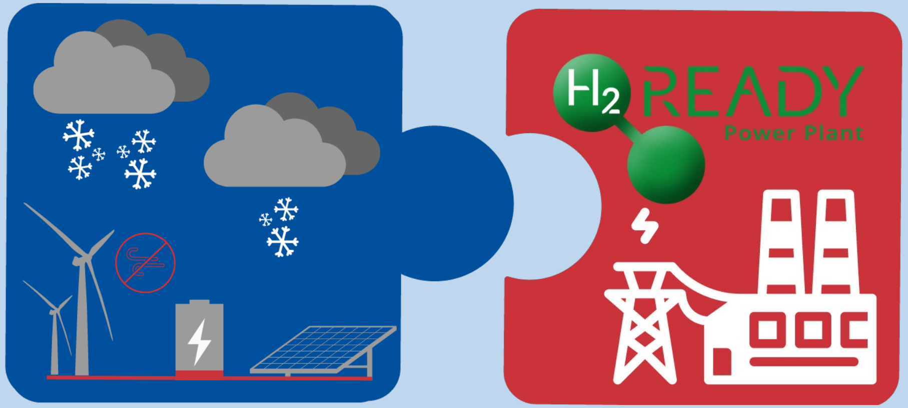


Will Europe still need flexible power generation in 2050?

Results of a Study by Frontier Economics, on behalf of EUGINE & EUTurbines

June 2023



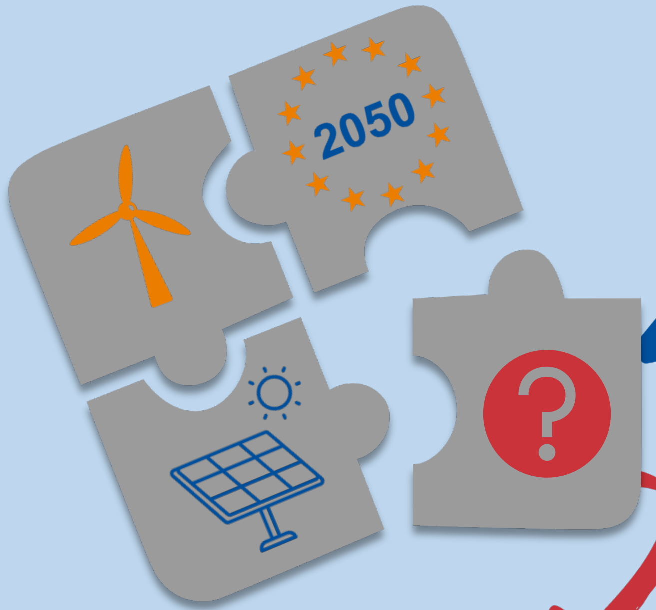
European Engine Power Plants Association EUGINE

EUTurbines

2050 the by far largest share of energy in Europe will come from wind & solar power … but there will be moments when the sun does not shine, and the wind does not blow.

