Second life: The case for performance optimisation, repowering and lifetime extension

O&M | As the world's global installed solar capacity ages, technology costs drop and sophistication grows, the benefits of a health check and potential plant upgrades also increase. As part of our repowering review, Mariano Melero, principal consultant, RINA Consulting discusses the benefits of looking after aging assets

Credit: Wikimedia/NREL

Make no mistake, utility-scale solar PV is still a young industry. Despite great strides in recent years towards the objectives of global deployment and becoming a truly investment-grade asset class, by comparison to other technologies – even wind and other renewables – its operational track record is limited.

While the lifetime of a typical solar project is expected to be at least 25 years, only a small proportion of the global installed asset base has exceeded 10 years of operations, of which the majority is concentrated in the more established markets of Germany, the USA and Spain. Indeed, even the oldest megawatt-scale PV project still in operation, in Toledo, Spain, has not yet reached the 25-year milestone, having been running since 1996.

The result is that there are still a lot of unknowns when it comes to assessing the true longevity of solar PV technology, and its reliability beyond the 10-year mark. Forecasts of when and where operational issues may arise are based on assumptions from other industries, accelerated aging testing, or extrapolations of just 5-10 years of data from PV projects, and must also take into account the additional variable of changing technology, which adds further uncertainty to the process.

Given this state of affairs – where assets are still new, mostly performing well, and with an expected lifetime that has not been fully ascertained – it may seem counterintuitive for asset owners to start thinking about options for repowering and lifetime extension.

In fact, the concept of 'repowering', as it has been applied in the wind energy sector, doesn't yet offer the same commercial opportunities for solar asset owners and investors. In wind, the drive towards maximising output has led to a three-fold increase in turbine capacity over the last 15 years. This means that, in theory at least, swapping out older turbines for new models can be a smart investment, providing a significant boost to the production and revenues of a wind farm, without increasing the footprint of the site. In the case of PV, while swapping modules might be more straightforward in practice than installing new turbines, efficiency hasn't improved significantly, especially with regards to space requirements, meaning that this model of repowering isn't a clear, economically viable, option at present.

However, there are other factors that may drive the adoption of lifetime extension and performance optimisation strategies as solar PV projects enter the long-term operational phases.

As the sector as a whole matures, the growing market for secondary acquisitions is creating a heightened focus on plant performance during the early years of operation. For secondary investors and their technical advisors looking at operational assets, seeing a detailed operational history, including historic performance, is critical – alongside factors such as operator performance, and contractual and legal risk. This is incentivising project owners to make sure that their assets are performing in line with expectations from day one.

Improved monitoring is one of the quickest ways of detecting and remedying poorly performing PV assets

Beyond these early phases, there is still room for improvement in the way performance is managed in the long-term. It's fairly evident that cost reduction is still the main driver for the PV market, above quality or reliability. Extending the lifetime of assets is an obvious way of increasing revenues, however the PV industry still needs to increase its efforts to ensure long-term reliability before this is generally feasible.

As a result of the drive to reduce costs, the standard of equipment monitoring and O&M in the PV sector is below market standards in other industries for similar equipment. Achieving a better balance between the upfront cost of measures to enhance reliability and performance and their long-term impact on revenues will be a crucial consideration as assets do start to age.

Older PV plants are likely to face a number of common technology issues, ranging from module degradation to spare parts availability for key components such as modules, inverters and trackers. The ever-present threat of manufacturer insolvency and its impact on replacement supplies means that thorough maintenance is increasingly important.

Additionally, as solar PV installations begin to proliferate in new territories, changing environmental conditions may place extra strain on components and affect degradation rates. Conditions in the Middle East and Asia, for example, may be vastly different from North America and Europe, raising questions as to how PV systems might respond in the long term to extremes of temperature and weather.

What's more, we may start to see manufacturing or installation errors that weren't immediately apparent during the development phases become exacerbated with time, leading to equipment failures, malfunctions or anomalies in performance.

So, faced with these potential problems, what options are currently available to project operators to optimise performance and extend the lifetime of their assets? And what is the economic case for undertaking them?

