

**Agora**  
Energiewende



# Climate Neutral Power System 2035

*How the German power sector can become climate neutral by 2035*

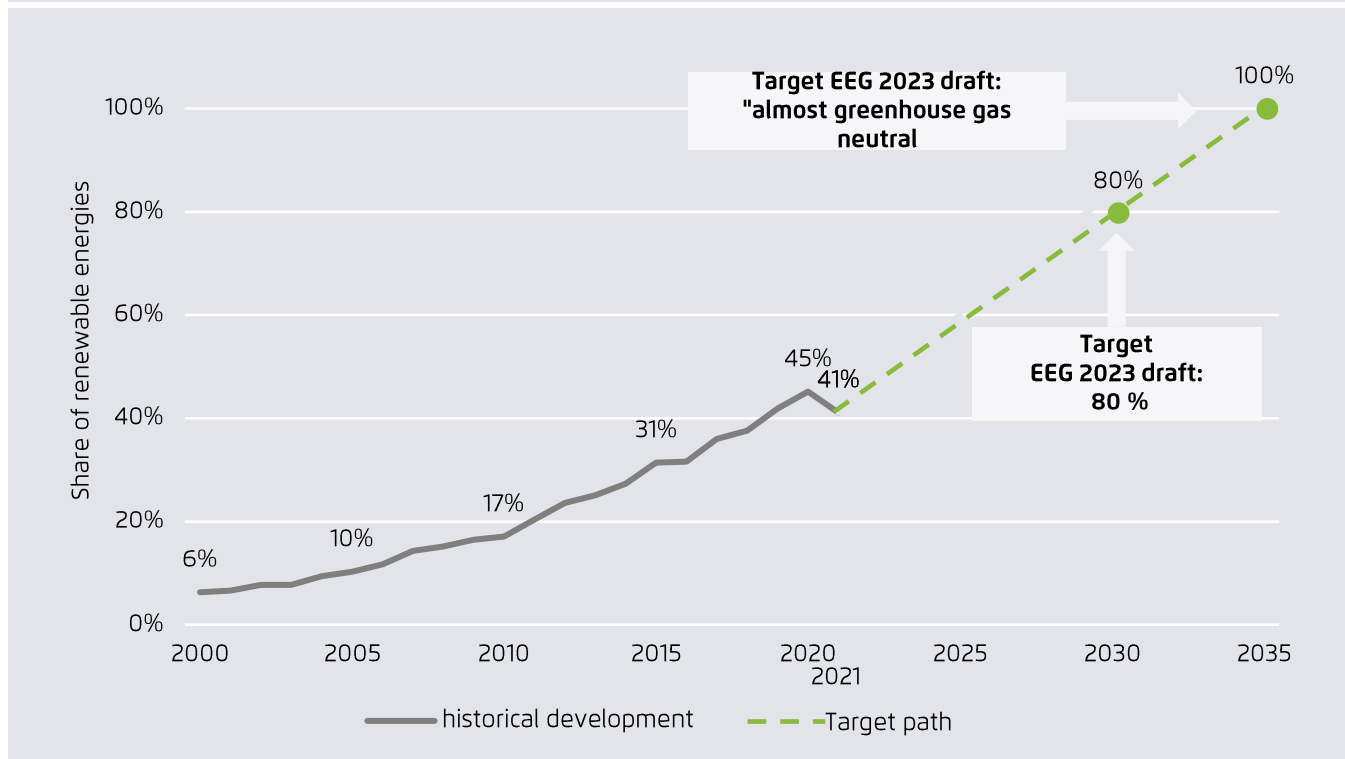
**Simon Müller**

**BERLIN / COPENHAGEN, 16 NOVEMBER 2023**



# Germany has set itself ambitious targets for renewable energies in late 2021 – and is making progress despite the impact of the energy crisis.

