Fine tuning the hybrid proposition

Technology | Realising the theoretical promise of solar-wind-storage hybrids is far from straightforward, with individual projects likely to vary considerably. Ben Willis examines some of the technical complexities of combining different technologies into a single, profitable entity

Large-scale solar-wind-storage projects present numerous technical challenges

Credit: Siemens Gamesa Renewable Energy

One site, one interconnection, multiple megawatts of clean energy from solar and wind systems, smoothed out and rendered grid-friendly with the addition of a co-located energy storage system. Such is the promise of hybrid renewable energy systems, which, as outlined on the previous pages, are seemingly poised to become an exciting new frontier in the decarbonisation of the global energy system.

The current interest in hybrids is perhaps unsurprising. Wind and solar have traditionally been thought of as having limitations related to their inherent intermittence. But side by side, those negatives are largely cancelled out, and coupled with storage offer the promise of reliable, dispatchable power traditionally thought of as the preserve of fossil fuel generation.

"Wind is typically strongest at night, solar production during the day, so if you put the two of them together you have a higher capacity factor," says Navigant senior analyst Alex Eller. "And if you add in storage, theoretically you could have round-the-clock output."

More surprising, perhaps, than the apparent interest in hybrids is the question of why it's taken this long for them to come to mainstream attention. Individually solar and wind have an enviable track record of rising deployment and falling costs, and the notion of putting them together to overcome their respective weaknesses is not a particularly new one. Storage is certainly a newer kid on the block, but as we hear elsewhere in this edition of PV Tech Power, in certain markets such as the US and Canada, the large-scale solar-plus-storage nut appears well on the way to being truly cracked (see p.87).

The reality, of course, is that what looks on paper like a seductively simple idea masks a number of interconnected complexities relating to cost, technology and market drivers that together make the

hybridisation of the three technologies (and possibly others too) far from a simple prospect.

Cost and complexity

According to Eller, cost has been a significant barrier to date. "If you're working within a set budget to develop a project maybe it doesn't make sense to do both [wind and solar] in one place because your overall price tag is going to be higher even though maybe the costs per megawatt of solar and wind are going to be lower," he says. "That has maybe prohibited some of this in the past."

Linked to that is the capacity of developers to take on the altogether more complex prospect of projects combining several technologies on a single site. "Until pretty recently you had your wind developers and your solar developers, who were separate for the most part," Eller says. "So if they had a site where they wanted to build a windfarm, a wind developer would say we're just going to do that, we're going to be experts in wind, and maybe though there are some advantages of having solar as well, the complexity of it all, and having maybe to bring in a separate [solar] company that's going to own some of the project, that was something that would slow things down a lot."

But there are signs of things changing. As Eller points out, some of the larger developers in the US and elsewhere now have the necessary in-house expertise across different technologies to handle the greater complexities of hybrid projects. This in turn helps reduce the costs associated with bringing in partner companies with different expertise to work on different aspects of a hybrid project.

Another benefit of the growing professional capacity of the industry to handle the multi-faceted nature of hybrid projects is that it should ultimately lead to a virtuous circle of better project outcomes and thus greater confidence among key stakeholders such as utilities to embrace the new paradigm.

Eller makes the comparison with solar-plus-storage, which has reached a "tipping point" in markets such as Australia and the US, where it now outcompetes fossil fuel generation on price. This is partly a consequence of years of steady work within in the industry to improve and standardise the technology and familiarise utilities with what it can offer.

"Having the utilities be more comfortable with [solar-plus-storage] has been a big factor," he says. "A few years ago, it was really only certain utilities that wanted to pay a little bit more for solar-plus-storage and have some of that control [it offers]. And then once it became more standardised, there was more understanding of how it operated and what the advantages and costs were... then the utilities got on board and were like, ok, yes, that's better than getting all these things separately, so we'll pay a little more for all of this together than we would for say just solar or just wind."

A similar process will influence the acceptance or otherwise of hybrids by utilities and grid operators, Eller says: "It's [a case of] can the developers standardise this a little bit more – the complexities of hybrids in terms of the hardware, the interconnection and the design – so that it's cheaper to do that than it is to build a wind project here and a solar project there."

