BayWa r.e.

Revamping and Repowering solar parks

Shedding light on futureproof PV

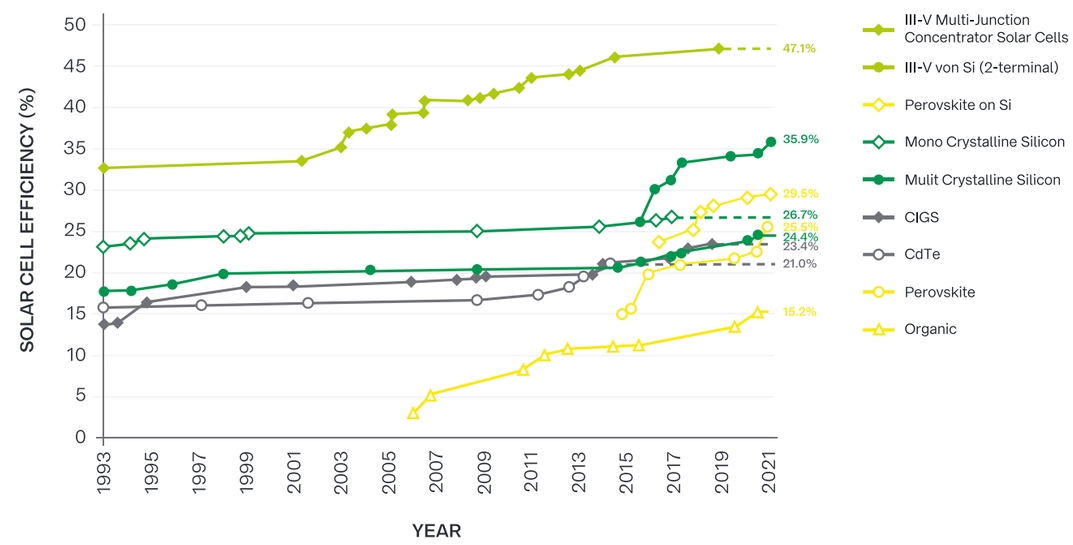
Contents

Solar technology’s rapid rise

The sun is one of our closest allies in the fight against climate change. The International Renewable Energy Agency (IRENA) claims that faster deployment of photovoltaic (PV) technology could herald a 21% reduction in global CO2 emissions by 2050[1].

This technology is advancing fast according to the Fraunhofer Institute for Solar Energy Systems’ photovoltaics report[2]:

- The efficiency of commercial wafer-based silicon modules increased from 15% to over 20% in the last 10 years
- Cadmium telluride (CdTe) modules increased from 9% to 19%
- High-concentration multi-junction solar cells achieved an efficiency of up to 47.1% in a lab setting



Solar Cell Efficiency Tables (Versions 1 to 59), Progress in Photovoltaics: Research and Applications, 1993-2021. Graph: Fraunhofer ISE 2021. Date of data: Nov 2021

Of course, PV assets need to be in peak condition to produce these kinds of results. Aged and outdated systems risk technical and operational issues. That means business downtime and financial losses.

Repowering or revamping the technology used in solar parks makes all the difference:

- Asset performance improves
- Operational and maintenance costs are reduced
- Integration with the latest technology becomes possible
- Asset lifespan increases, along with ROI

It’s time to talk about repowering

Some big module and inverter companies like Swiss ABB[3] and US LG Electronics[4] have quit the market entirely. This leaves owners who don’t repower or revamp their assets in a precarious situation.

