Solar PV repowering: opportunities and challenges

With well over 100 GW of solar photovoltaic (PV) expected to reach the end of its design life by 2030 (mainly in early adopter markets in the US and Europe), asset owners face challenging questions about repowering. As a leading provider of owner's engineering and technical advisory services, Natural Power helps tackle tough questions about codes and standards, technology compatibility and cost-effectiveness that impact investment in these legacy-but-still-valuable projects.

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1 INTRODUCTION

While solar PV technology is still fairly new to many, there is a large fleet of PV projects reaching its tenth birthday in 2021, and some analysts expect up to 70 GW of PV to reach the 20-year-old mark by 2030. To put this in context, EU member states installed 18.2 GW in 2020, according to Solar Power Europe, making the potential repowering market an appreciable fraction of total new PV installations.

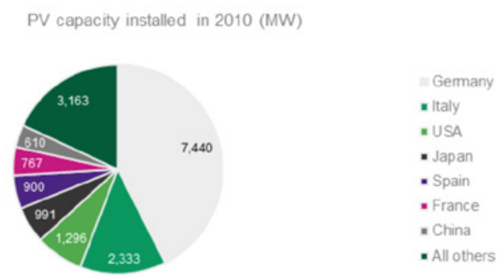
Ageing PV assets often receive less attention than new projects, which are growing ever more cost-effective and are generally much larger than projects built in previous years. However, assets that have been operational for some years still represent a significant opportunity for asset owners who might want to consider repowering for a variety of reasons, such as:

- difficulty maintaining and obtaining parts for older equipment;
- improving availability and/or performance;
- maintaining favourable interconnection or site control agreements.

In most cases, asset owners currently considering repowering, be it either partial (e.g. replacing inverters) or thorough (requiring re-engineering of the whole DC system), are doing so to address challenges with existing equipment that may be performing poorly, such as inverters. However, equipment suppliers going out of business or no longer offering these parts can make the replacement or repair of this equipment complicated. For instance, many of the market leaders in 2010 inverter sales, such as Advanced Energy (AE) and Satcon, are no longer selling or servicing inverters. This leaves asset owners struggling to keep ageing assets operating. Repowering can be the way to address these issues while also allowing for some performance improvements and possibly squeezing more generation out of the PV plant in the process.

Additionally, while it is true that modern PV plants use more robust and proven equipment than plants installed in the past, repowering remains an ongoing opportunity, as the strong year-on-year growth seen in installation rates outstrips the comparatively modest increases in plant design life over the same period. Put simply, repowering PV plants, whether for operational or performance improvement reasons, is a growing trend that is here to stay.

2 KEY MARKETS FOR REPOWERING



To understand which countries have the potential of emerging as the first major markets for PV repowering, one must look into the GWs that were being brought online in the late 2000s and the early 2010s. Or, put differently, the GWs that have reached the 10-year operational milestone. Taking 2010 as a reference, 17.5 GW of new solar PV capacity was connected worldwide, as per International Renewable Energy Agency's (IRENA) statistics.[1]

1 IRENA Renewable Capacity Statistics 2016 (ISBN 978-92-95111-83-7)

Germany claimed 43% of the word's solar PV uptake that year, followed by Italy with 19% and the USA with 7% of the total capacity installed.

Along with Japan, Spain, France and China, these countries are expected to be the first major single-country markets for repowering.

3 IF IT WERE EASY, EVERYONE WOULD DO IT - CHALLENGES IN REPOWERING

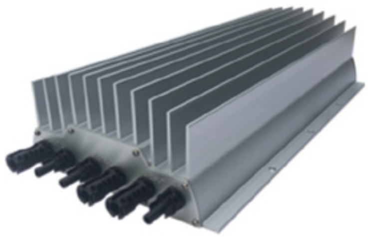
3.1 STAYING CURRENT ON VOLTAGE

PV technology has evolved considerably in the past 10 years and continues to do so. These differences are great for new projects, but it can pose challenges for repowering. For instance, replacing a defective inverter with a new one might be difficult because of the voltage of PV arrays from 10 years ago being generally 600 V, whereas modern inverters are designed to operate at 1,000 V or 1,500 V. It might seem obvious to simply rewire the PV array for this higher voltage. Unfortunately, most PV modules, conductors, disconnectors and other devices were not designed for these higher voltages.

Luckily, there are a number of possible solutions that can be employed. These include specialized DC optimizer/DC-DC converter products that can be placed near the new inverter and step up the existing array voltage to make it compatible or a small number of inverters specially designed for repowering applications.

Source: Alencon

Figure 3.1: The Alencon SPOT (string power optimizer and transmitter) DC-DC converter.



Source: Ampt

Figure 3.1.1: The Ampt DC optimizer. String-level DC-DC converter.

In the case of central inverters being replaced with string ones, there are also products designed to minimize the amount of physical works performed within PV fields, such as reverse combiner boxes. Specific products are also available for managing potential induced degradation (PID) losses. Selecting the right option, however, can significantly impact repowering cost-effectiveness.

3.2 A GROUNDING IN GALVANIC ISOLATION

Modern PV arrays are often referred to as being "ungrounded" or of "floating earth". Early on, such terms caused some confusion because PV arrays are still electrically bonded to the earth for providing safe fault current pathways through conductive equipment (e.g. module frames and mounting structures). However, what has changed is that there is no longer an earth reference for the output circuit of the PV array itself (e.g. the positive or negative conductor).

