OPERATING TEMPERATURE DEVELOPMENT OF OVERCOMMITTED INVERTERS

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ABSTRACT: PV plants in Central Europe reach about 1,000 full load hours. So, they produce 1'000kWh / kWp. If a high expansion of PV power is sought, often an additional network expansion is necessary to absorb short-term power peaks. The grid expansion costs contrast with the peak output, which takes only a few hours each year. At the Technology Center of BKW Energie AG, this led to the idea of expanding the DC power more strongly than the AC side (for example, by parallel string assignment) and thereby increasing the amount of electricity per installed grid capacity. As a result, more solar energy is produced in the marginal times, while the midday peaks are flatter. To expand the DC side more than the AC side, the inverters must adjust the power. In order to keep the costs low and to increase security, commercially available inverters should be used. They are, with some exceptions, not designed for a PV array that has much more power than the peak power of the inverter. To learn the behavior of the devices, several inverters were offered up to 200% of the specified DC power (increased DC current) and simultaneously recorded the inverters MPP tracking and development of the operating temperature. The result of the investigation is that all tested inverters coped with the power surplus. They regulated the DC current by shifting the MPP and thus the operating temperature did not increase any further. The only limitations are the warranty of the equipment manufacturer if the inverters are operated outside the specifications. In addition, the specified system voltage must not be exceeded, otherwise the device will be damaged.
Keywords: Inverter, Performance, Grid-Connected, Grid-Integration, PV-Array

1 INTRODUCTION

PV plants in Central Europe reach about 1,000 full load hours. So, they produce 1'000kWh / kWp [1]. If a high expansion of PV power is sought, often an additional network expansion is necessary to absorb short-term power peaks. The grid expansion costs contrast with the peak output, which takes only a few hours each year. At the Technology Center of BKW Energie AG, this led to the idea of expanding the DC power more strongly than the AC side (for example, by parallel string assignment) and thereby increasing the amount of electricity per installed grid capacity. As a result, more solar energy is produced in the marginal times, while the midday peaks are flatter.

2 SWITZERLAND – HIGH POWER EXPECTED IN THE FUTURE

The Berner Kraftwerke BKW, one of the three major electricity companies in Switzerland, supplies many end customers. For decades, BKW has operated various PV systems such as the 560 kWp ground-mounted system (installed in 1992) on Mont-Soleil in the Jura mountains [2]. It is thus located in the "Swiss Energypark" of the electricity supplier "La Goule" in the cantons of Bern and Jura (http://swiss-energypark.ch).

The "Swiss Energypark" is a so-called Demonstrator in the Swiss Energy Competence Center SCCER-FURIES (https://sccer-furies.epfl.ch), a research program of the Swiss Ministry of Economic Affairs for the implementation of the "Energy Strategy 2050". This was confirmed in the summer of 2017 by the Swiss voters at the ballot box. The five nuclear power plants will be phased out and will not be replaced. Electricity needs to be met with a mix of energy efficiency and new renewable electricity sources. The new power sources are primarily photovoltaic with 12 TWh annual production, which corresponds to an installed capacity of 12 GWp (converted to Germany 120 GWp) [3]. This requires "managing" the PV peak power, which is significantly above the maximum power of the consumers in the Swiss utility grid. The "Swiss Energypark" already covers more than 100% of the electricity needs of the region with hydropower, wind energy and PV (www.swissenergypark.ch).

3 PRACTICE GIVES IMPETUS TO INVESTIGATIONS

BKW became aware of this topic by accident. One customer built a large 135 kWp PV system, but the submission request was filed late. The application was submitted after completion of the roof construction, including the PV system, and approved by BKW with grid reinforcement. This meant high costs for the customer and BKW, as the grid connection had to be increased from 60 kVA to 135 kVA. However, to make the system more economical, BKW recommended that the customer downsize the inverters to 55%, i.e. 60 kVA, using the entire PV module area. This resulted in a reduction of less than 15% in production, but the inverter costs could be reduced by about 50%. As a result of the lower reimbursement fee, the customer even loses less than 5% of the financial return. This means that no expensive network gain was required, with only a small loss of yield.

4 HIGH GRID EXTENSION COSTS FOR PV PEAK POWER

If the grid supply is insufficient for a PV system, the question of grid reinforcement arises. The cost of network reinforcement is borne by the subscriber and the network charges from the general public.

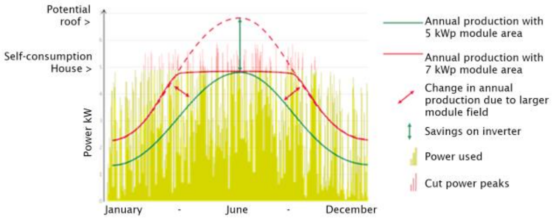

Figure 1: In practice, only power peaks are cut off - the energy loss is small

5 SOFTWARE AND HARDWARE LIMITATION OF PV PEAK POWER

The limitation of the PV peak power can be set by software in the PV inverter. In the worst case, the settings in the software can be canceled or overwritten by faulty or malign software updates.