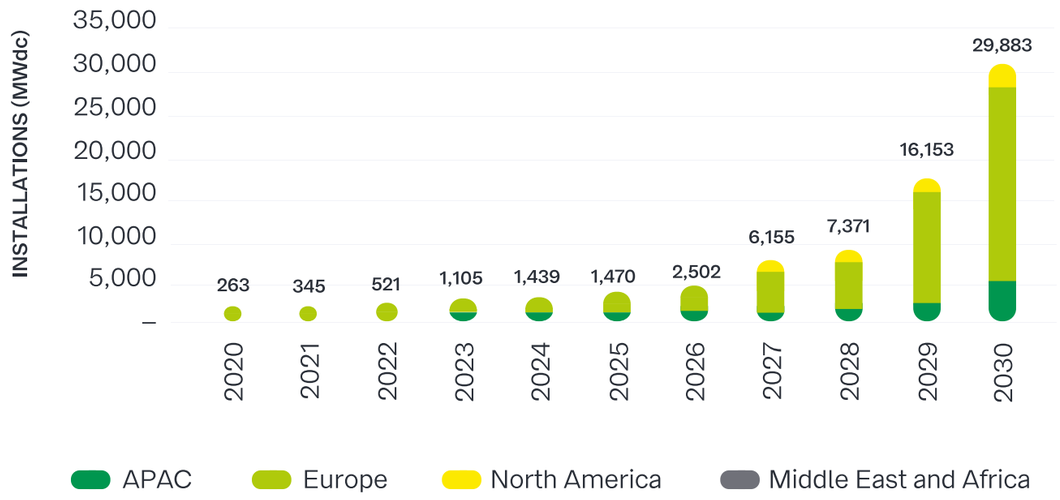
This paper explores the growing repowering and revamping market for ground-mounted solar PV assets. We’ll also discuss the many benefits that come from keeping your solar park in peak operating condition.

What does the market say?

Solar power itself is, in the grand scheme of things, a relatively new industry. Replacing faulty equipment has mostly fallen under routine O&M, but that’s all about to change. Worldwide, more than 67GW of solar capacity[5] will become 20 years old in the 2020. Most of that is in Europe, where many pre-2013 plants were rushed to meet feed-in tariff deadlines.

That presents significant opportunity for repowering and revamping as those installations reach the end of their warranties and subsidy periods. Researchers Wood Mackenzie[6] predict repowering to be one of threemain themes underpinning the market’s next decade: 29.883GW of potential could exist around the world by 2030.

Potential repowering market by year for 20-year-old system, 2020 - 2030 (MWdc)



Source: Wood Mackenzie

There are obstacles standing in the way of that boom. Legislation needs to catch up in some countries. France imposes a 10% cap on capacity increase from repowering, compared to Italy’s 1%.

Despite this, Europe is set to lead the way over the coming decade. The UK, Germany, Italy, Spain and France are the biggest repowering markets today.

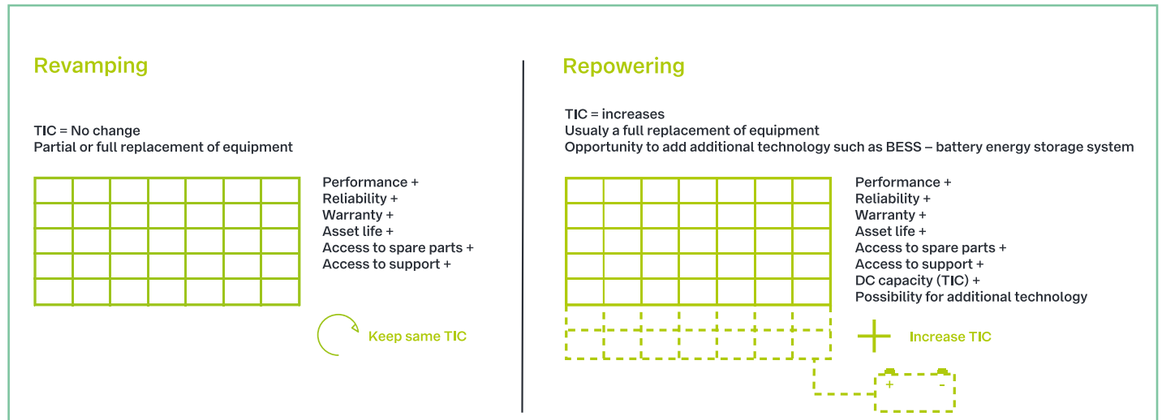
Repowering vs revamping: what‘s the difference?