Share of renewable energies in gross electricity consumption

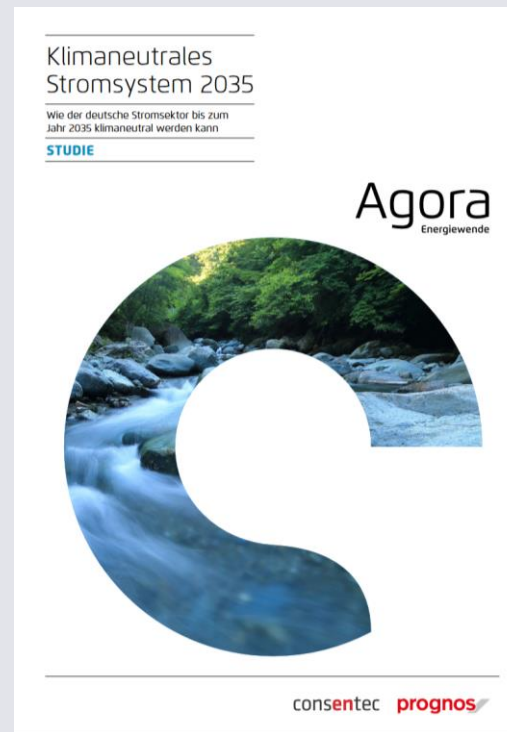
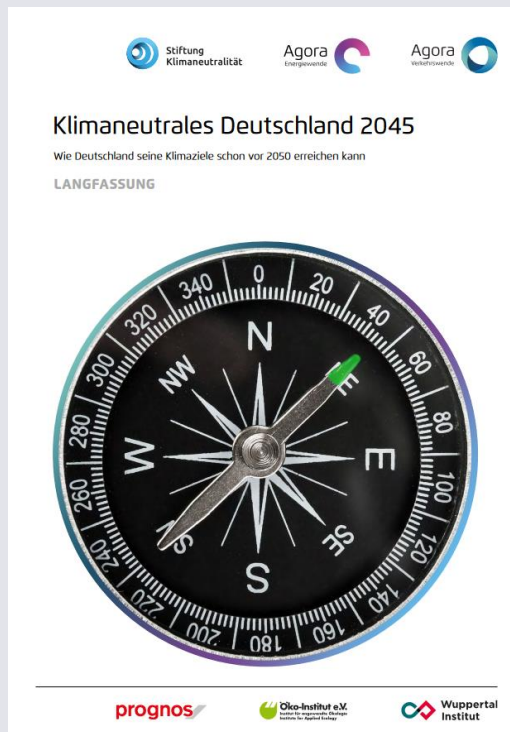


Historical development: AGEE-Stat (2022)

- **Target 2030** according to coalition agreement: **80% electricity generation from renewable energies** with 750 TWh gross electricity consumption
- **Adjustment of tender quantities** taking into account construction and planning times as well as offshore grid connections
- **Multiple measures to accelerate project implementation** and scale renewables deployment. **Solar PV exceeding targets in 2023**, but wind lagging behind.
- **The use of renewable energies is in the overriding public interest** and serves **national security**
- **Additional measures to scale grid infrastructure and flexibility.**

# Agora Energiewende has commissioned Prognos and Consentec to investigate what is needed to achieve the 80 percent target and a climate-neutral electricity system by 2035.

KNS2035 is based on the "Climate Neutral Germany 2045" study



- The study "Climate Neutral Electricity System 2035" (KNS2035) further develops "Climate Neutral Germany 2045" (KNDE2045).
- KNS2035 picks up on the new federal government's targets for renewable electricity generation and consumption.
- The study examines electricity generation, -consumption and transmission networks and derives political recommendations for action.
- Prognos AG has modelled electricity generation and -consumption, based on which Consentec GmbH prepared a supplementary grid analysis.

