How do you solve a problem like the grid?

Credit: SMA

The grid | As the proliferation of grid-scale renewables accelerates, capacity on national grids is diminishing just as quickly, leading to harder to find and ever-costlier connection agreements. Liam Stoker assesses some of the alternative options grid operators are exploring to extortionate grid upgrades.

In a year that has witnessed marked advancements in the stated power of solar modules, documented significant decreases in levelised cost of electricity and seen financiers sidestep warnings of the deepest economic recession in living memory, it would be easy to consider there nothing left in solar PV's path to domination of the power market. But ask any seasoned developer to name one issue that continues to be a thorn in the technology's side, and the majority – if not all – will return the same answer: The grid.

In reality, the grid is not a particularly new or emergent obstacle to solar, or indeed the wider renewables sector. Shelved as an 'intermittent' or 'variable' generator, renewables' relationship with the grid hasn't exactly been harmonious since the first great quantities of renewable power were connected. Most electricity grids are decades old, consisting of legacy infrastructure that creaks under modest pressure, and managing an influx of nascent technologies has become an unenviable task of spinning many, many plates, all at once.

More established solar markets are now feeling the pinch years of express renewables connections, with grid connection capacity sparse and, in some regions, almost non-existent. Solar-rich regions such as the UK's south coast and Extremadura in Spain are now near battlegrounds for grid connection agreements, battling it out for whatever scrap of spare capacity they can identify.

As the proliferation of renewables accelerates, the grid has become the chief concern of solar developers.

Queues can be lengthy, backed up by a sea of requests. Earlier this summer, Spain's backlog of renewables projects vying for grid connection agreements was said to have stood at hundreds of gigawatts, a figure one developer described as "mindboggling". And as supply and demand dynamics play out, the result is grid connection agreements skyrocketing in price. Another UK-based developer told this publication that the sums quoted to his company for a grid connection agreement were "astronomical" compared to what they have been historically.

Some markets have indeed been handed legislative support. A national decree on grid access in Spain, passed earlier this year, requires guarantees

to be paid for grid connection agreements and certain project milestones to be met at specific deadlines. If those deadlines are missed without good reason, permits are deemed null and void, and the project cannot connect to the grid. A similar policy was enforced two years ago in the UK, after two of the country's distribution network operators (DNOs) fired warnings at so-called "Grid Grabbers" – described as companies amassing grid connection agreements only to idle projects or attempt to sell them on at profit – outlining measures to prevent distribution grids from descending into a "wild west scenario". Comprehensive evidence of intent to proceed with projects is now required for a permit to be granted.

Visibility also remains problematic, both in terms of spare capacity and what, exactly, is connected to distribution grids. A study conducted by UK DNO Western Power Distribution last year uncovered thousands of connected distributed energy resources – commonly residential solar installs and electric vehicle chargers – that were not acknowledged in its system, seemingly caused by installers failing to file the proper paperwork. Last September the UK's electricity system operator National Grid ESO launched its own study to map out so-called "invisible" solar panels on the country's networks in order to improve its own forecasting.

Grid capacity is, unfortunately, a finite resource and not every solar farm, battery storage facility – or combination thereof – will be able to connect to the grid. And with distribution grid improvements or capacity expansions proving extortionate, coupled with a lack of political will to pass those costs onto the consumer, attention has turned onto better understanding how to eke out every last spare drop of grid capacity, either through more flexible connection agreements, better understanding generation portfolios, or the adoption of more novel technologies.

Knowing your load

One particular lesson that most seasoned developers will share is to work with your network operator, and not around them, and identify precisely what kind of load and generation profile you intend to connect. In markets where grid capacity constraints have been long-standing, there have been many examples of renewables operators being able to find middle grounds that support, rather than hinder, development. Ian Cameron, head of innovation at DNO UK Power Networks, says solar developers can help themselves hugely by steering away from so-called 'Square Requests', described as unrefined bids for "big lumps of capacity" at any one time. Instead, Cameron says developers must better understand what precise capacity is available and where, and tailor applications accordingly. To that end, UKPN has launched a 'DSO Dashboard' tool, which aims to provide that information in near real-time. This kind of "symbiotic relationship", as Cameron describes it, is pivotal to the progress of renewables.

> "Precise projections and forecasts regarding grid feed-in and consumption are therefore becoming increasingly important for reliable, efficient and cost-effective grid operation."

More recently, network operators in the Netherlands struck an agreement with renewables organisations in the country which promise to accelerate the grid connection process. The deal, enshrined within a legal covenant, sees solar operators agree to maximum export limits of 70% of its peak generation capacity – reflecting how a solar asset's performance only exceeds that figure for around 3% of its operational lifespan – in exchange for grid operators identifying more spare capacity on the grid.

In addition, network operators in the country have also agreed to share details around what areas of the grid are more likely to be constrained and where more capacity may be available, helping developers identify more ideal sites for future projects. A roundtable of UK network companies and renewables developers organised by PV Tech Power's sister publication Current± last summer on the subject of facilitating change on the networks also found that this amendment would be warmly received. Members of trade body Holland Solar have also agreed to a further amendment which ensures grid connection agreements are signed for a minimum of 20 years to ensure grid investments deliver better value for money, although with solar project expected lifespans now exceeding 35 years – and product warranties expanding to follow suit – this should not be a particularly surprising leap.

This can also be seen in a recently unveiled programme between inverter supplier SMA and German grid operator TransnetBW, which will see SMA supply generation and feed-in data from solar systems in Transnet's operation area, with the aim of helping better understand how the behaviour of connected solar systems are changing due to the use of battery energy storage systems and other technologies boosting self-consumption rates. Transnet is to use the data to identify region-specific projections and forecasts for solar power, improving the management of bottlenecks on its network.