Revamping returns an ageing solar plant to its original capacity.
Repowering goes one better and actually improves on the original asset’s capacity.

Achieving either outcome[7] might mean:

- Replacing obsolete components like inverters and PV modules
- Improving grid connection and redistributing the system
- Replacing balance of system (BOS) components
- Adjusting support structures
- Changing the system’s electrical configuration
- Adding retrofit technologies (like coatings designed for pre-2013 uncoated modules)
- Installing new software platforms

The goal is restoring (revamping) or increasing (repowering) the asset’s original total direct current (DC) power. This is known as its total installed capacity (TIC). If you’re revamping, you might also free up land to be used for different technologies.



Why revamp or repower your PV assets?

Repowering or revamping a solar park translates into a range of business benefits:

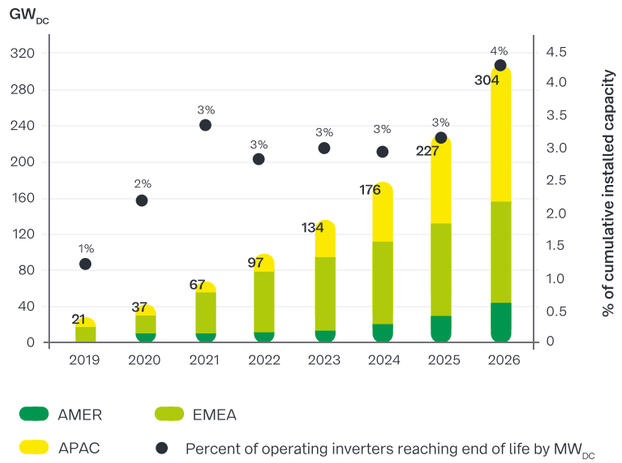
- **Maintaining performance:** Replacing old, worn equipment cuts failure rates and business downtime. It can also increase the asset's lifespan

"The output of solar panels can drop ~12.5% over 25 years, that drop could be even higher in hotter climates" [8]

- **Sourcing critical components:** Some legacy manufacturers have left the market, invalidating warranties and making important spare parts harder or more expensive to find

"Currently more than 69GWdc of solar PV inverters are over 10 years old in operation and 2.9GWdc at end of life expected"

Forecast solar systems operating beyond 10 years inverter's lifespan (GW_{DC})



EMEA	2022	2023	2024	2025	2026
Inverters > 10 years	69,8	80,4	89,8	99,9	109,4
End of Life Inverters	2,9	4,0	5,3	6,8	12,2

- **Embracing new technology:** Recent advancements make today's PV tech far more efficient than legacy systems, often with a smaller physical footprint and renewed warranties

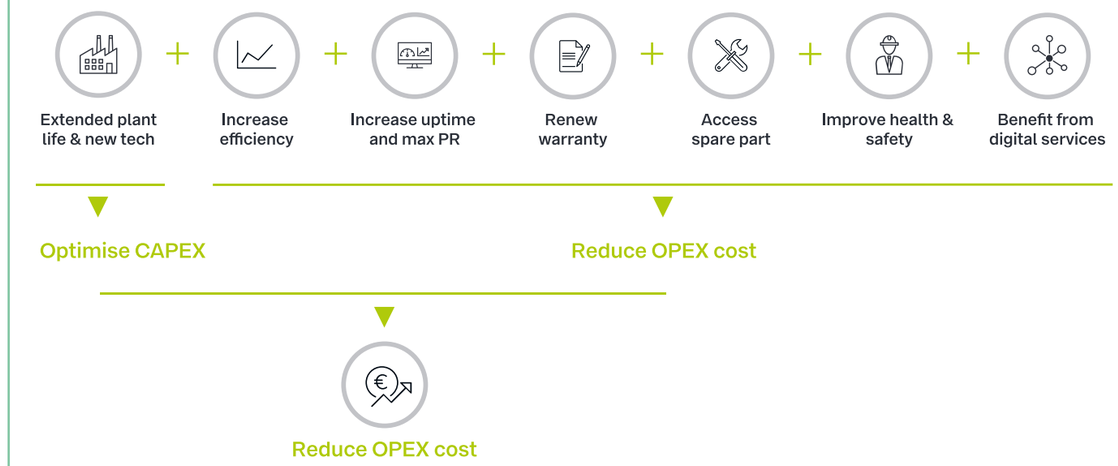
"PV modules are now hitting output of 650Wp and greater, boosting at least three times as much power output as 8 years ago. This means less than a third of area is now needed for same capacity generation" [9]

