How flexible nuclear power can help to balance the grid

The next generation of nuclear plants are designed to work perfectly with the variable output from renewables

By David Landon, CEO, MoltexFLEX

The laudable growth in wind and solar generation in recent years brings with it a new challenge of providing reliable power for homes, businesses and industry. Electricity grids must be precisely balanced to function properly. If they are not, blackouts and damage to vital infrastructure could ensue.

The variability of wind and solar output makes balancing the grid a massive challenge and this task only becomes more difficult as more of our energy demand is transferred to the grid and ever-greater volumes of electricity are produced by intermittent sources. For the most part, countries rely on fossil fuels to address the intermittency of renewables and fill the gaps in supply, but that creates large volumes of the very carbon emissions that renewables are aiming to eliminate.

The development of large-scale battery storage, pumped hydro systems (like the Dinorwig plant in Wales) or compressed air or mechanical systems employing gravity are all either in existence or on the horizon. However, there is another new solution that involves a new generation of nuclear reactors that can complement intermittent renewables.

It would take a huge amount of storage to cover an extended period of little sun and wind that could last for days or even weeks (also known as a 'dunkelflaute' – yes, the Germans have a word for it!). Even the mighty Dinorwig, mentioned above, has a capacity of only around 9 GWh – while the UK uses well over 500 GWh of electricity in a single day.

Add in the fact that few (if any) of these proposed storage solutions have been proven at scale, plus the cost in terms of capital and mineral resources in manufacturing them, and they quickly start to look less than ideal.

While traditional hydropower is a dispatchable solution, whether a country can use it at scale depends very much on geography. So, desirable as it is, it won't be scalable everywhere. This leaves nuclear as the only solution that is truly viable worldwide.

Generally speaking, there are two types of flexibility that nuclear plants can offer: operational flexibility and deployment flexibility. Let's look at both in turn.

Conventional nuclear plants are typically used to provide baseload power rather than covering peaks in demand – it makes more sense economically for them to be run flat out rather than ramp up and down, as this is more efficient. This has led critics to label them as inflexible.

Nevertheless, many are, in fact, able to vary their output to a degree to follow load on the grid. This has been done in France for many years, and modern designs such as the EPR (currently under construction at Hinkley) can do this more readily. But for older designs, it's by no means simple or straightforward.

Moreover, the large capital costs and long build times typical of conventional plants limits flexibility in their deployment.

New designs are being planned with flexible output in mind, however, as well as catering for deployment flexibility. Many proposed small modular reactors (SMRs) are designed to employ production line techniques, enabling their components to be manufactured en masse in a factory and shipped to the construction site, hugely cutting costs and build times. Other designs are aimed at 'plug and play' capability to make use of existing infrastructure – for example, being deployed at existing (or retired) coal power plant sites. Some are even designed to be small enough to fit within standard shipping containers and are road transportable via HGVs, enabling them to be sent to operate in remote and off-grid locations, perhaps to complement local renewable generation.

Even more exciting is the prospect of designs that employ innovative coolants. While many SMR designs use scaled-down versions of existing water-cooled reactor technology, other more advanced versions use molten metals (such as sodium or lead) or molten salt as coolants, as well as for the radioactive fuel elements. This enables these reactors to run at a much higher temperature than water-cooled designs, making it possible to store this heat (once again using tanks of molten salt) and feed it to steam turbines to produce electricity when needed. It is this technology that is used to enhance the flexibility of MoltexFLEX's FLEX reactor.

This ability to store energy at grid level, and at low cost, is a game-changing technology. It represents a reliable method to compensate for gaps in wind and solar generation – and, crucially, one that is scalable in a way that other proposed solutions (such as massed lithium-ion batteries) are not. By combining operational and deployment flexibility, the next generation of nuclear plants will go a long way towards working with renewables in achieving a net zero-carbon economy by 2050.

Importantly, the new generation of nuclear plants will provide solutions for a range of functions beyond producing low-cost and reliable, low-carbon electricity. They can go a long way to cleaning up the more difficult-to-decarbonise sectors – by producing hydrogen economically at scale, supplying heat for heavy industry and district heating schemes, and providing maritime propulsion.

While traditional nuclear plants will continue to play a key role in providing baseload generation, the next generation – especially SMR designs – will be far nimbler both in their operation and their deployment. What's more, their flexibility will help counter the intermittency of renewables and balance the grid, making them vital tools in the fight against climate change.