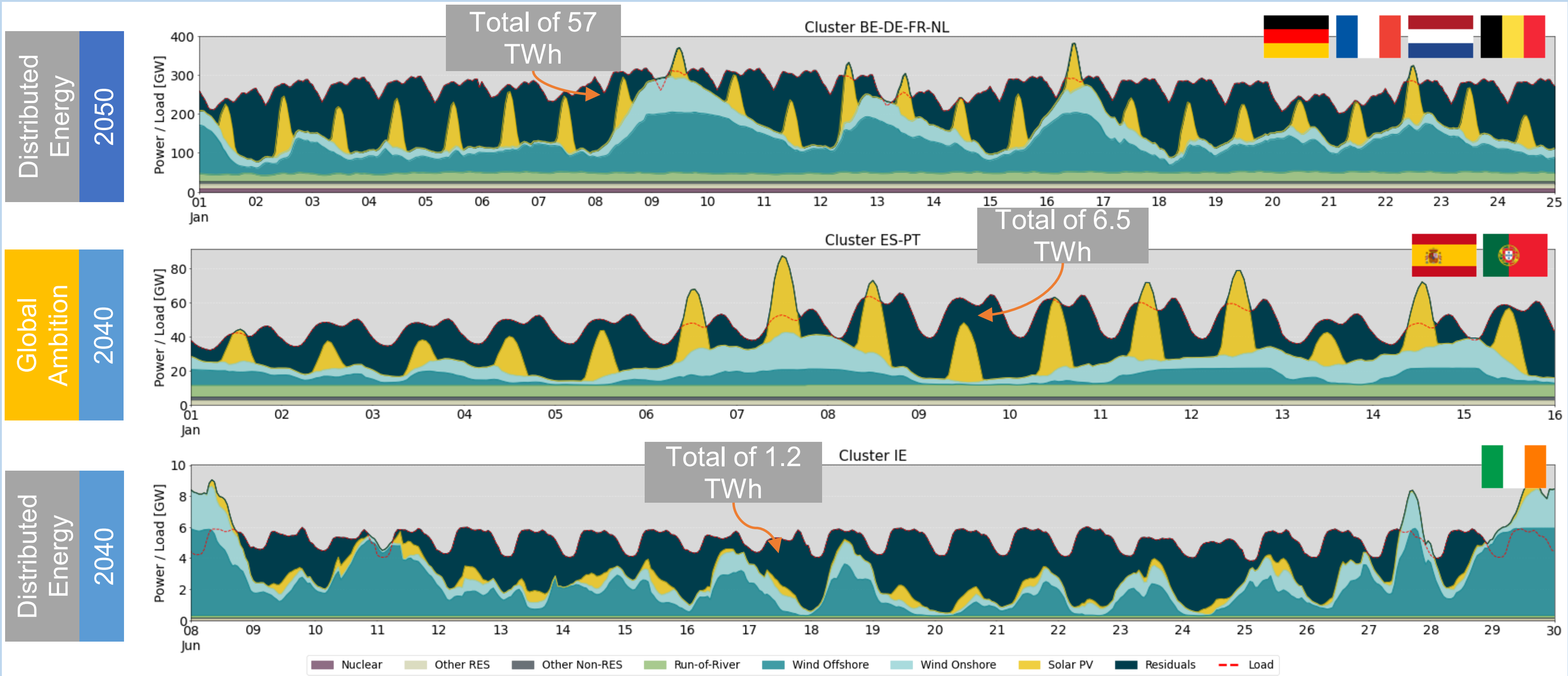
How often will that happen? How big will the gaps be? And can we fill those gaps with batteries and temporarily reducing demand?

The Frontier Economics study tries to answer this by using the recognised scenario data on electricity demand and supply for 2040 and 2050 from the European transmission grid operators (ENTSO-E TYNDP) and historical weather data. The key assumption is to meet the 1.5 degree climate target.