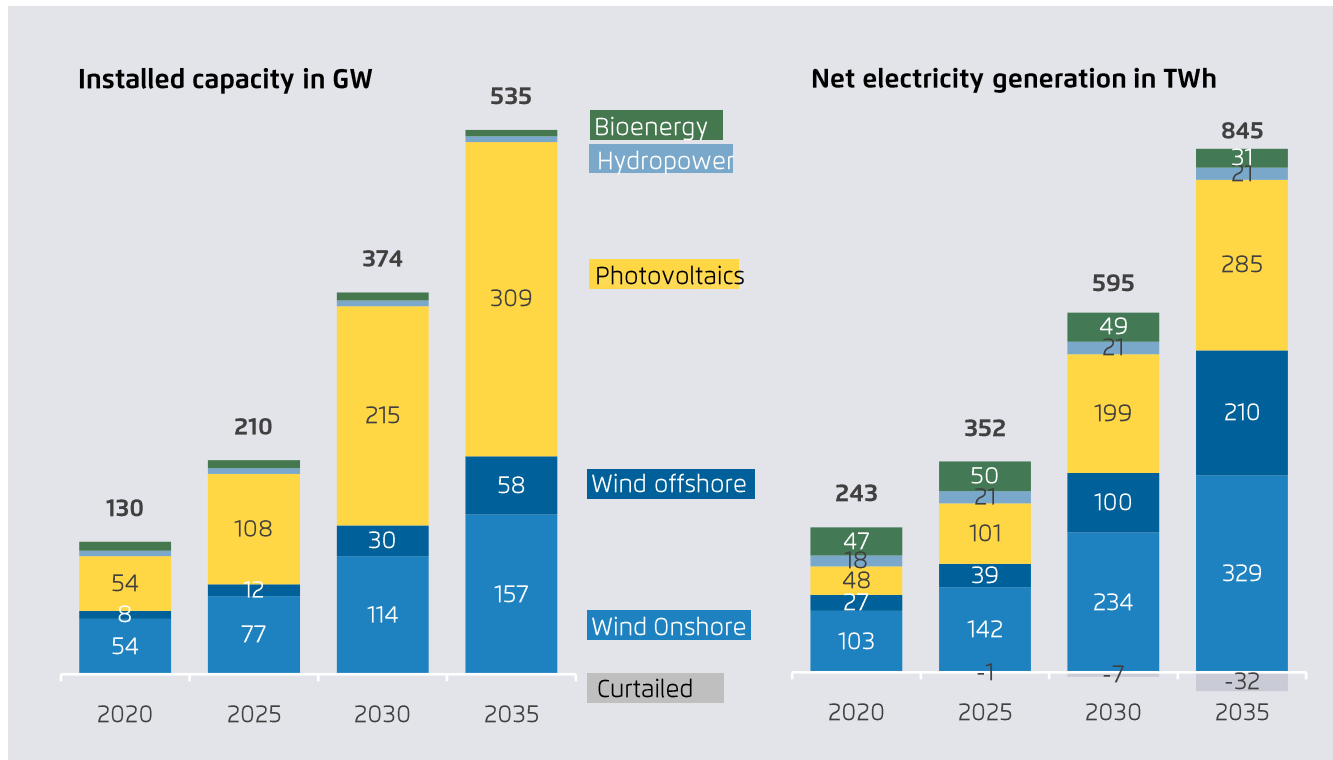
Agora Energiewende (2021), Agora Energiewende (2022)



**Electricity market  
modelling: Climate-  
neutral electricity system  
2035**

# With a massive expansion, wind and solar are the supporting pillars of the climate-neutral electricity system in 2035.

Renewable energies (installed capacity and net electricity generation)