Technology

To be sure, work to develop the necessary technical backbone for hybrid systems is well underway, with some heavyweight technology companies already well embedded in this emerging space. Notable examples include GE, which has launched a dedicated 'renewable hybrids' unit, and Siemens Gamesa Renewable Energy, which has a dedicated test hybrid facility in Spain where it has been trialling solar, wind and various battery technologies in combination.

GE's technology formed a central element of one of the first solar-wind hybrid systems in the US, the 2MW Lake Region community hybrid built by Juhl Energy in Minnesota in 2018 (see box). Meanwhile, the new unit is working on new hybrids technologies, leveraging expertise drawn from several of the company's business areas, such as battery storage and solar power electronics.

According to Mike Bowman, the unit's chief technology officer, the primary technical challenge with hybrids is balancing a system's different generation and storage assets to give the grid what it wants, when it wants it.

"If you have a single-asset install like a wind farm, there are fairly sophisticated controls that make that wind farm operate," Bowman explains. "If you bring in solar to the same site, now you've got two generating assets behind a single interconnect, and so now you need to manage the generation of those to make sure you're delivering the power in the most efficient way. And then when you bring in a storage asset, you now have the ability for electrons to go in multiple directions: you can ship them out to the grid, you can push some of them into the battery...

"And then the grid is looking at a variety of services. It is looking for forward-looking delivery of power, maybe looking for frequency control; there's a variety of markets that you can play in. So how do you take all that information and control those operating assets in an optimal way that obviously maximises the capability of them, as well as participates in the markets of interest of the customer? It is quite a complicated system."

Essential to achieving this juggling act is a sufficiently sophisticated control system that can function as the digital brains of the hybrid, and this is where GE's hybrids team is focusing a lot of its R&D currently and most likely an ongoing basis, Bowman says. "Like any good software package, it is a continual development process," he says.

The development of a hybrid control system has also been a key focus for Siemens Gamesa's activity in the hybrid space thus far. Since 2015 the company has been trialling various hybrid technologies at its La Plana test site in Zaragoza, Spain (pictured below). Currently the site incorporates 850kW of wind, 245kW of PV, three diesel gensets and both lithium-ion and redox-flow batteries.

According to Antonio Segarra, the company's corporate development and strategy new business director, the controller is integral to any hybrid's ability

Credit: Siemens Gamesa Renewable Energy

Siemens Gamesa's La Plana test site in Spain is trialling various hybrid technologies

to operate profitably.

"What the controller is doing is basically integrating the forecast demand and the generation [to] manage and optimise the system," he says. "If I know in the next couple of hours I am going to have an excess of energy, I need to have a battery empty to be able to allocate this energy on the battery to later on put on the system. Also, it needs to understand the behaviour of the grid and when the grid requires more energy or some kind of service. So, the control is the brain that puts it all together in order to warranty that there is a return on the investment in the installation."

No two hybrids the same

An added challenge for hybrids is the likelihood that as more systems are built, very rarely are two going to be the same. Market by market, even site by site, exactly what a hybrid will look like will vary considerably depending on the drivers of individual markets. In India, for example, grid constraints are a big factor, and hybrids offer a good route to achieving high capacity factors on precious interconnections; in Australia, grid stability is the main driver; while in the UK and other penetrated markets, hybrids are most likely to be required to provide fast-response ancillary services.

This patchwork of possible use cases makes the nascent hybrids sector potentially fearsomely complex. "What works in one country sometimes doesn't work for another," Segarra says. "It depends a lot on the behaviour of the grid and the service being paid for. So what we cannot say is that all the hybrid models will apply everywhere."

This has implications at many levels. On the one hand, it means hybrid control systems must be sufficiently flexible to adapt to the drivers of particular markets. On the other, it means careful modelling to ensure hybrids systems are sized correctly and the right mix of technologies is deployed to maximise returns.