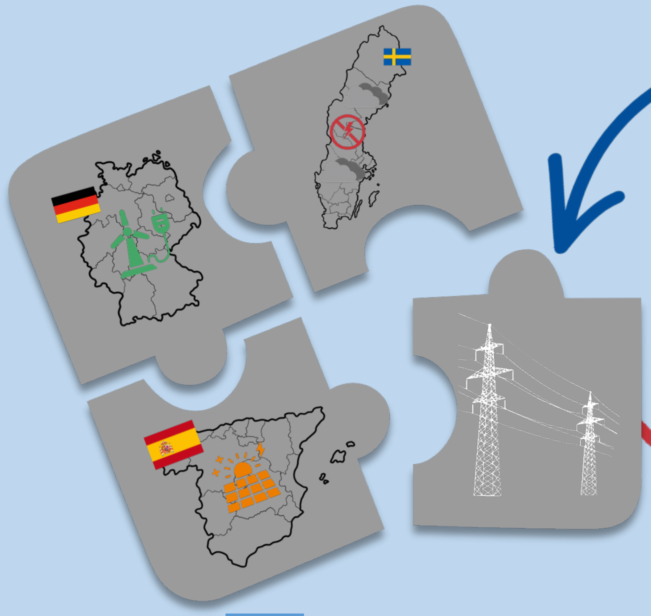


Europe will switch to a fully decarbonised energy system by 2050. By far the largest share of energy used will be electricity generated by wind turbines and photovoltaic.
Already today we reach moments when renewable electricity production meets demand.
Assuming we have built enough wind and solar capacities - do we need anything else?

The modelling of the hourly electricity generation from wind, solar, nuclear and run-of-river vs demand in EU Member States in 2040 & 2050 show that **in all countries, and all scenarios, there will be gaps where supply from renewables cannot meet demand**, of more than a day – often between Nov and February and **lasting up to 3 weeks**



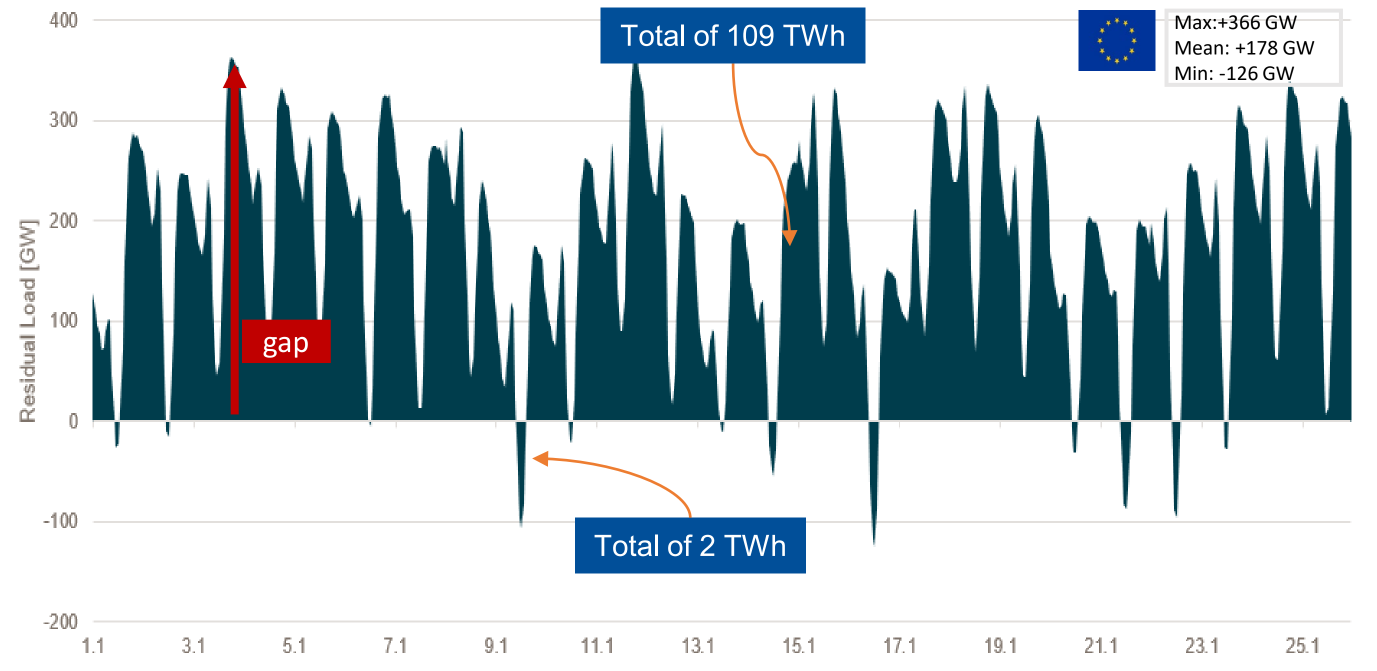
Source: Frontier Economics based on TYNDP
Note: Production profiles for RES for the first figure are based on Dec 1995 while for the second are based on Jan 2010 which has been similarly stressful in terms of weather conditions as 1995 according to TYND 2022



But if the sun does not shine in Sweden, can the gap be filled with solar electricity from Spain or wind power from Germany if we just invest in enough electricity grids?