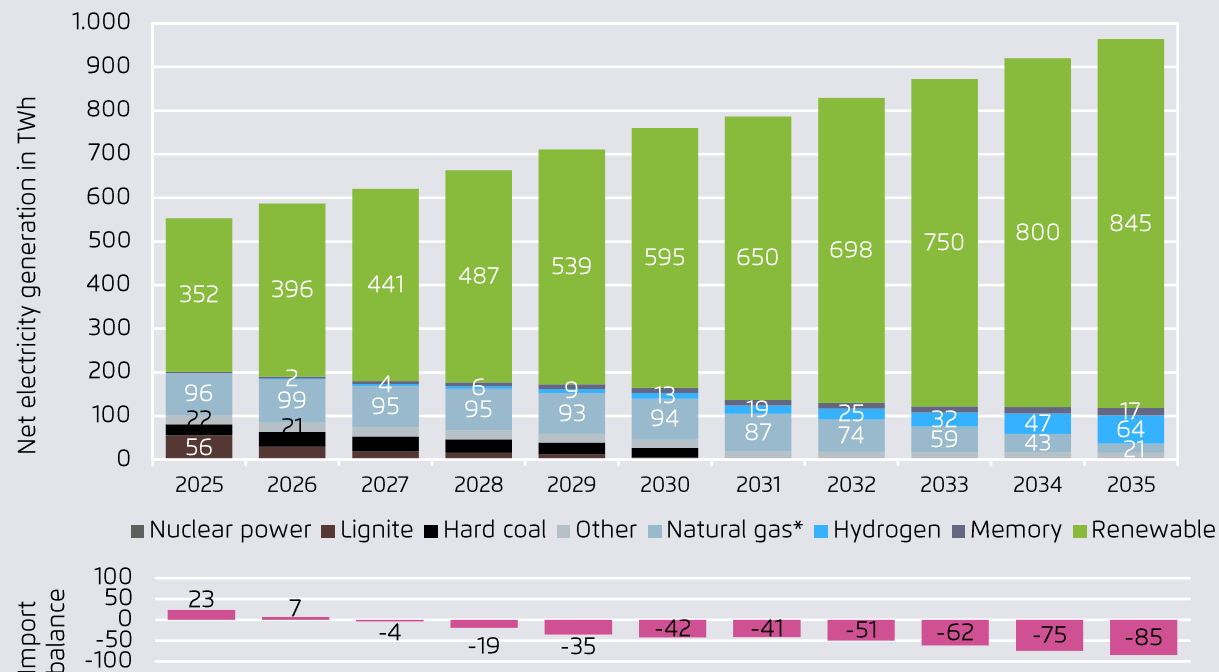


Prognos (2022)

- Onshore wind is the largest contributor to net RES-E generation, accounting for 40 percent. Photovoltaics make a contribution of one third, while offshore accounts for one quarter.
- In 2035, the share of renewables in electricity generation is 89 per cent direct generation from renewables and 7 per cent generation from hydrogen power plants.
- Since Germany is a net exporter, the share of renewables in electricity consumption is arithmetically over 100 percent.

# 80 percent renewable electricity by 2030 and gas-fired power plants increasingly powered by green hydrogen secure the coal phase-out by 2030 and enable a climate-neutral electricity system by 2035.