This approach became increasingly common in the 2010s, as inverters became "transformerless" (again, this term can be a bit confusing), meaning that there is no longer a physical separation in the inverter between the DC and AC circuits. This separation is known as galvanic isolation. While modern inverter topology provides a lot of benefits over the older, galvanically-isolated designs, one potential downside to this shift in technology is that PV arrays no longer have a ground reference in the output circuit, which increases the risk of PID.

Source: Oseane

Figure 3.2: Anti-PID LKPID Box.

Source: Huawei

Figure 3.2.1: Huawei SmartPID2000.

When faced with a repowering project, it is generally not possible to obtain a galvanically isolated inverter, as the market has moved away from this topology. Even if all of the other considerations can be addressed, adding a modern inverter to an older system that relies on galvanic isolation to protect the PV modules from PID may inadvertently reduce generation considerably. This is due to older PV modules not having necessarily been optimized for reducing PID losses.

In order to manage the risk of PID, repowering projects will need to add galvanic isolation to the PV output circuit or include a means of introducing a reverse bias voltage on the PV modules (generally during night-time hours). Some DC optimizer products, like the Alencon SPOT, provide the necessary galvanic isolation for existing PV arrays to maintain their original PID protection. However, not every project is a good fit for this type of solution, and there are a growing number of inverters that can accept a wider range of input voltages, removing the need for an intermediary DC optimizer. In these cases, a PID module can be used to supply the necessary reverse voltage to protect against PID. Such modules can be provided as optional equipment by some inverter manufacturers, such as Huawei and Sungrow, or via standalone projects, such as the LKPID Box from

Oseane. Such add-on options are typically less expensive than optimizers but provide none of the other benefits, such as improving performance of maximum power point tracking functions or increasing PV output circuit voltages.

3.3 GOLDEN GEESE AND VIOLATING KEY AGREEMENTS

Many older projects relied upon generous incentives or offtake agreements to be cost-effective, and those agreements may place limits on parameters like AC system size. Changing equipment onsite may, if not carefully considered, inadvertently void these lucrative agreements and negatively impact the cost-effectiveness of a project. Alternatively, interconnection agreements typically specify a maximum AC capacity for the PV plant. Exceeding this value may trigger expensive and time-consuming hosting capacity studies by the grid operator, as they will have done years of planning based on the already-approved capacity and they may view any changes similarly to an application for a new system.

Therefore, any equipment replacements or increase in PV capacity will have to be meticulously planned so as to ensure that a project remains compliant with the offtake agreement, grid code and any accreditation requirements that may be applicable (e.g. feed-in tariff or other subsidy accreditation).

4 THE UPSIDE TO REPOWERING

4.1 INCREASING PV PLANT DC CAPACITY

Grid connection agreements typically quantify an AC capacity limit; however, depending on the country and, more specifically, the network operator, they rarely define a threshold for the DC capacity. Provided that an increase in DC capacity would not be restricted from the offtake agreement, repowering can indeed be an opportunity for increasing the DC capacity of a PV asset.

Older inverters typically allowed for up to a maximum of 1.3 of DC capacity to be connected per unit of AC output; however, modern ones generally allow for higher DC to AC ratios – some up to 1.6. Increasing an asset's DC to AC ratio can generally increase the energy captured during early morning and late afternoon hours, but, if not carefully designed, it can also considerably increase clipping losses during peak generation hours, and that can lead to accelerated inverter fatigue. Vintage assets that are located in climates with a medium-to-high cloud coverage (e.g. the UK) are the ones that can benefit the most from a boost in their DC power, with such an exercise nonetheless requiring the replacement of inverters and the re-assessment of the DC system to a certain extent.

4.2 A BIFACIAL MAKEOVER

The nameplate capacity of bifacial PV modules is currently quantified by accounting for only the front side capacity or, in other words, by flash-testing the front side while eliminating completely the contribution of the rear side by creating a non-irradiating background per IEC 60904-1-2:2019. A bifacial makeover can thus be particularly useful for ageing assets in need of repowering and where there is a desire to increase yield, but which are bounded by a DC capacity threshold.

Replacement of conventional PV modules with bifacial ones may also make sense for certain repowering projects not limited by DC capacity, such as for free standing systems requiring a complete DC system re-engineering.

4.3 WATTS IN STORE FOR STORAGE

Co-locating battery energy storage systems (BESS) and solar PV was not an option during the late 2000s. This was mainly due to the battery technology not being available or, more precisely, not being sufficiently proven for commercial purposes. Nonetheless, grid-connected BESS projects made their appearance during mid-2010, with more and more BESS projects, including co-located solar (or wind) and BESS, having been developed or announced during recent years.

PV inverter manufacturers such as Power Electronics and Sungrow offer commercial- and utility-scale BESS products that can be integrated with their PV inverter solutions. Therefore, PV repowering can represent an opportunity for co-locating BESS with solar PV and, in effect, an opportunity for adding flexibility and increasing revenue streams.

5 CONCLUSIONS

The GWs of solar PV projects that will require some form of repowering is expected to grow year-on-year and, even if the trend were to be a fraction of the exponential growth of solar PV observed from the beginning of the century, a considerable market is expected to emerge. Natural Power's team of solar experts has an in-depth understanding of the challenges and opportunities that go hand-in-hand with repowering projects. So do not hesitate to reach out to us for project-specific advice and get in touch:

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