Top four tips for repowering

Mariano Melero, principal consultant, RINA Consulting

As a technical advisor to PV owners, operators and investors, my main pieces of advice for those looking at optimisation and lifetime extension would be:

- Where possible, explore the use of co-located energy storage systems (ESS) with your existing PV assets. This will help maximise production and unlock additional revenue streams from ancillary services to the grid.
- Improve your control of energy exports at the point of connection. Use an appropriate power plant controller that is able to adapt to new power requirements from the grid operator.
- Identify and monitor the specific energy losses taking place at your site. Targeting your efforts towards addressing specific problems – for example soiling losses – is likely to be more beneficial and cost-effective in the long-term than only monitoring overall performance.
- Finally, maintain the highest standard of O&M and monitoring that is economically viable at your site. Preventing production shortfalls by identifying and mitigating performance issues as soon as they arise will keep your asset running and your stakeholders happy.

Inverter swap outs

Replacing inverters or inverter components would typically be undertaken during the 25-year lifetime of a PV system. Inverter lifetimes are estimated to be between 10-15 years, and so this is always a consideration for long-term asset owners.

As a rule, inverter efficiencies cannot be improved significantly and performance improvements will be limited to specific projects that may have atypical string configurations or suffer from shading issues. However, due to the potential size of this market, it's expected that brand new equivalent inverters will become available for the purpose of regular replacements at projects where inverters have reached the end of their lifetimes, or experienced faults.

Potential-induced degradation mitigation

Potential-induced degradation (PID), typically caused by ions migrating from the glass surface of the module to the active material, shunting the p-n junction of the cell (PID-shunting degradation mechanism), has been known to reduce output by more than 40% over a short timeframe.

PID is reversible to a certain degree, and curing methods are increasingly being developed and used to restore the performance of modules. These include referencing the negative pole to ground (for p-type cells), which completely removes the negative potential stress on the module, reversing the string polarity periodically, or applying a positive system voltage bias on modules at night to accelerate recovery.

However, some of these PID curing methods have been shown to impact the rate of module degradation in the long term, and can invalidate module performance warranties, so the economic benefit must be carefully evaluated on a site-by-site basis before a decision is made.

There are several other methods of mitigating PID degradation – ranging from changes to the electrical configuration of the plant, to replacement of affected modules, or recovering part of the original capacity in a laboratory with heat and time – each with different levels of power recovery. Grounding of one of the DC poles is a common solution – but the future impact on module degradation associated with other methods is still under investigation.

Module degradation testing

Accelerated degradation testing, carried out by an IEC 17025-accredited laboratory, or equivalent, is an effective means of assessing how the performance of modules is changing over time.

Putting a testing programme in place, including aging tests, during the operation of the plant enables the operator to call in the performance warranty as soon as an anomalous degradation trend is detected. This can be a particular advantage in the secondary market.

Optimisers

Power optimisers are DC/DC converters, which can replace the standard junction box in each PV module. Optimisers track the maximum power point of each module individually to increase the overall power output. They can also monitor and transmit performance data to a central system.

While the upfront costs of installing optimisers across a plant must be considered, doing so can provide greater control over maintenance, enabling preventative action, and boost performance in the long-term. The use of optimisers allows full modularity when it comes to replacement of modules, with clear potential benefits for lifetime extension.

Advanced monitoring

Improving monitoring quality, with advanced systems such as the above, is the most effective means of helping asset operators and maintenance providers to identify and address issues or anomalous performance trends as soon as possible. Advanced monitoring may also assist independent performance evaluation as part of refinancing operations.

Common monitoring solutions include the use of web interfaces and standard protocols, monitoring of IED (Intelligence Electronic Devices, including meters, protections, etc.), improved data buffering capabilities in case of communication failures and other control features.

However, achieving a balance between the level of monitoring and its cost is always complex. A monitoring solution that works for one plant may not be economically viable in the long term at another.

Overall, the common theme is that there is no single solution for performance optimisation and lifetime extension. While each of the above options can deliver long-term benefits if deployed correctly, the economic case for each option must be evaluated via a detailed, project-specific analysis.