## Net electricity generation



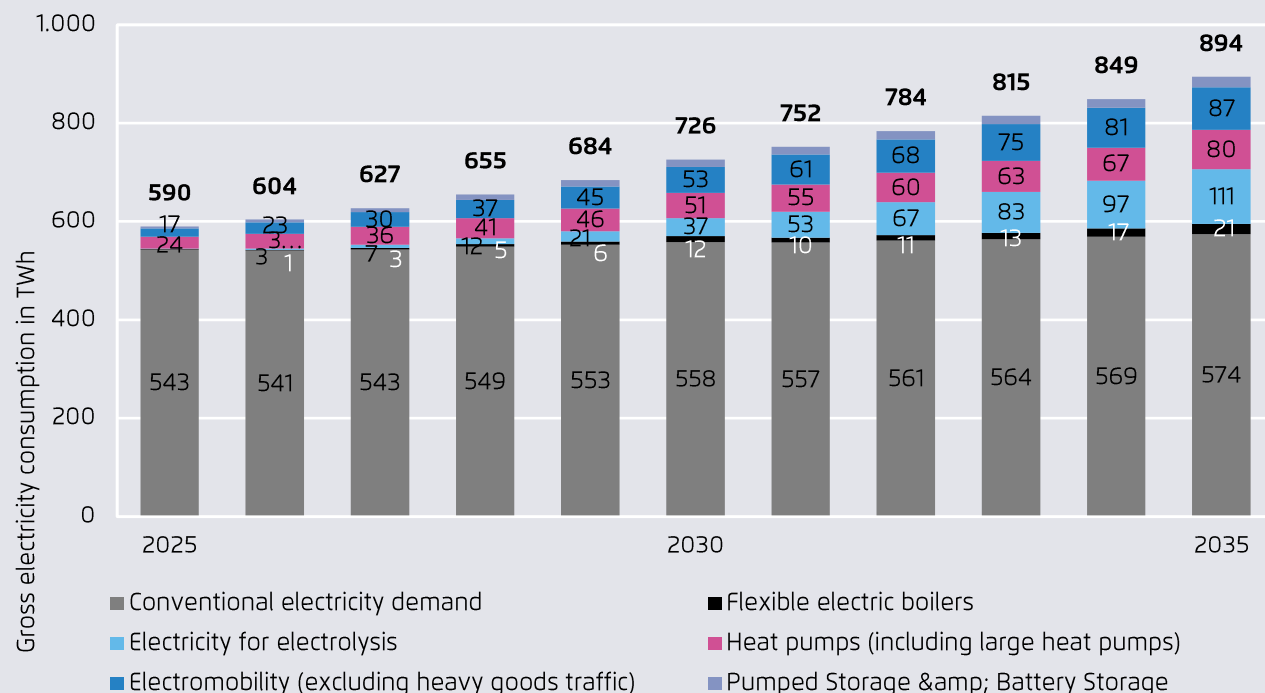
\*Electricity generation from natural gas, which can lead to further GHG savings when replaced by electricity-based energy sources.

Prognos AG (2022)

- The KNS2035 scenario shows a viable path to achieving 80 per cent RE in 2030 and climate-neutral electricity in 2035.
- The coal phase-out in 2030 remains possible through market instruments and RE expansion.
- A rapid switch to hydrogen reduces natural gas consumption and thus emissions. The share of natural gas in electricity generation is only 2 per cent in 2035. In addition, there is 1 per cent electricity generation from the combustion of waste and blast furnace gas.
- Parallel to the RE expansion, dispatchable gas-fired power plants will be used in the 2030s to cover the residual load
- High export surpluses in the long term if Germany proceeds with RE expansion compared to other countries.

# Electrolysers, electric vehicles, heat pumps and electric boilers increase the demand for electricity. Their flexibility potential must be increased in order to use wind and solar power efficiently.

