Solar PV – the ultimate in reliable baseload generation?

Electricity generation from large fossil and nuclear power stations is necessarily intermittent, due to occasional plant outages, whereas the output from solar generators is variable but readily predictable, argues *Blaise Kelly*, suggesting that PV is the better baseload provider.

When baseload generation is mentioned, people automatically think of large centralised power plants churning out the steady power the grid has depended on since its inception. As action on climate change has intensified, the perceived ultimate in steady power generator, nuclear, has once again had the limelight shone on it as the essential technology to maintaining this *status quo*.

In 2010 it was announced that eight new nuclear reactors would be built in the UK; the first and most high profile of these is to be Hinkley Point C, a 3.2 GW addition to the system, currently under construction.

Two years prior to this, legislation on the small-scale renewables feed-in tariff was passed. When the feed-in tariff went live in April 2010, the UK had less than 30 MW of solar photovoltaic (PV) connected to the national grid. Ten years later, in September 2019 this had risen to 13,284 MW, a staggering increase and all the more impressive given that the industry had almost started from scratch.

The only government support for this huge increase in generation capacity was the feed-in tariff, the success of which vastly exceeded expectations. **Figure 1** shows how the average daily generation has changed since 2010.

Because PV only generates at certain times of the day, considerably more generating capacity needs to be installed per unit of energy generated. For nuclear, between 5.4 and 8 TWh per GW has been typical over the past 15 years or so, with PV producing a stable 0.8 TWh/GW.

To match the predicted annual output from the 3.2 GW Hinkley Point C reactor, annual output from PV would require between 17.2 and 25.6 GW of solar generating capacity.

The highest number of new PV systems went live in March 2015, with a total of 2.3 GW of new capacity registered on the network. On average in 2015, 0.35 GW of capacity was installed each month. Had the peak build out rate continued, more than 25 GW of installed capacity would have been realised by March 2019.

Cloudy days in winter?

But how can PV meet our needs on cloudy days and during the winter? The Bristol Energy Coop (BEC) has 12 community rooftop installations with a total capacity of 194 kW.

All BEC installations have detailed logging. Matching this with measured weather data from Bristol and Filton airports, both of which record hourly cloud cover from 0 to 8 (where 0 is clear sky and 8 is heavy cloud). Even on a heavily clouded day in winter, around one-third of the average peak generation of a typical clear sky day is possible. Whilst irradiation might not be as high, PV modules are more efficient at cooler temperatures.

Averaging year-round generation for a typical 24 hour period for a given level of cloud cover would see the profile in **Figure 2**.

Neutralising demand

The total number of PV installations since 2010 amount to over one million separate systems. The smaller rooftop systems serve to neutralise demand, as opposed to pushing huge amounts of power down large pylons long distances.

Hinkley Point C, like all large power stations, will require dedicated infrastructure to transmit the huge loads to the grid. To connect Hinkley to the national grid has been estimated to cost £637mn. To connect the equivalent PV generation distributed around the grid would require little to no upgrades.

One expert estimate suggests

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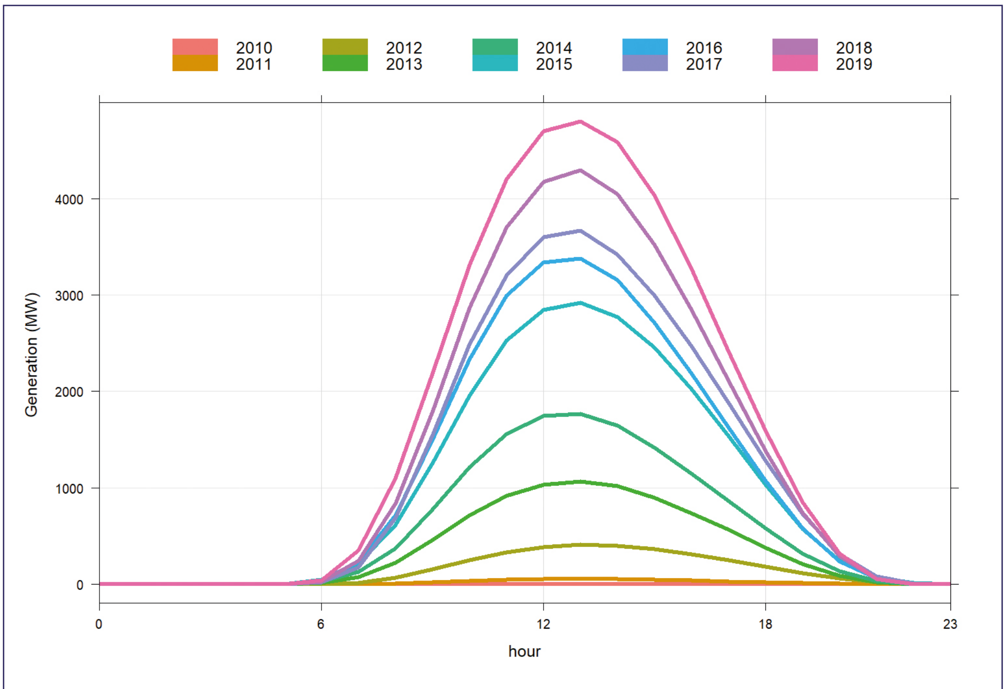

