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RENEWABLE ENERGY INSTITUTE

18 September 2025

Coal Power Is Replaced by Renewables, Batteries, and Modern Electronics

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The phaseout of coal-fired power is progressing in many countries — not only to reduce the risk of unmanageable climate change but also because it now makes economic sense. The falling costs of renewable energy, battery storage, and advanced power electronics have enabled countries to replace coal while maintaining grid stability and reliability. In some cases, the transition has gone even further — with renewables, batteries and electro-fuels beginning to replace fossil fuels in other sectors of the economy.

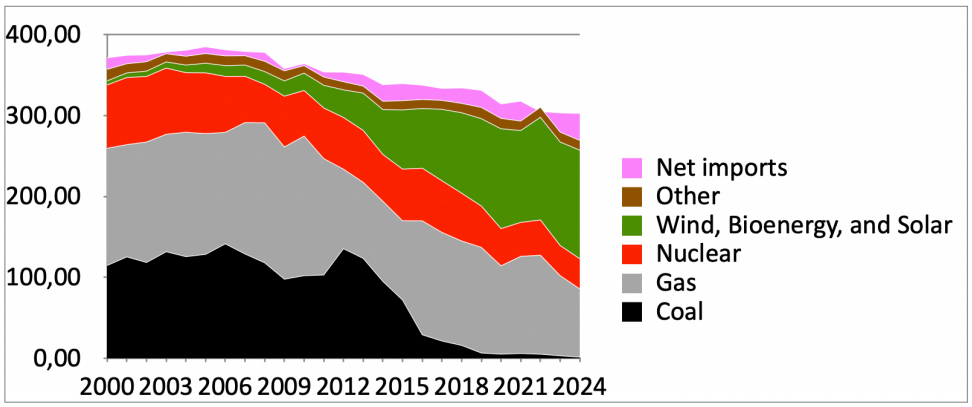
The transition has followed different paths in different countries. Below are some examples that illustrate how coal power is being phased out and replaced.

United Kingdom: From coal and nuclear to renewables and batteries

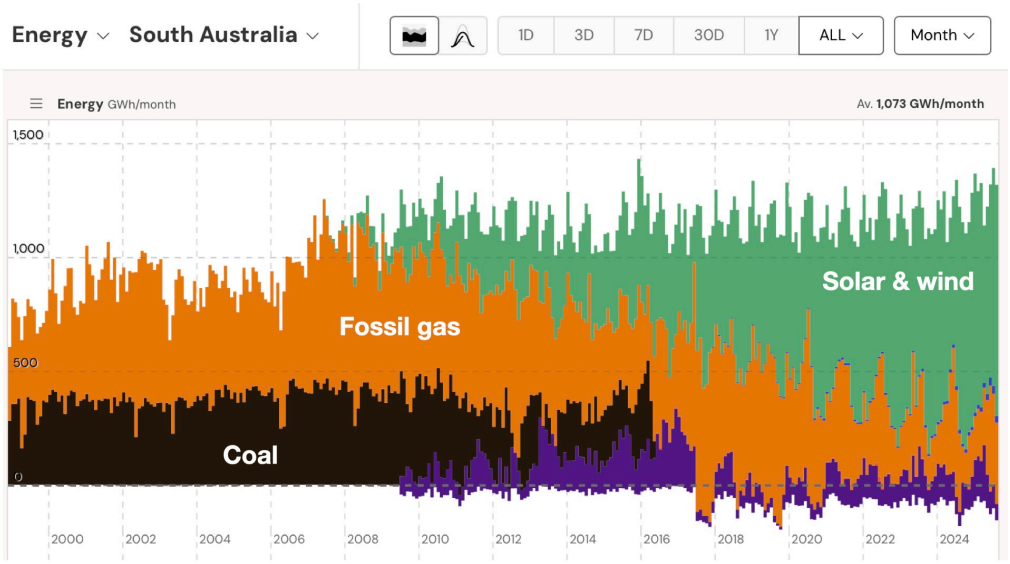
The UK's journey away from coal reached a major milestone in April 2017, when it recorded its first full day without any coal-fired electricity since 1880. In 2019, it saw its first coal-free week, and in May 2020, an entire month. On September 30, 2024, the last coal-fired power station was permanently shut down.

This transition is even more significant considering that, since 2000, the UK has closed 26 of its 35 nuclear reactors. Initially, natural gas filled the gap left by coal. However, starting around 2005, wind, bioenergy and solar began to gain traction, and by 2010 they were outcompeting gas and the remaining nuclear power. Today, the UK has more grid-connected battery storage than any other country in Europe, increasingly providing affordable and effective stabilization services.