Gross electricity consumption in the KNS2035 scenario

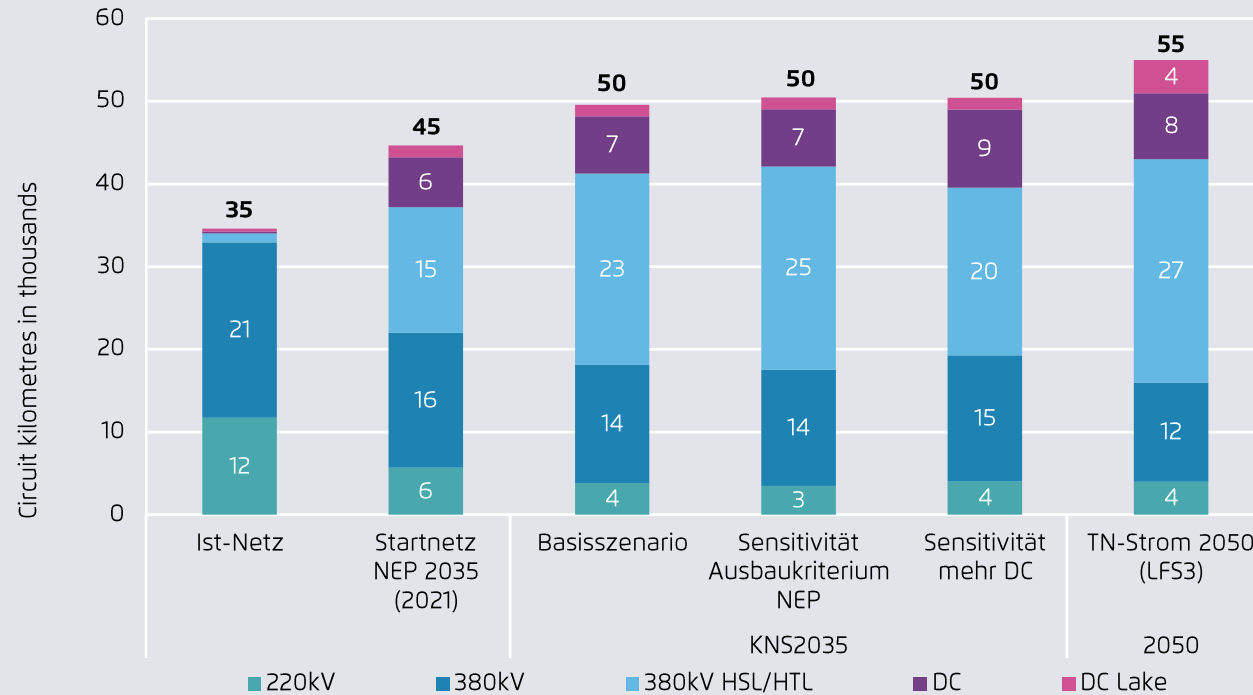


- The level of future electricity demand is a key driver for the necessary RE expansion demand and the electricity system as a whole. It is crucial that electricity is used efficiently and, where possible, flexibly.
- The increasing electrification of heat generation, industry and transport as well as hydrogen production will increase electricity demand to around 726 TWh by 2030.
- Conventional electricity consumption stagnates as efficiency gains and more consumers offset each other.
- New consumers offer considerable flexibility potential. These must be mobilised comprehensively in order to efficiently match supply and demand.

Prognos (2022)

# A climate-neutral electricity grid in 2035 requires a considerably faster grid expansion to 50,000 electricity circuit kilometres.

Grid quantity structures of the German transmission grid



- The total circuit length in the German transmission grid will grow from approx. 35,000 km today to approx. 50,000 km in 2035 - in all sensitivities. For this, grid expansion and reinforcement measures are preferable.
- The expansion of renewable energies and grid expansion must continue beyond 2035 in order to meet the increase in electricity demand through electrification and the rising demand for European electricity exchange.
- Forward-looking and integrated planning of the electricity, gas and heat grids is necessary to guarantee the economic and speedy grid expansion and conversion of the entire German energy infrastructure

Consentec GmbH (2022)



## Recommendations for action (1/2)

- **Develop an integrated system development plan by mid-2024** that includes the overall grid infrastructure required for climate neutrality.
- **Continued acceleration of planning and approval procedures** to enable the timely expansion of renewable electricity generation as well as electricity and hydrogen grids.
- **Maintain the necessary investment conditions for the expansion of renewable energies:** in future introduce a symmetrical market premium; support expansion on the basis of long-term supply contracts (PPAs) and further simplify the rules for self-consumption and local concepts.
- **Ensure the necessary expansion of controllable power plants and their switch to 100% hydrogen:** Clarify the investment framework for controllable power plants; introduce a market ramp-up instrument for hydrogen use, especially in the CHP sector → Power Plant strategy