The study shows that even with a perfect grid (Europe as one big “copper-plate”) there will be **longer periods when in total in the EU not enough renewable electricity is generated to meet demand** (“residual load”) - so just building “interconnectors” alone, will not be sufficient.

Residual loads in the EU-27 in 2050 during a 3-week-period in January



During the typical 3 weeks:

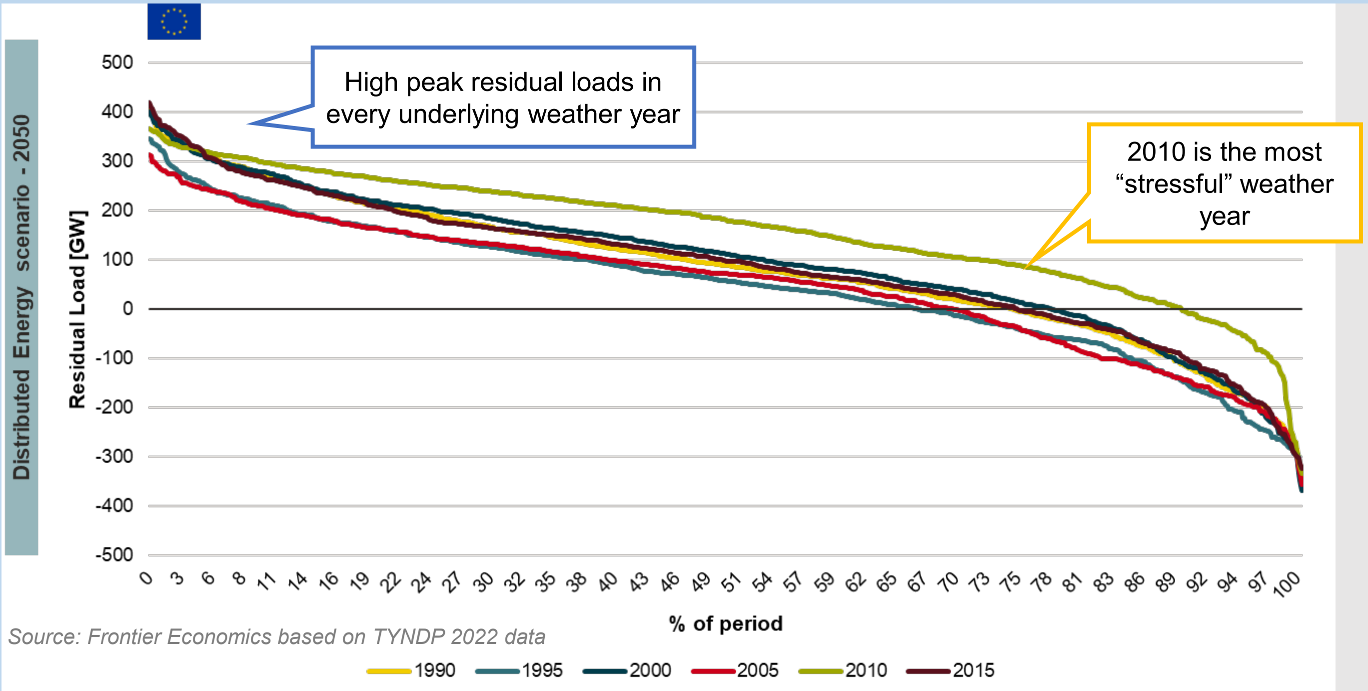
- demand exceeds renewable generation by 109 TWh (residual load)
- surplus energy moments (e.g., to re-load batteries) will be scarce and only provide 2TWh
- 366 GW are the maximum residual load needed to fill a gap. The potential contribution from demand management is 35 GW, from pumped hydro 59 GW

Source: Frontier Economics based on TYNDP data and weather year 2010

Will the situation of 3 weeks without enough renewable electricity happen only once in 100 years (so that we can take the risk) or will it happen regularly?

