Safely navigating dark doldrums

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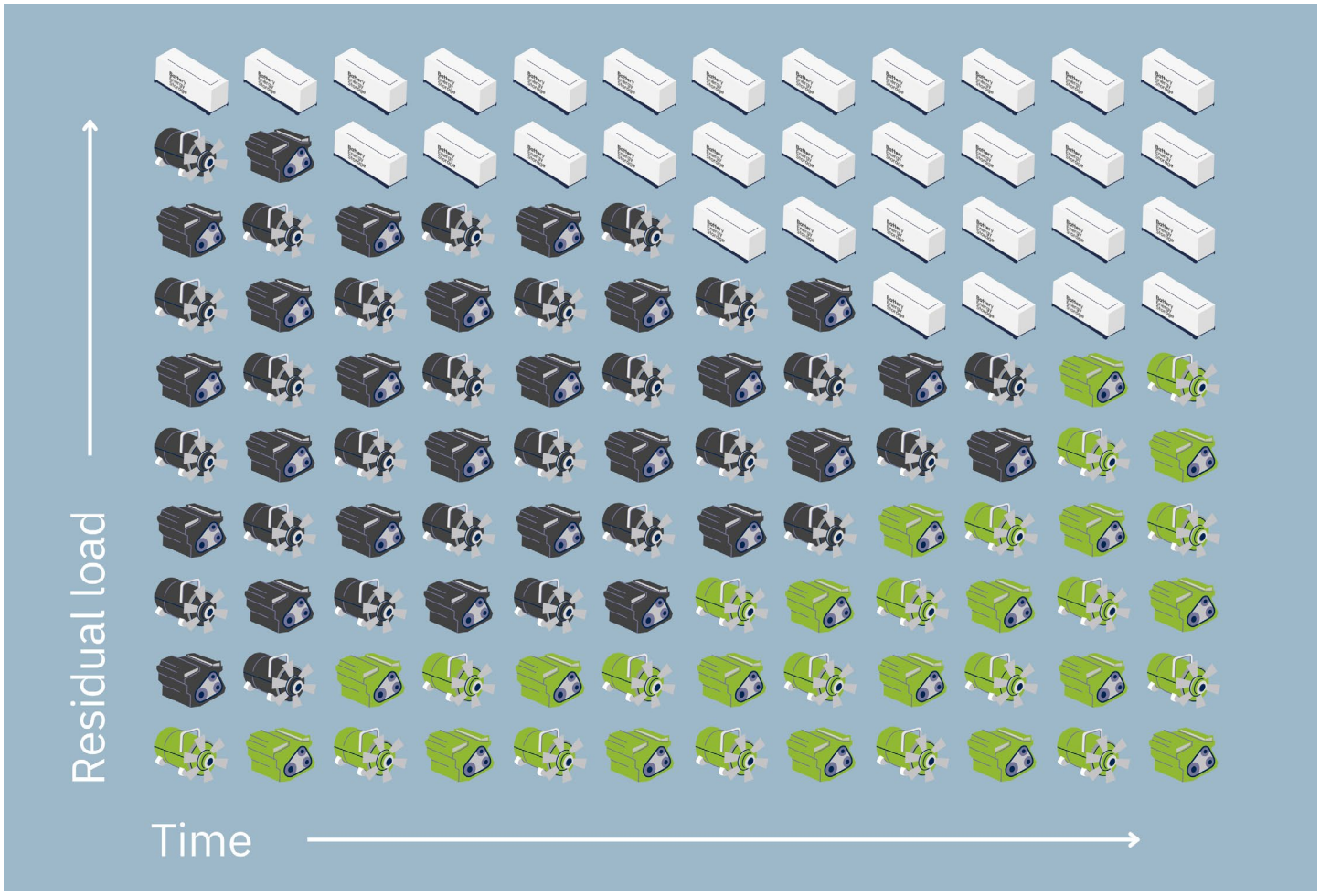
Dark doldrums … so what? We have safely come through these Dunkelflauten in the past, we are still managing to do so in the present time, and we will continue to master the challenge in the future. Even when the wind and sun generate little electricity, the energy industry will continue to maintain a **secure energy supply.** The necessary **technologies are already available today.** Technological advancements will make it easier to solve the problems.

In Germany, we currently still have an energy mix consisting of renewable energy sources and coal and gas power plants. This fact sheet explains **how the supply can be secured tomorrow and beyond** – even after the market exit of coal power plants and the eventual conversion of engine and turbine power plants to run on **climate-neutral gases.**

It is a good idea here to distinguish between **technologies** on the one hand and **energy sources** on the other. Just as **turbines and engines are available as back-ups**[1] today, **storage systems and other flexible options** will take on part of this role in the future. What changes is the amount of energy stored and the **fuels.**

Development of fuels and storage facilities to cover residual load

Over time, more storage systems enter our electricity system. At the same time, the fuels used are becoming ever more sustainable.