Figure 1. Average hourly generation from solar PV in the UK between 2010 and 2018

that if all 600mn m^2 of roof surface in the UK had PV installed, the total generating capacity would be nearly 90 GW. Whilst this seems a tall order, improvements in panel efficiency, and the types of surface that can generate, plus ground mounted systems (which have made up 44% of total installed capacity, since 2010) may make this figure more achievable.

National Grid publishes half hourly demand data, including solar and small-scale wind estimates. Factoring the build out rate for PV from the feed-in tariff by seven times would have yielded a total capacity of 90 GW in 2018. Applied to demand data from those years, the average daily demand curve would look like **Figure 3**.

This would have produced a total of 72 TWh in 2018, 23% more than nuclear power's 58 TWh. The peak generation of approximately 64.8 GW would have required a storage requirement of 41 GW at 1pm on 30 June 2018. In reality, whilst there is no doubt more storage is required, the market would adapt to make use of this surplus, which conveniently coincides with human diurnal activity profiles.

The fuel for solar power gets delivered for free, every day, without the need to secure overseas reserves or for staff to commute. It empowers homeowners and businesses to take control of how they consume energy. In terms of reliable baseload generation, there is no better technology than decentralised PV.

Blaise Kelly is a Senior Air Quality engineer at Hydrock and has worked on smart city and energy projects for nearly ten years, since completing his MSc at the Centre for Alternative Technology.

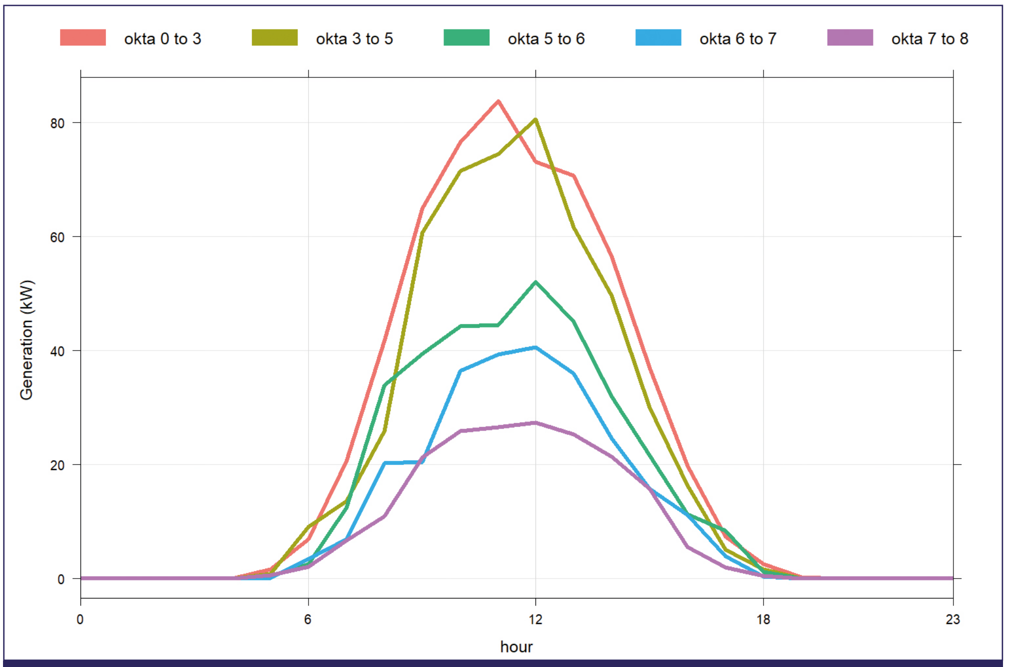

Figure 2. Generation for different levels of cloud cover (kW) for the BEC installations