## Recommendations for action (2/2)

- **Explore options for the introduction of geographic signals in the electricity market to** address structural congestion in the transmission grid.
- Implement **innovative operating concepts and technologies for electricity grid operation** quickly and reliably: Development of a package of measures for *100% RE system operation*; introduction of a monitoring process for *100% RE system operation*.
- **Immediate reform of grid charges in order to increase flexibility potential:** Incentivise consumption in times of high RES-E generation; abolish existing exceptions that hinder flexible use; push at EU level for more energy transition-oriented specifications on grid charges.
- **Intelligent distribution grid operation and faster smart meter rollout to control decentralised flexibilities:** Adapt grid regulation to encourage intelligent distribution grid operation; significantly simplify framework conditions for smart meter rollout; direct supply of important decentralised flexibilities such as e-cars or decentralised storage (split supply).

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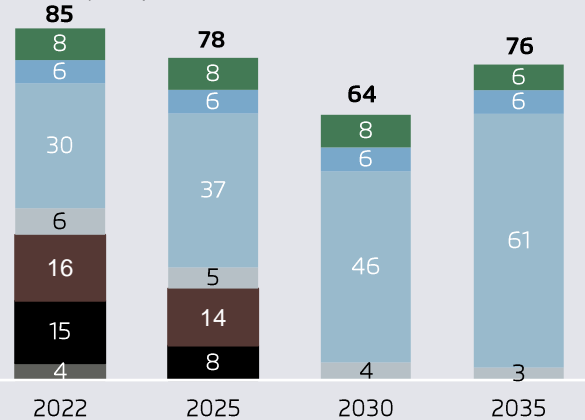
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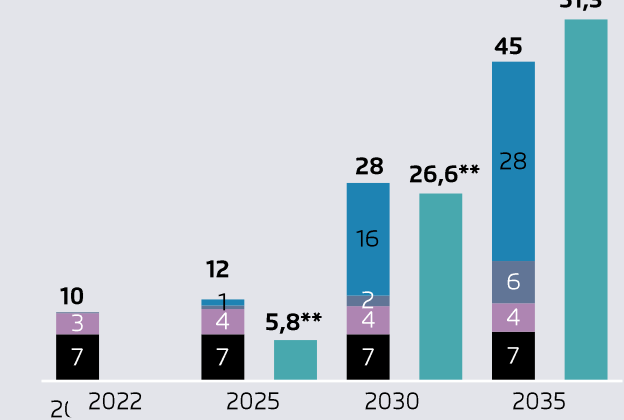
# Adjustable power plants, storage facilities, electricity exchange with European neighbours and flexible consumers ensure the balance between supply and demand.

## Adjustable power

**Adjustable power plant output**  
Net capacity in GW



**Storage and demand-side management**  
Net capacity in GW\*



■ Nuclear power  
■ Lignite  
■ Gases/Hydrogen  
■ Hard coal  
■ Other  
■ Hydropower

■ Home battery storage  
■ Large battery storage  
■ Pumped storage  
■ Vehicle-to-Grid  
■ Demand-side management