- **Lowering costs:** Today's PV technology is significantly more cost-effective. Replacing legacy equipment represents long-term savings, as well as easier compliance with evolving regulations

"Solar PV costs fell 82% over the last decade and forecast to further reduce 59% by 2025" [10]

- **Accessing new features:** As well as extra capacity, new PV tech could add features like string-level monitoring. Huawei, for example, offers a smart IV curve function to reduce intervention costs and speed up analysis

Build 'Fit for future' PV plant with latest technology and design architecture, optimising CAPEX, reducing OPEX and achieving higher ROI



Should you revamp or repower your solar park?

Any level of adjustments to a PV installation should improve performance[11] for the asset manager. To calculate whether that improvement is worth the investment, compare two scenarios:

- The cost of extra maintenance on ageing systems and lost business across the plant's remaining lifecycle
- Projected ROI from increasing performance and less maintenance over a potentially extended lifecycle

Repowering is most commonly discussed once there's a notable drop in overall plant performance. By that point, inverters may be failing. Access to spare parts might be limited, if their manufacturers are no longer active in the market.

That means protracted periods of downtime – business suffers. Taking a proactive stance towards repowering can significantly increase profitability even before these problems start arising.

It's also worth mentioning the potential to forge closer relationships with installers. Many might only sell to a customer once at any real scale, when the plant is first constructed. Afterwards, they'd only be called upon for replacement parts every once in a while.

Regular repowering gives installers more of a chance to familiarise themselves with your asset. Efficiencies increase, and they're able to offer better professional advice about adding complementary systems like battery storage.

PV revamping / repowering: project lifecycle

Every stage of a repowering or revamping project presents challenges and opportunities:

Development

Challenges:

- Planning permission or Non Material Amendments (NMA)
- Grid connection agreements
- OFGEM applications (The Office of Gas and Electricity Markets in the UK)
- Extending or amending leases

Solutions:

- Minimise visible changes to the site
- Keep new layout in line with original planning
- Maintain import/export limits
- Apply to amend grid connection agreement

Engineering

Challenges:

- Integrating new equipment within existing parameters
- Limits of the available technology

Solutions:

- Find new inverters to match existing equipment
- Collaborate with manufacturers to adjust parameters
- Replace inverters and to optimise modules

Construction

Challenges:

- Working on a live site
- Minimising downtime
- Accessing equipment
- Available welfare space

Solutions:

- Checking and repairing access routes
- Communicating early with landowners
- Careful project planning
- Ideally undertake work during winter period to minimise loss of generation
- Use of digital twin technology

Handover

Challenges:

- Knowledge sharing
- Highlighting plant changes
- Correct handover timing

Solutions:

- Implementing structured file sharing
- Updating O&M manual and training
- Sharing new manuals and essential info
- Use of digital twin technology

O&M

Challenges:

- Working with new equipment
- Changes to routine
- Distinguishing O&M from EPC (Engineering, Procurement and Construction)

Solutions:

- Detailed handover
- Training on new equipment and plant layout

The challenges of PV repowering

Revamping or repowering your site brings some challenges:

Working with the existing site

It can be tricky to conduct a repowering project within the constraints of the existing installation. You may want to replace the inverters, in which case the DC voltage and power from the PV module strings must be matched with the new inverters. The same goes for the AC voltage and transformer power.