International inter-connectors have increased energy trade with neighboring countries. Notably, the UK assisted France during its 2022 nuclear shortfall and was a net exporter to Norway during the fourth quarter the same year — though it is usually a net importer.



South Australia: With 100% solar, wind and batteries in sight



South Australia underwent a similar but earlier and more far-reaching transition. Its last coal plant shut down in 2016 due to uncompetitive costs, as rooftop solar and wind power gained market shares. Renewable electricity grew from under 30% in 2011 to approximately 75% in 2024. The state now aims for 100% renewables by 2027 (See diagram above.)

Even with failures of large thermal plants no longer possible, grid stability measures are still required — to respond to power line failures that can disturb frequency or voltage. Rather than relying on old mechanical inertia, South Australia pioneered the use of batteries and digital systems to provide these critical services.

Without access to hydro power, South Australia maintains stability using a mix of:

- Battery storage for frequency regulation and daily balancing
- Advanced inverters in solar installations
- Static VAR compensators
- Rotating synchronous condensers ("syncons")
- Remaining gas generators used for system support even when not needed for electricity

The new stabilizing techniques made it possible, in September 2025, to operate with just one thermal generator online — all other electricity came from solar and wind. In a recent report, the Australian Energy Market Operator conclude that the isolated South Australia grid is now able to keep stable grid reference without any thermal power plant operating. The last thermal unit is expected to be retired by end of 2027.

United States: Coal decline driven by economics and innovation

The U.S. coal phaseout is one of the largest globally. From 2010 to 2024:

- Coal-based electricity fell by 1.2 petawatt-hours (PWh)
- Fossil gas and other fuels grew by 0.85 PWh
- Renewable electricity increased by 0.6 PWh

California: From Gas to Batteries

California has nearly eliminated coal, and renewables are now the state's largest electricity source. Fossil gas was once the primary backup, but from 2018 onward, battery capacity grew rapidly — from 0.5 GW to 15.8 GW by early 2025, with an additional 8.6 GW planned by 2027. These batteries, charged by solar during the day, now provide electricity during evening and morning demand peaks, replacing

gas.

In 2025 alone, California's gas consumption dropped 25%, and 46% over two years.

Nationwide, over 90% of new electricity capacity additions in 2025 are solar, batteries, and wind — in that order — according to the U.S. Energy Information Administration (EIA).

Unfortunately, recent policy shifts raise barriers. For example, President Trump issued executive orders to halt an 80%-complete offshore wind project (700 MW) and mandated continued operation of some unprofitable fossil fuel plants — moves criticized for increasing costs to consumers.

Other noteworthy transitions

Svalbard

An extreme case: despite heavy reliance on diesel, the Arctic territory is now integrating batteries and advanced electronics to modernize its energy system.

Denmark

Denmark benefits from strong interconnections with neighboring countries, enabling both energy flexibility and trading profits. It's also pioneering "sector coupling" — using low-cost renewables to replace fossil fuels in the production of plastics, fuels, and fertilizers.

Germany

Germany has phased out nuclear power entirely and reduced coal use by 60% since 2010. It was a consistent net exporter of electricity from 2003 to 2022, helping France during its nuclear crisis in 2022. However, since then, it has become a net importer due to the high cost of remaining, marginal fossil fuels. Germany is trading with 11 neighboring countries. Net export in 2022 was 27 TWh, net import in 2024 was 28 TWh. In 2024 imports från fossil fre Nordic countries and France while exporting to fossil intensive countries south and east.

Sweden

Sweden transitioned away from oil in the 1970s using coal and nuclear, which were later replaced by bioenergy — supported by a carbon tax. However, political barriers are currently stalling the development of new, low-cost renewables, which may delay industrial decarbonization.

Four lessons from coal phaseouts

1. Gas was a bridge, not the destination. Initially, natural gas replaced coal. But in the last decade, wind and solar have increasingly replaced both coal and gas — thanks to their low costs.
2. Batteries provide stability and flexibility Batteries and advanced inverters provide stability in a time scale from milli-seconds to days, while allowing solar and wind energy to power the grid even when the sun isn't shining and the wind isn't blowing — displacing gas in critical peak periods.
3. Modern Grids No Longer Depend on Thermal Power Electronic controls, batteries, and advanced grid devices (like inverters and Statcom, VAR compensators) can now handle frequency control, voltage stability, black start, and reactive power — all without relying on large spinning generators.
4. Electro-chemicals and -fuels, will provide for replacement of fossil fuels and long term stability of electricity systems.

Conclusion: Coal is ending — grid stability will improve

Spain recently completed its first coal-free month, August — yet another milestone that shows how renewable electricity, battery storage, and smart electronics are not just environmentally necessary but also economically desirable. As more countries follow this path, the

electricity sector is the solution to climate stability — rather than a threat to it.