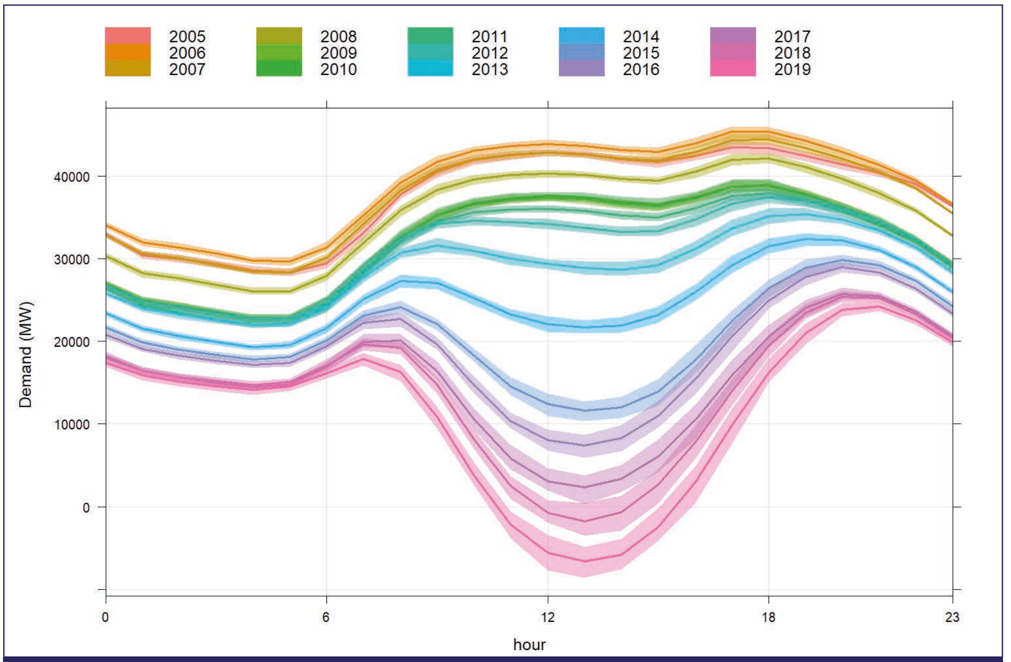

Figure 3. Adjusted National Grid demand curve for a build out rate seven times higher than actual

Intermittent or variable?

No energy technology can supply power all of the time. Renewables are often described as intermittent. The definition of intermittent, according to the Cambridge Dictionary, is: 'not happening regularly or continuously, stopping and starting repeatedly or with long periods in between.'

PV is the most reliable energy technology on the grid, with no moving parts, minimal maintenance and distributed across the network. If the sun rises, PV will supply electricity. The generation of PV can be predicted with good accuracy days ahead, if a few more clouds appear on the day, generation will vary, but it will never suddenly stop.

The IEA describes PV as 'variable', defined in the Cambridge Dictionary as: 'Likely to change or showing change or difference as a characteristic.'

In fact, it is large centralised power stations that meet the definition of intermittent, as they never generate continuously, a single fault potentially wiping out generation for long periods of time. Sizewell B is the largest single generator on the network, at 1.2 GW. In order to mitigate against sudden shutdown, it requires 1 GW of standby generation.

Our electricity consumption is notoriously intermittent. Consumers currently think little about how and when they use electricity and there is little incentive to do so. The uptake of smart energy systems will enable people to easily shift their consumption to the times of day or day of the week when electricity is cheapest or at the lowest carbon-emitting level.

In the same way we use clean drinking water for flushing toilets and washing cars, there are many electrical applications, such as space and hot water heating and cooling systems, and battery charging, that don't need the high quality electricity the current grid provides.