Of course, there's also the simple limitations of space to think about. When replacing PV modules with larger ones, the module structure dimensions need to fit or be replaced, adding additional cost and complexity.

Updating a live site

Safely repowering an operational solar park without harming productivity raises a number of questions. Adding the logistics of the project on top of the site's day-to-day traffic also takes careful planning.

And, of course, there are relationships to consider and maintain. Landowners, local authorities and the workforce itself all need to be communicated with. Disruption is inevitable, it has to be mitigated.

Managing supply chains

In the current market, there are procurement challenges like long lead times for certain parts to think about. There can be delays when purchasing equipment from outside the UK due to transport disruption.

As well as new parts coming in, there are also old parts that need to be disposed of. Some could be kept as a spare parts pool for emergencies. Others will require a robust disposal process that recycles as much material as possible.

Planning and permissions

If repowering means a big visible change to the original installation, you might need planning permission. OFGEM applications will need updating to reflect the newly installed equipment.

A new or updated grid connection agreement might also be needed. If you're replacing key equipment like inverters and transformers, that might call for engineering studies like a P28 or G5/5 – both of which are studies aimed at measuring impact on the grid.

Finding the right solutions

Each PV plant is different. The specific demands of the site and the mix of technologies being used means revamping and repowering solutions should be tailored project by project. That being said, some solutions are more widely applicable than others. Examples include:

Inverter revamping

Plants can change from central to string inverters or vice versa during repowering. Designs are engineered to match the inverter voltage, current and power with the existing PV modules and transformers.
This approach might require the installation of new AC cables and switchgear or could utilise the plant's existing infrastructure.

Revamping is often focused on inverters because they offer the greatest potential for performance remediation. They convert direct current (DC) electricity that solar panels generate to alternating current (AC) electricity used by the grid. In addition to power conversion, inverters are also responsible for grid services, control and monitoring.

Module revamping and repowering

When replacing old modules with new ones, a plant's TIC can often be matched using less land. Today's PV technology offers a much higher power output. That gives asset owners the option to increase TIC with more modules, or add additional technology like on-site battery storage. The latter option could unlock additional grid support services.

Full revamping

A comprehensive replacement of all PV modules and inverters offers a lot of flexibility in terms of the new components. The more equipment gets replaced, the fewer pre-existing parameters there are to plan around.

Asset managers could enjoy even further flexibility by replacing transformers, as voltages and power can be designed to optimise the solution. Additional communication and security technology can be incorporated at the same time.

Voice of industry: Shyam Lohidakshan

Shyam Lohidakshan is Product Manager Repowering at SMA Solar AG who are a leading global specialist in photovoltaic system technology. Employing over 3,000 people and with a turnover of more than €900 million, they're a significant force within the solar power community. How should the sector be approaching PV repowering? According to Shyam:

"Operators and investors should be urgently looking for information on modernizing their power plants, even before they're technically due for an upgrade. After all, repowering solutions can significantly increase profitability.

Yes, the engineering can be challenging. You have to think about matching power capacity, meeting regulatory requirements, minimising operational expense and more. But it also opens up new income opportunities like added battery storage and grid management services.

Factory warranties get renewed, often with cheaper extension contracts. The positives add up quickly".

When determining an effective solution, repowering teams must analyse:

- MPP input voltage and current
- Derating of PV panels over the plant's lifetime
- Output voltage
- Short circuit current
- Local installation requirements
- Transformer integration capabilities

"Then, if you've got a strong product portfolio, it's best to propose more than one solution for the customer to choose from. Determining ROI means factoring in various inputs; existing feed in tariffs, liquidated damages, spare part costs, lead times and labour.

Despite the benefits, many shy away from the effort involved in repowering. That's mainly due to nerves about complexity but, with effective planning, projects can be completed in stages. This spreads out the logistical headache, as well as the cost.