"What you end up doing is sizing the asset around those markets you want to play in," says Bowman. "We've got sophisticated models that will allow us to say, based on this level of generation, this level of interconnect, the market you want to play in, what is the optimal size of storage, whatever your optimal function is... we can run that model, whether you're doing an install in New York or California or the UK or Israel or wherever it might be. It's going to vary in the size of the asset you put in and then the type of battery you put in."

Future developments

Looking ahead, one of the aspects of hybrids that is likely to see most development is the type of batteries they incorporate. Battery technology generally is evolving rapidly, and although lithium-ion today is clearly the go-to technology, that is unlikely to remain the case forever.

Alongside a lithium-ion battery, Siemens Gamesa is also testing a 120kW/400kWh vanadium redox-flow battery systems at its La Plana site. Segarra says that although such flow batteries are not presently commercially mainstream, and would be unsuitable for providing the sort of short-term peaking capacity to which lithium-ion batteries are well suited, as demand for systems able to provide time-shifting capabilities grows, flow batteries are likely to come of age.

Eller concurs: "With these kinds of projects, there are two things the storage is going to need to do: it needs to smooth the output to make sure you have that consistent output and consist frequency. And then you want to store any excess energy or just a portion of the generation and shift that around so you try to get 24-7 output. And in those cases, something like a flow battery is well suited. I would not expect to see something like that any time soon, just because with some of the advances in lithium-ion batteries they're really cutting out everybody else. But definitely down the road I'm sure there will be opportunities for the longer duration things where you could do multiple days of output."

As for the trajectory of hybrids more generally, while there is agreement that deployment will be uneven across different markets depending on their individual circumstances, the reality is that the global community's aspirations to decarbonise the energy system means it is more case of 'when' than 'if' hybrids take off at scale.

"In countries like Spain, or Germany or Denmark, where renewable penetration in 2030 or 2040 is going to be higher than 70%, there's no other option than hybrids," says Juan Diego Díaz, onshore marketing director at Siemens Gamesa. "It seems impossible to reach these penetration level without any other technology than hybrid systems, including storage and obviously taking advantage of the best technology in each of the regions. Hyrbids are a quicker way to meet national climate change targets, because they're not going to be something that will be imposed top down; they're something that developers are going to do by themselves, because of the better investment returns. So it's clear." ■

Testing the tech

In 2018, Minnesota-based wind energy developer Juhl Energy and GE teamed up on what was billed as the first truly hybrid project in the US, a wind and solar installation combining a 2MW turbine and 500kW of solar on a single site.

The thinking behind the Lake Region project (pictured below) was to capitalise on the complementary generation curves of the two technologies – wind production being at its lowest during the summer months when solar is at its highest.

According to Clay Norrbom, managing director of Juhl Clean Energy Assets, the key enabler of the project was a newly developed piece of hardware from GE specifically designed to blend the electrical current from the combined wind and solar generators. The so-called WISE (Wind Integrated Solar Energy) technology removes the need for a dedicated solar inverter by routing the DC current from the PV element through the wind converter.

"From a hardware perspective, the biggest point there is the shared converter," says Norrbom. "The DC input from both the wind generator and the solar are both converted into AC in a common converter. The solar doesn't need a separate inverter."

Eliminating the need for an inverter clearly means capex savings in the project. The converter also has 'smart' capabilities that control the hybrid system's interaction with the grid, ensuring that should the generation from the wind and solar peak at the same time, their combined output never exceeds the project's 2MW grid reservation.

"We have a 2MW wind turbine plus 500kW of solar, but GE is able to represent to the utility that this is only 2MW, because the smart controller will limit it so that it never puts out more than 2MW," explains Norrbom. "When you model it, you know there is only a handful of hours in the year that it would or could ever do that. But the smart controller will guarantee to the grid that you're not going to over-produce in those few hours that the two things happen to be together. So you can give maximum certainty to the grid."

As yet, Lake Region does not incorporate storage, but Norrbom says the project is designed so that batteries can be retrofitted as and when they reach the right price point.

"That is the Holy Grail," he says. "And that is certainly where this technology is going and where it will need to go in order to really be interesting."

Credit: Juhl Energy