Today – the energy supply is secure

When there is little wind in Germany and the sun isn't shining, the necessary **back-up comes largely in the form of fossil sources** such as natural gas and coal. Yet even then, **renewable energy sources** are still very much present in the grid. **Hydropower** and **bioenergy (biomethane, biogas, waste)** already play a key role during a dark doldrum. Where gaps remain, engines or turbines that run on natural gas and coal step in. **Pumped storage hydropower and the first battery energy storage systems** are increasingly helping to bridge **short-term shortages.** The batteries are self-financing through the market, supplementing photovoltaics in summer. These storage systems are available to the electricity system even during a dark doldrum. **Reserves are also available in the form of coal and gas power plants.** Then there is the **European electricity market,** where suppliers are involved in mutual hedging to reduce costs.

Tomorrow – more storage systems and fuel switching

Coal power plants will gradually exit the market over the coming years, although some will remain available as reserve power plants. **Battery energy storage systems capable of storing dozens of gigawatts** will be added in the next few years. Just like **load flexibility** (such as cold storage facilities or heat pumps), the storage systems significantly reduce the **residual load during electricity price peaks.**[2]
Storage systems are charged at times of low residual load, such as at night, and flexibilities are prepared for the next time they are needed. The remaining **residual load generation**[3] will also be covered by engines and turbines in 2030. Alongside the gas power plants that still exist, this will preferably be done using **biomass in the biogas plants and waste as fuels** to cut carbon emissions. Biomethane and, if need be, natural gas can also be used in these engines and turbines, and large **natural gas storage facilities** already exist. The more **biogas plants are able to provide greater flexibility** [4], the **fewer new gas power plants** will be needed.
Energy is also increasingly being shifted from weeks when generation levels are high to weeks when less power is generated, e.g. in **thermal energy storage systems of heating networks or via renewable gas storage facilities (**biomethane).

Beyond – many storage systems, carbon-neutral fuels

Fossil natural gas is only being used for a transitional period and will be increasingly replaced by **other gases** in the 2030s. Continuing **efforts to make biogas more flexible** will play a role here. **Biomethane** will be stored in existing long-term storage facilities for use during dark doldrums.
Hydrogen is also gradually being used – ideally produced from renewable energy sources. The hydrogen is produced mainly during the summer months when the sun is shining. The **dischargers are engines and turbines,** potentially also fuel cells.
Long-term thermal energy storage systems charged during the summer months reduce the need to generate electricity capacity in times of dark doldrums. **Short-term energy storage systems and greater flexibility** help to bear the residual load peaks during dark doldrums.
Long-term energy storage systems may potentially also play a role. Some examples of corresponding technologies are already in development.[5]

Secure energy supply	Today	Tomorrow	Beyond
Renewable energy sources	• Hydropower • Bioenergy, including biomethane and biogas • Wind energy (small but useful) • Waste	• Hydropower • Bioenergy, including biomethane and **partially flexible biogas** • Wind energy (small but useful) • Waste	• Hydropower • Bioenergy, including biomethane and **fully flexible biogas** • Wind energy (small but useful) • Waste
Storage system	• First battery energy storage systems • Pumped storage hydropower	• **Many battery energy storage systems** • Pumped storage hydropower	• **Very many battery energy storage systems** • Pumped storage hydropower • **Long-term storage systems (electricity/gas)** • **Long-term thermal energy storage systems**
Residual load generation technologies	• Engines • Turbines	• Engines • Turbines • First fuel cells	• Engines • Turbines • **Fuel cells**
Fuels for engines and turbines / potentially fuel cells	• Biomass (including biomethane and biogas) • Waste • Natural gas • Coal	• Biomass (including biomethane and biogas) • Waste • Natural gas	• Biomass (including biomethane and biogas) • Waste • **Gas (e.g. green hydrogen, syngas)**
Reserves as insurance	• Coal power plants • Gas power plants	• Hard coal power plants • Gas power plants	• **Gas power plants (GHG-neutral)**

[1]This refers to the back-up available within the market as opposed to the reserves that are outside the market.
[2]Residual load describes the remaining electricity demand after deducting the power fed in from solar and wind energy, which must be covered by other energy sources.
[3]Residual load generation refers to the power that needs to be generated in order to cover the residual load.
[4]The biogas installations can be made more flexible to a relevant extent by adding extra digesters, gas storage facilities and gas engines, making it possible to deliver much more power with the same amount of fuel. With a short lead time, the methane produced by the biogas plants can be increased in phases by adapting the feeding process. The biogas output can thus be ramped up over a longer period of time during dark doldrums.
[5]Carbon capture at the gas power plant would be theoretically conceivable, although very expensive.

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