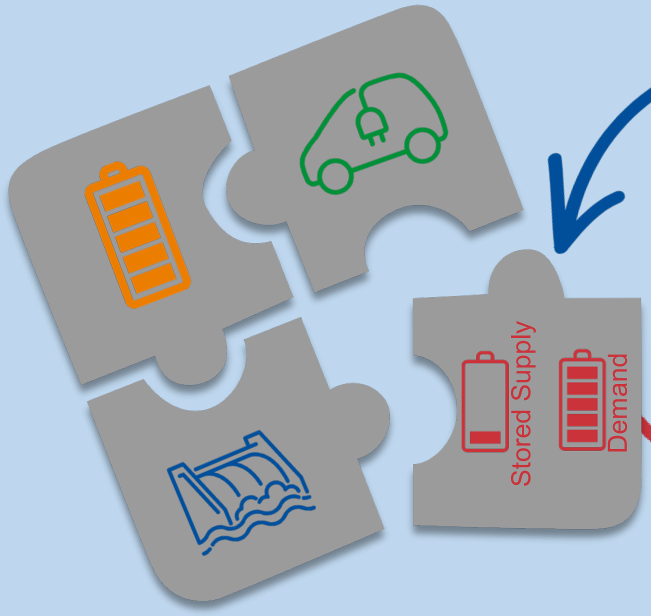
The study shows that in the worst case with weather conditions like in 2010, a 3-week period gap would amount to 109 TWh (4% of the total annual generation) – but using every 5th weather year it shows that **the gaps in total may be smaller in "normal" years but will occur very regularly – and the gap sizes more extreme**.

Residual load duration curves for January 2050, EU-27 (copper plate), different weather years



Source: Frontier Economics based on TYNDP 2022 data

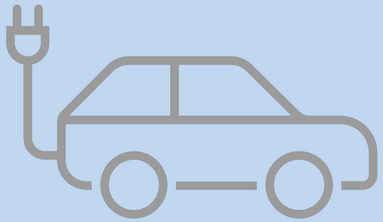
- The chart shows the residual load duration curves during a January month for different weather years
- Different historic weather patterns for January show diverging, but always positive, high residual loads…
- …. some with even higher peak residual load than the most extreme weather years
- Flexible backup must also cover the more extreme situations (not only the average) to ensure a reliable electricity supply



Would it be possible to fill the gap by temporarily reducing demand (DSM = demand-side management) and using electricity stored in batteries when having a surplus generation?

Both options are excellent solutions for **covering shorter gaps**. But during the critical weeks there is **not enough excess energy to load batteries adequately and a longer reduction of industrial electricity demand causes high economic losses** - it would need 1.4 billion electric vehicle batteries.

Typical battery in a modern electric vehicle



Tesla Model 3

- Capacity: 75 kWh
- Base power: 75-125 kW
- Peak power: 175 kW

>1,400,000,000 BEVs

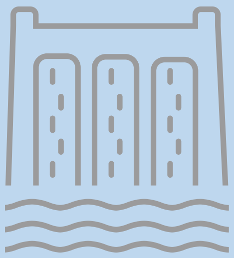
... fully charged and all connected to the grid would be needed across Europe (and BEV are empty afterwards)!

Today we “only” have ~250 million cars (mainly ICE).