SMA's repowering goal is to maximise availability and increase yield, while minimising operational costs. We look at each plant individually and put together a customised solution that fits its architecture and gets ROI back on track. Once we're done, projects are ready to integrate with a lot of new technologies."

Voice of industry: Will Hitchcock

Will Hitchcock is the founder and CEO of Above, an aerial inspection and data analytics service provider to the utility scale solar industry. Having operated for 7 years, Above has inspected thousands of assets throughout the world, with a significant number being the ageing assets across Europe.

"Above's experience has provided us with a unique view across different module technologies ageing in different environments and the challenges this presents our clients.

What's abundantly clear is that waiting for an asset to underperform before initiating robust module condition monitoring is flawed thinking. With robust condition monitoring comes full asset digitalisation enabling informed decision making about when to repower as well as options around partial or phased repowering. Ultimately reducing asset risk and operational costs.

Conclusion

More and more PV plants are reaching their 20th year of operations. More than 69GWdc is coming from projects already over 10 years old. And each year, more and more owners and investor are struggling with low PR or availability, as well as high maintenance costs. We're hearing more owners and investors each year struggling with low PR or availability, as well as high maintenance costs.

Meeting the challenges of repowering is well worth your time and effort.

- Increased production
- Better accessibility
- Ddrastically reduced failure rates and costs
- Renewed warranties
- Efficient access to spare parts and support
- Extended plant lifespan

All of that goes towards increasing your ROI. Now is the time to revamp or repower your PV plant!

Glossary of terms

AC	Alternating current.
Availability	The ratio of plant operational time vs theoretical operational time measured as a percentage.
BESS	Battery energy storage systems.
Central inverter	Centralised inverters that collect PV power from combiner boxes that combine the PV strings connected to them. Central inverters usually have an output rated above 100KW. An inverter converts the DC electricity to AC electricity.
DC	Direct current.
Grid connection agreement	An agreement with the district network operator (DNO) for a connection to the electricity grid.
Grid flexibility	A power system's capability to maintain balance between generation and load during uncertainty.
ODFM	Operational downward flexibility management is a service which allows the ESO (electricity system operator) to access downward flexibility that is not currently accessible in real time. It also expands their ability to control output from providers they cannot currently access through the balancing mechanism and the platform for ancillary services.
OFGEM	The Office of Gas and Electricity Markets in the UK.
Plant	Refers to the utility-scale solar PV power plant connected to the grid.
PR	Performance ratio. This is the ratio of generated electricity in Kwh (kilowatt hours) vs the theoretical maximum generation possible based on the TIC of the PV plant and the solar irradiation for the given period.
PV	Photovoltaic is the conversion of light into electricity.
PV module	Is a module built from cells made of crystalline silicon, also known as a solar panel.
String	A string is a number of PV modules connected in series.
String inverter	A decentralised inverter that Solar PV strings connect directly to. In general, string inverters have a smaller output than central inverters. An inverter converts the DC electricity to AC electricity.
Switchgear	In an electric power system, switchgear is composed of electrical disconnect switches, fuses or circuit breakers used to control, protect and isolate electrical equipment.
TIC	Total Installed Capacity refers to the total installed DC power of the solar PV modules installed in a PV plant, measured in Kwp (Kilowatt peak)
Transformer	A device that transform voltage by either increasing (stepping up) or reducing (stepping down) the voltage.

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Contact

BayWa r.e. Operation Services Limited
Percivals Barn, Fairfield Farm, Upper Weald
Milton Keynes MK19 6EL
www.baywa-re.co.uk

Sam Hamilton
Technical Projects Engineering Manager
BayWa r.e. Operations Services Limited
Sam.Hamilton@BayWa-re.co.uk

Saurabh Saxena
Product Manager PV Revamping / Repowering
BayWa r.e. Operations Services Limited
Saurabh.Saxena@BayWa-re.co.uk