Authors

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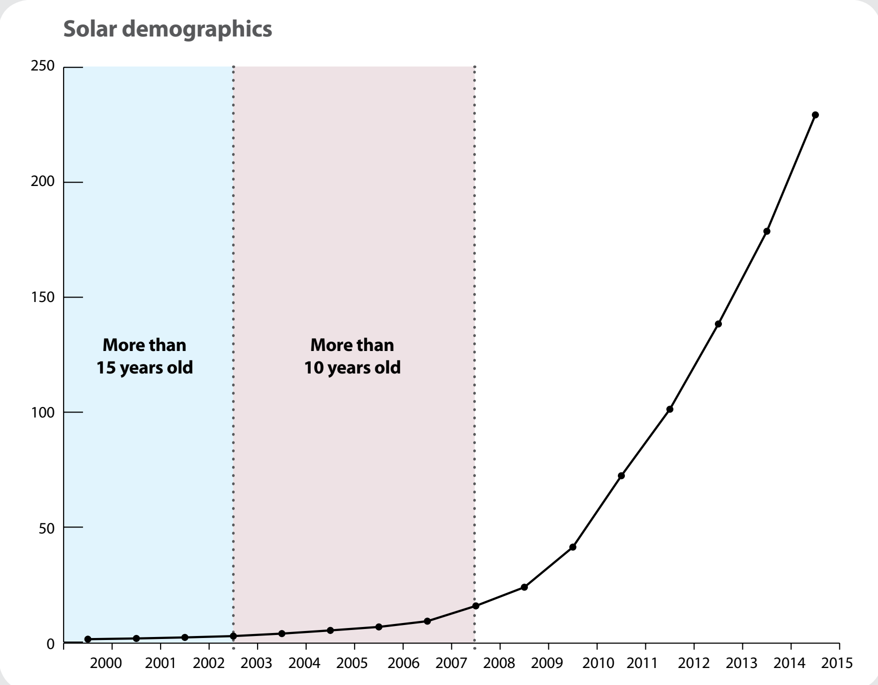
Repowering lessons

The market for repowering can only grow as projects age. Already, many lessons from older plants and even the experiences of rooftop installers can help prepare the industry for what is ahead. John Parnell looks at how investors, developers and manufacturers alike can play their role in mitigating the risk of problems and dealing with those already out in the field

Respect your elders

While annual installs of grid-connected solar PV have run into the double-figure gigawatts every year since 2009, the most fruitful opportunities for repowering may lie with older assets. These are currently in short supply and our knowledge and experience with older plants is somewhat limited. Less than 10GW of solar is currently more than 10 years old. By the end of the decade the figure will be more than 40GW.



Credit: SolarPower Europe/Global Market Outlook 2016-2020

Inverters out

When recently visiting the control centre of a major PV monitoring base with almost 1GW of European solar assets under control, there was a clear winner of the 'greatest source of headaches' award. One screen in the dizzying array of visuals was flagging issues in real time and almost every fault worth its own entry was from an inverter.

Replacing inverters is not exclusively about occasional and isolated faults. Many are reaching their natural end of life, some are no longer covered by warranty as manufacturers have folded. In other cases a firm may have left the solar industry leaving owners with token support.

Credit: Siemens

Siemens is one of many companies to exit the solar inverter business.

Inverter manufacturer SolarMax has found success with repowering systems, initially in the residential market but the expectation is for large-scale plants to gain a similar focus.

"SolarMax has been able to successfully implement several repowering projects. Since many systems are currently getting old, it is necessary to exchange many outdated inverters piece by piece," says Pierre Kraus, managing director, SolarMax Sales and Service.

"Many plant operators want to make their systems fit for the future in view of the many technological advances of recent years and thus secure their earnings. Therefore, this market ▸▸

Inverters out cont…

►► is interesting for us because it offers an exciting potential to find customers," adds Kraus.

In July 2016, Fronius announced it was establishing a base in Greece.

"Until 2012, Greece was a major photovoltaics market," said Hannes Wendeler, area sales manager at the time of the announcement. "Some of these PV systems are now coming out of warranty, and many of the inverter manufacturers from those days are no longer in business or do not offer any technical support services. This is a huge opportunity for the repowering service from Fronius."

Another critical new development that could stimulate inverter swap-outs is the rise in demand for energy storage. A modern inverter and energy management system offers access to new revenue streams that could more than tip the economic scales in favour of what might seem like a daunting hardware investment and logistical nightmare. With tenders in the UK and US for utility-scale storage projects already complete and more in the pipeline, storage offers a stable source of revenue to utilise any spare grid capacity at an existing site. But those vintage inverters could very well hold you back.