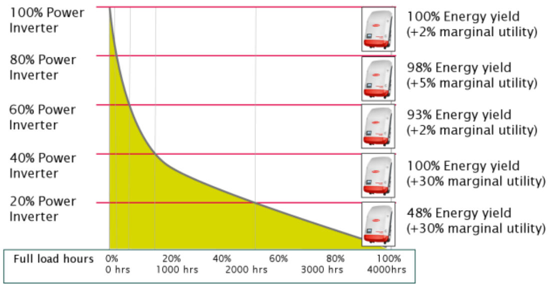

Figure 2: Full load hours increase with power limitation

6 HARDWARE LIMITATION OF PV POWER

Electricity companies, therefore, prefer a hardware limitation of the PV peak power. The question now is how the PV inverters deal with this "extra power". We measured various inverters in the accredited PV Inverter Laboratory at the PV LAB of Bern University of Applied Sciences BFH in Burgdorf. The DC power was set to 200% of the PV power specified by the manufacturer (parallel string assignment). The function of the inverter was monitored with increasing PV power. The study investigated how the PV inverters deal with this "extra power". Among other things, the thermal behavior of the inverter was investigated.

In addition, in a survey, inverter manufacturers were asked how the manufacturer assesses this mode of operation. This is to ensure that the warranty of the device is not affected.

7 MEASUREMENTS ON HARDWARE LIMITED PV INVERTERS

The following devices were selected for the tests: SMA Sunny Boy 3600, Solutronic Solplus 35, StecaGrid 2000+ master / slave system, Delta H3 Flex and Santerno Sunway M XS 3000-A TL. For the investigation, we had to operate the subjects with a defined range of power. With our PV simulator we can, as the name implies, simulate a PV system on the DC side. In the PV LABs accredited PV Inverter Laboratory at BFH Burgdorf, we have operated the string inverters at three different operating voltages: minimum, nominal and maximum MPP voltage, each with a short-circuit current of 100% to 200% in 20%. steps. This means a performance range of 100 to 200% with three MPP voltages. We monitored the operating temperature of the inverters with a thermal imaging camera to observe the heat development of the components inside the device. With these findings, PT-100 temperature sensors could be distributed among the important components and the development of the component temperature recorded during operation.

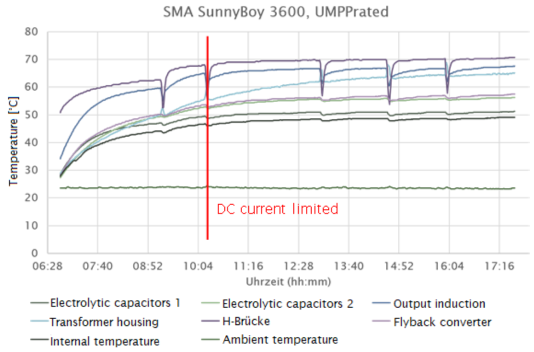

Figure 3: Typical operating temperature curves of the electronic components of an inverter

The temperature of components such as electrolytic capacitors of a PV inverter is a limiting factor for the lifetime. It is hence of great interest to keep the temperatures of the components of the PV-WR as low as possible, even if the maximum operating temperature of the manufacturer is set higher. This extends the life of the device and keeps service and replacement costs low.

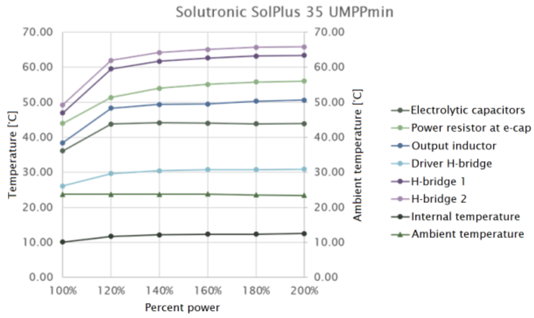

Figure 4: Comparison of the operating temperatures of the various inverters

Bringing the seven maximum temperatures per power level - considering the ambient temperature in the laboratory - in a graph, the temperature curve is a bit clearer. From 120% offered DC power, the Solutronic SolPlus 35 regulates the current and accordingly, the operating temperature of the components does not increase any further. The results are the same for all tested devices, with the difference that some inverters restrict the DC current sooner or later, or that the larger heat sink will extend the series of measurements over several days. In summary, it can be stated that all tested inverters can handle a power admission of up to 200%.

8 SURVEY OF PV INVERTER MANUFACTURERS

In addition, we started a survey with inverter manufacturers that gave us mixed answers. An inverter manufacturer confirmed that some models are designed for this type of operation and can be over-dimensioned to up to 50%, 80% or 100% of the power stated on the rating plate. Other manufacturers warned of overcommitting inverters, as they could be damaged by overheating and would operate out of specification. Especially inverters with multiple MPP trackers can damage assemblies, especially the booster and DC / AC stages, when all trackers are operating at maximum power.

Therefore, the PV planer needs to check the data sheet of the PV inverter producer. We see more and more models which allows up to 200% DC power compared with the AC-value. Such models fit well for such system configurations.

9 OUTLOOK

PV systems with DC-side over-dimensioning make better use of the infrastructure. EWs can thus avoid grid expansion and optimize costs. Such PV systems reach up to 2,000 full load hours on the installed inverters. This design is another way to achieve a high PV share in the network at optimized costs.

However, this mode of operation must be carefully coordinated with the manufacturer of the inverter. Not all devices are suitable. The measurements were only performed on string inverters with one MPP tracker. Therefore, in autumn 2019, a new series of tests will be carried out with multistring devices.

We are still interested in statements from PV inverter manufacturers. An open question is also how the authorities in Switzerland, the Swiss Federal Electricity Inspectorate (ESTI) reacts to this mode of operation. Here, the PV Laboratory at Bern University of Applied Sciences BFH will play an active role.

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