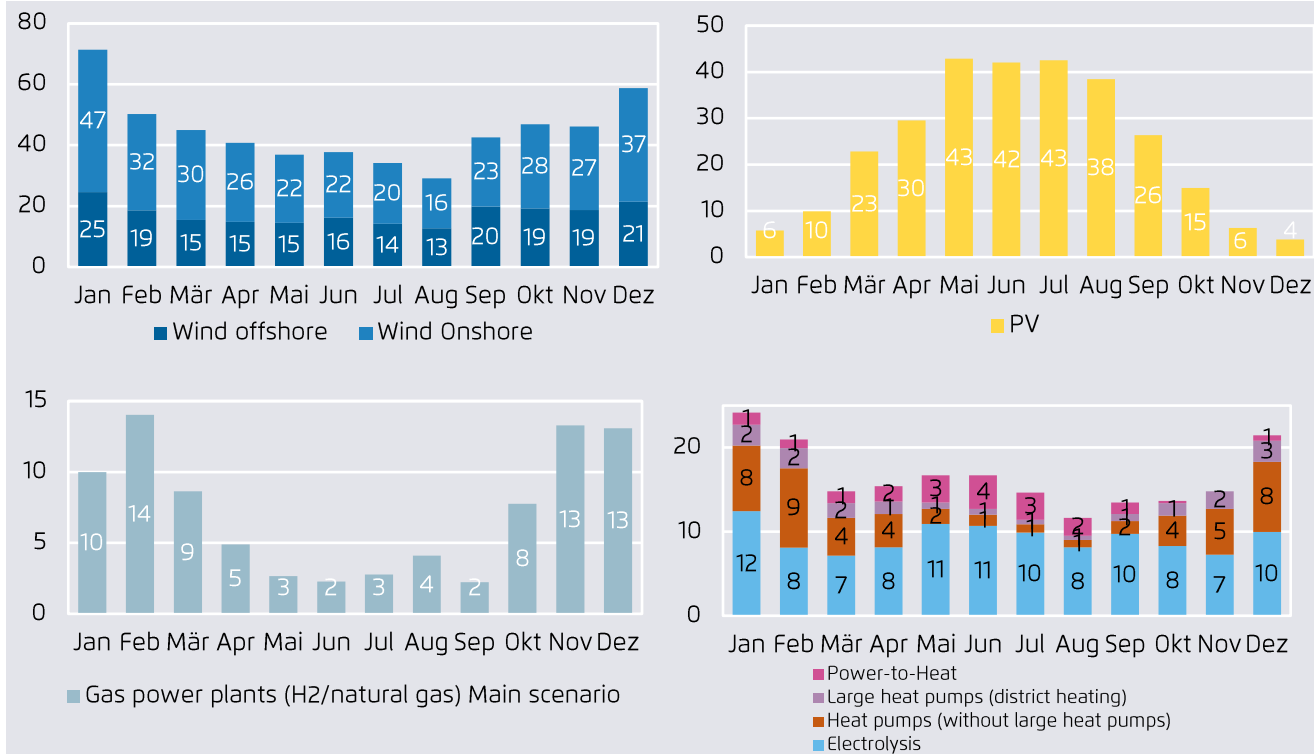
\*Average storage capacity: battery storage 1 hour, pumped storage 8 hours | Demand-side management (DSM) = short-term load shifting potential in industry | Vehicle-to-grid: battery-electric vehicles that can also feed into the electricity grid from their battery. \*\* Home storage systems are partly operated for self-consumption.

- In the climate-neutral electricity system of 2035, the installed capacity of gas-fired power plants doubles from 30 GW (2022) to 61 GW (2035). New power plants must already be 100 per cent H<sub>2</sub>-ready today.
- Flexible consumers contribute to short-term balancing and thus to the efficient use of renewables.
- Demand-side management - electromobility, heat generators and electrolyzers - must be operated in a system-serving and thus flexible manner from the outset in order to strengthen RE system integration (e.g. *vehicle-to-grid*).
- Battery storage and pumped storage power plants also offer considerable flexibility potential.

Prognos AG (2022)

## Gas-fired power plants are needed above all for security of supply in the winter half-year.

Monthly structure of generation and consumption  
(Electricity generation or demand., 2035, in TWh)



Prognos AG (2022)

- Controllable gas-fired power plants generate between 107 TWh (2030) and 86 TWh (2035) of electricity, with a downward trend.
- Hydrogen is increasingly replacing natural gas (share of natural gas in electricity generation 2035: 2 percent).
- Gas-fired power plants are mainly needed for security of supply in the winter half-year. 1/3 (20 GW) generates 75 per cent of the total gas-fired power generation in 2035. The last third is operated for only a few hours per year.
- Electrolysers use surplus RE electricity and work in a mirror image of gas-fired power plants.