Speaking of the project, SMA's Jochen Bornemann says that the swift pace of the energy transition has posed serious challenges for grid operators. "Precise projections and forecasts regarding grid feed-in and consumption are therefore becoming increasingly important for reliable, efficient and cost-effective grid operation," he adds. Distributed resources like these could equally play a far more significant role in helping clear the runway for their larger cousins.

A more distributed resource

Research from TransnetBW indicates that increases in self-consumption witnessed on its network shows that around 10% of power that might have otherwise seen itself exported onto distribution grids is no longer arriving there. "At times, the grid feed-in in the control area of TransnetBW alone is around 500MW below the generation power as a result," Dr. Philipp Guthke, an expert in special prognosis and optimisation tasks at TransnetBW, said within a press statement accompanying news of the programme with SMA in early December 2020. Could that loss of grid demand make way for further renewables capacity?

A study joint-commissioned by US trade group Vote Solar and installer

Sunrun would attest to just that conclusion. Published in December 2020, the study used an advanced grid planning tool developed by Vibrant Clean Energy which leverages big data and analytics to put together a complete picture of the clean energy resources necessary to achieve a truly decarbonised grid. The study itself concluded that developing 247GW of local rooftop and community solar, combined with 160GW of local, distributed energy story, would not only save consumers hundred of billions of dollars on their energy bills, but also pave the way to deliver the cheapest transition to a net zero electricity system for the US by 2050, some US$88 billion cheaper than expanding on existing models of deployment.

Deploying those quantities of solar and storage would "unlock the potential" of utility-scale solar and wind, allowing them to connect to grids more cheaply by opening more grid capacity. The study found that in achieving installs of the figures quoted above, nearly 800GW of utility-scale solar and wind each would be more efficiently integrated by 2050. "This study indicates that the current practice of ignoring (or assuming) distributed-scale resources in utility plans will result in higher costs for customers, higher GHG emissions, and lower job prospects for the industry compared with coordinated planning," Christopher Clack, founder and CEO at Vibrant Energy, said at the time of the report's launch.

Forecasts of this kind are invaluable in calculating the potential capacity that lies within existing grids, and how other energy generation technologies at the distributed scale can play a role in facilitating greater quantities to connect. Understanding of the whole energy system is continuing to evolve, but it is undeniable that infrastructure upgrades will play a pivotal role in opening up new grid capacity. But, in the true sense of innovation, network operators are now looking at other areas than simply deploying more, costly cables and substations.

Supercomputers, super grids

In addition to its DSO Dashboard and various other tools – including a 'Timed Connection' offer which flexes accordingly to match generation with demand – UKPN has also launched a trial of new technology at the distribution level. Dubbed 'Constellation' and described as a world-first, the programme will see new computers installed at a series of substations on UKPN's network. "At the moment [the infrastructure] has a bit of copper and metal, maybe some telecoms," Cameron says, with the intent of Constellation to future-proof legacy systems for a more distributed future.

Cameron uses the analogy of the grid being akin to an athlete, facing a race towards decarbonisation that it must win. It has the tools available (distribution infrastructure being an athlete's trainers in this analogy), but it still needs to operate as efficiently as possible in order to compete. The lack of fine tuning has left the grid "with a bit of a potbelly", Cameron says, and is not optimized to compete.

> "We already have smart control rooms and grid edge devices… having smart substations in the middle pulling it all together is a logical next step."

"Constellation is the six-pack of the grid," Cameron adds. It gathers enormous quantities of data, can be set to operate within different parameters and facilitates much more efficient operating conditions. The result is a system that can reconfigure itself according to demand, and release latent capacity by utilising and optimizing energy flows. The trial is to launch soon, but UKPN suspects that should it prove successful, as much as 1.4GW of spare capacity could be freed, ready to be taken up by renewables.

Efforts from network operators to open up more capacity are expected to grow, especially under the weight of legislation pushing hard for net zero targets to become enshrined. But there is, equally, more that developers could be doing themselves to put network operators at ease by taking some of the load off the grid, or at least at more opportunistic times, using technologies already at their disposal.

Storage to the rescue, again?

Smart grid technologies, like those seen in Constellation and a handful of projects, form just one of the missing pieces of a much larger energy system puzzle says Ann Davies, chief operating officer at developer Lightsource BP.

Davies' experience at oil and gas major BP, where she started her career and is seconded into Lightsource from, leads her to conclude that improving the relationship with the grid is a "natural progression" for solar, referencing her time working on gas pipeline projects spanning thousands of kilometres and crossing several countries. "None of these [grid] challenges are impossible," she says. "If you have the right alignment with policy and you have the right investment going in the right place, we will solve it."

Other technologies, more specifically those on the generation side of the meter, will play their role. Energy storage has of course long been regarded a crucial enabler to a more solar-heavy grid, and asset operators are quickly deepening their understanding as to how the technology can remove some of the grid burden from operators, helping solar more appropriately managed its load profile to offer more certainty over export profiles. While the need for a bidirectional connection complicates the process somewhat, it is by no means an insurmountable hurdle.

Davies also points to another potential energy storage technology in hydrogen – a market which has taken enormous strides in 2020 – as yet another potential enabler for a smoother grid connection process in the future. Negotiating a grid connection agreement at a certain export limit, with any excess used to generate hydrogen crucial to decarbonising other sectors of the economy, is emerging not only as a clear remedy for grid congestion, but opening up solar to deeper decarbonisation potential.

Problems with grid connections, their cost, availability and often complicated nature, are unlikely to disappear overnight. And situations could, indeed, get worse before they get better as connection queues extend. But it is evident that grid operators and developers have all the tools required to hurdle any constraints or issues that arise and, through more considerable dialogue between both parties, the worst grid constraints could become a thing of the past. ■