Energy:
109 TWh in ~3 weeks

Peak load:
366 GW

Typical large pumped storage plant in Europe



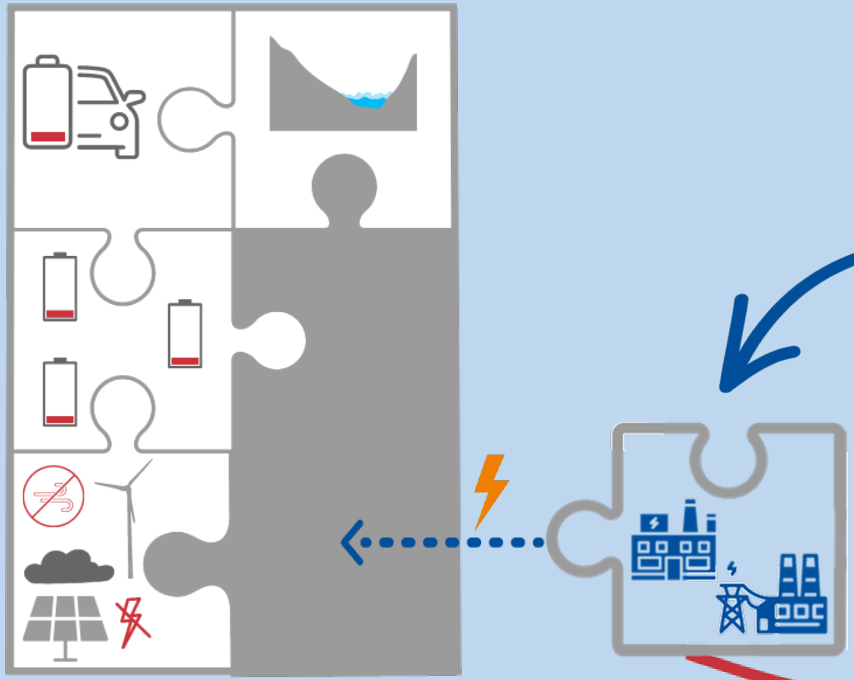
Goldisthal pumped storage

- Storage capacity: 8.5 GWh
- Power capacity: 1060 MW

>12,500 pumped storages

... completely filled would be needed across Europe!

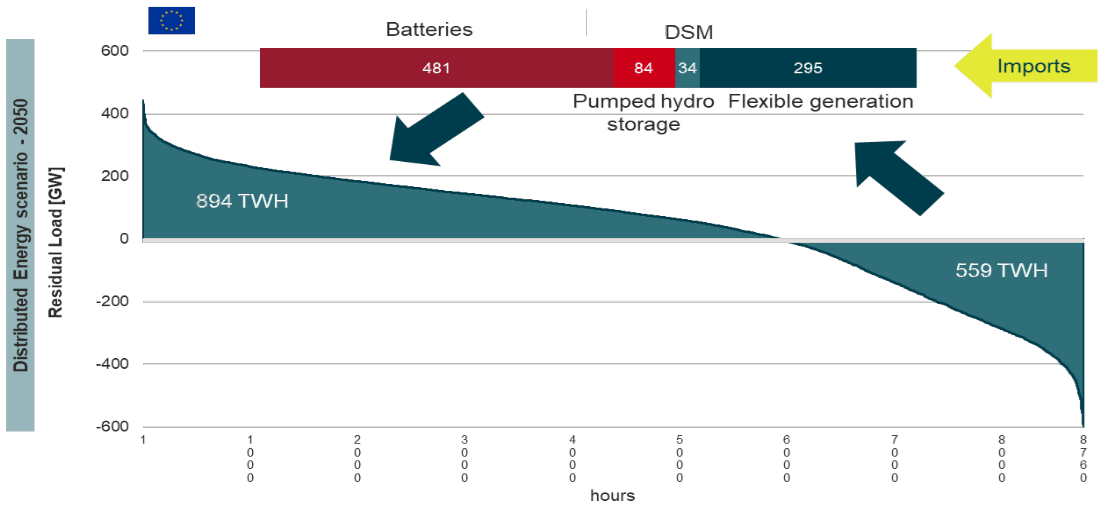
Today the estimated pumped hydro capacity is 59 GW



The consequence: To ensure a reliable electricity supply, **it requires also a certain amount of flexible power plants** that can produce electricity during periods when renewable electricity is insufficient to meet demand, and the renewable supply gap is too long to be met by batteries and demand side management.