Lessons from the rooftops

Ryan McShea, managing director of UK installer Empower Energy.

Rooftop solar is a little ahead of the curve when it comes to retrofits and repowering. While much of the engineering and technology won't translate, some of it does.

Ryan McShea is the managing director of UK installer Empower Energy. The company has already carried out a number of refits for residential customers as well as on larger rooftop portfolios.

Its own analysis has found variations in the performance of modules in the same system of as much as 5% inside one year of operation.

"That's purely from module mismatch," he explains. "We all age differently, it's the same for modules, and as time goes on that difference could expand further."

Empower insists that a vital tool in its repowering arsenal is microinverters and optimisers.

"A few years ago we had a client with 0.5MW across eight roofs. They were having problems with warranties from their inverter manufacturer. We installed SolarEdge inverters and optimisers. Since then they have done another 1MW and now SolarEdge is all they will fit. We practise what we preach and we have two 250kW of our own and they both use SolarEdge too."

McShea insists the benefits of this approach carry across to larger plants.

"It's scalable. A lot of utility-scale plants have fairly primitive monitoring. If I owned a 20MW solar farm I'd want to know what it was doing right down to the nuts and bolts," adds McShea.

He suggests that large-scale projects could have further challenges ahead as the investor is often less likely to be attached to the plant throughout its full lifespan.

"Unfortunately, a lot of people have invested in a race to the bottom. A lot of the value has been lost and quite frankly, the important thing is that with utility-scale, investors will flip projects every three years so as far as they are concerned its someone else's problem anyway. They'll have the same asset value whether or not they have initially installed panels that will create problems further down the line.

"I always sell quality but because I have panel-level monitoring, in the event that there is a problem, it will highlight that to me straight away. We have 350 sites and I can see all of them," says McShea.

"If your O&M supplier can only see at the inverter level then all the investor has is the data on the meter for the whole site. It leaves the scope for so many problems to slip under the net. But it will be the second or third investors down the line that end up footing the bill for it."

Diffusing the PID timebomb

PID is in some ways the great unknown. Its development has been modelled but there is now real world evidence that in some markets, its onset is faster than expected.

Belgian developer Edison Energy spun out a PID-focused solution provider Pidbull. Its managing director Davy Verheyden explains what they have learned from their experiences so far.

"With PID there is the timing effect, it takes a few years before you see the first impacts and there are also the environmental conditions, the humidity and temperature. A lot of solar was installed in western European countries in 2008-2010 so they are now six or seven years old. But we are getting a lot of inquiries about projects in places like the Philippines and India where there is both high humidity and temperature. So there you see the effects very clearly. In our opinion it is also the reason that, for example in Greece, there is more PID."

The trend for higher voltage architecture is also creating headaches according to Verheyden.

"As voltages increase, we are now seeing 1,500V used more often, which is a disaster for PID! Instead of taking three to four years to present it takes two years," he claims.

The second reason why PID could yet present headaches for existing assets is the lack of sufficient monitoring on many older projects, both in terms of the scrutiny of data and the availability of that data in the first place.

"In the beginning of PID you get losses on the worst-affected panels of around 20% but in total across the power plant only 2-3%. That is very difficult to detect. Not least because you can have more than 2-3% variation in radiation each year and a lot of financial institutions just look at the final numbers. But what we are seeing in countries like Greece and Italy is a lack of monitoring, some plants don't even have decent monitoring to do the detection in the first place. We are sure there is a lot of PID in the market, it's just undetected.

Verheyden estimates that only 20% of Greek plants have sufficient monitoring compared with around 60% of those in France and Pidbull's native Belgium. He says addressing PID on older plants offer a direct and indirect benefit.

Credit: JA Solar

JA Solar modules undergoing a 500 hour PID test.

"There are two aspects: first of all of course, the higher yield leads directly to a positive cashflow effect. Secondly, risk mitigation – if you wait too long it can be too late for some panels."

Ensuring a site with 'PID-free' modules delivers just that requires a deal of due diligence that Verheyden says must occur at the point of origin.

"If you want to be 100% confident in a PID-free panel, you should do a PID stress-test first, and ask the manufacturer of the exact bill of materials used for all delivered panels. Ideally, check on site during the manufacturing process that the exact materials are used [in production] as for the panel in the PID-free test." ■