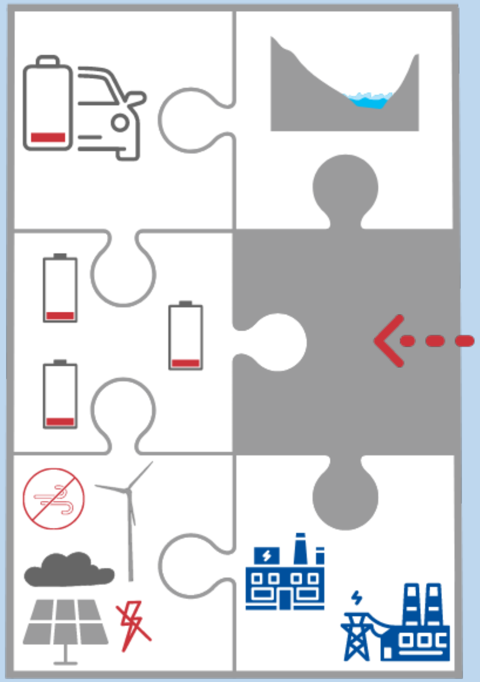
The study shows that the despite sufficient renewable capacities to cover demand over a full year, a residual load of 894 TWh needs to be covered.
For 60% surplus energy of other days can be shifted by batteries or pumped hydro. **1/3 of residual load (8% of total electricity demand) needs to be generated from flexible power plants**

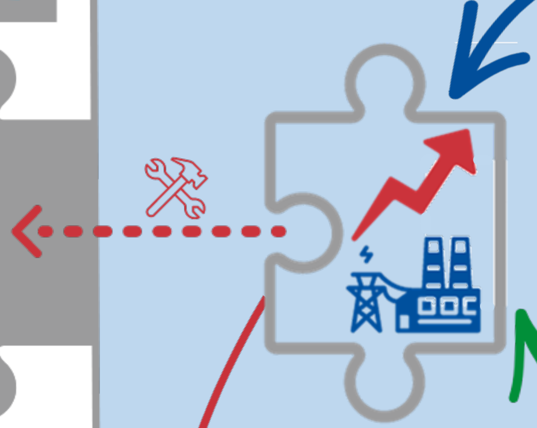
Residual load duration curve for EU-27 in 2050 (Distributed Energy scenario, weather conditions from 2010)



Source: Frontier Economics based on TYNDP data and weather year 2010

- Over the full year, demand exceeds renewable supply during 6,000 hrs
- Total supply gap to require flexibility option: 894 TWh, of which:
  - 559 TWh can be shifted with batteries & pumped hydro to shorter gaps
  - 34 TWh of demand could be reduced temporarily
  - 295 TWh (=8% of total demand) require additional flexible generation





If we need still need flexible power plants to fill these gaps caused by the unavailability of wind and solar generation, how many of them do we need? Will the existing power plant capacities be sufficient?
And how to avoid that they continue contributing to climate change?

How many flexible power plants?

The study assumes that in total a flexible power plant capacity of 350GW must be available to cover also the remaining peak loads.

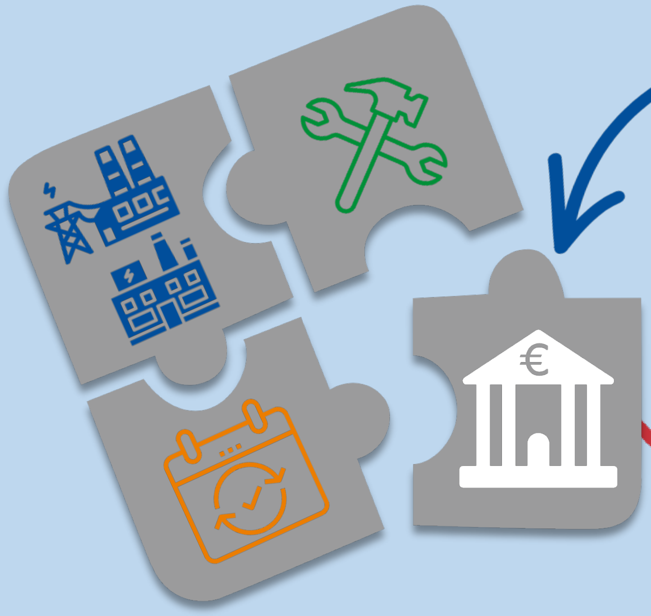
According to the study this means that an additional 200GW of capacity is required.

These plants would on average operate only 850 hrs (copper-plate assumption) to around 1500 hrs per year

Can power plants operate climate-neutral?

Using “green molecules” from gases like biomethane or renewable hydrogen instead of fossil gas in gas power plant technology is possible as the study outlines. New plants will all be H2-ready.

However, to ensure the reliable backup to renewables in a climate-neutral way, requires the necessary infrastructure incl. storage and the availability of green gas for power generation.



If the operating hours are low, what would make this an attractive investment to ensure that the additional 200 GW will be built?

The study states that these plants will not earn enough money from selling the generated electricity during the limited hours. It therefore recommends to remunerate them in addition for providing the needed flexibility and other capabilities needed by the grid to remain stable

Policy Recommendations of the study

1. **Recognising the need for all type of climate-neutral flexibility technologies**
2. **Designing a flexibility needs assessment that is technology neutral and focuses on actual flexibility needs**
3. **Ensuring sufficient and fair income from reliable revenue streams**
4. **Synchronising and accelerating the provision of climate-neutral fuels and infrastructures**
5. **Rebuilding trust through a stable regulatory environment for investors**

The Need for Clean Flexibility in Europe's Electricity System: In Summary

1. Increasing electricity demand and intermittent generation pose challenges for Europe's electricity supply security.
2. "Dunkelflaute" periods, characterised by low wind and PV in-feed, lasting several days can be observed all across Europe.
3. Expansion of interconnection capacity alone is not enough to bridge supply gaps during Dunkelflaute periods.
4. Electricity supply gaps during these periods can exceed 100 TWh in just a few weeks, requiring additional flexibility measures.
5. Short-term flexibility solutions like DSM, batteries, and pumped hydro storage are insufficient to bridge these gaps.
6. Even in less stressful years, significant backup capacities are required to cope with peak residual loads.
7. Overall annual electricity generation from flexible capacity will be limited, primarily serving as backup during Dunkelflaute periods.

Study Links: EUTurbines | European Engine Power Plants Association EUGINE | frontier economics

Questions? Comments? Let us know!

European Engine Power Plants Association EUGINE

EUTurbines

Ralf Wezel
General Secretary
+49 (0)69 6603 1309
ralf.wezel@euturbines.eu
ralf.wezel@eugine.eu

European Engine Power Plants Association EUGINE

Annette Jantzen
Manager Policy & Public Affairs
+32 (0)2 70 68 297
annette.jantzen@eugine.eu

Giovanna Tanda
Junior Policy & Communication Advisor
+32 (0)2 706 82 12
giovanna.tanda@euturbines.eu
giovanna.tanda@eugine.eu

Julia Luna Peter
Team Assistant
+49 (0)69 6603 1936
julia.luna-peter@euturbines.eu
julia.luna-peter@eugine.eu

EUTurbines

Luis Ruspoli
Policy Advisor
+32 (0)2 706 8211
luis.ruspoli@euturbines.eu

Diana Santiago
Communication Advisor
+32 (0) 456 53 94 80
diana.santiago@euturbines.eu