Energy
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Project

SiC solid-state transformer in the grid

More scope for photovoltaics – thanks to new transformers

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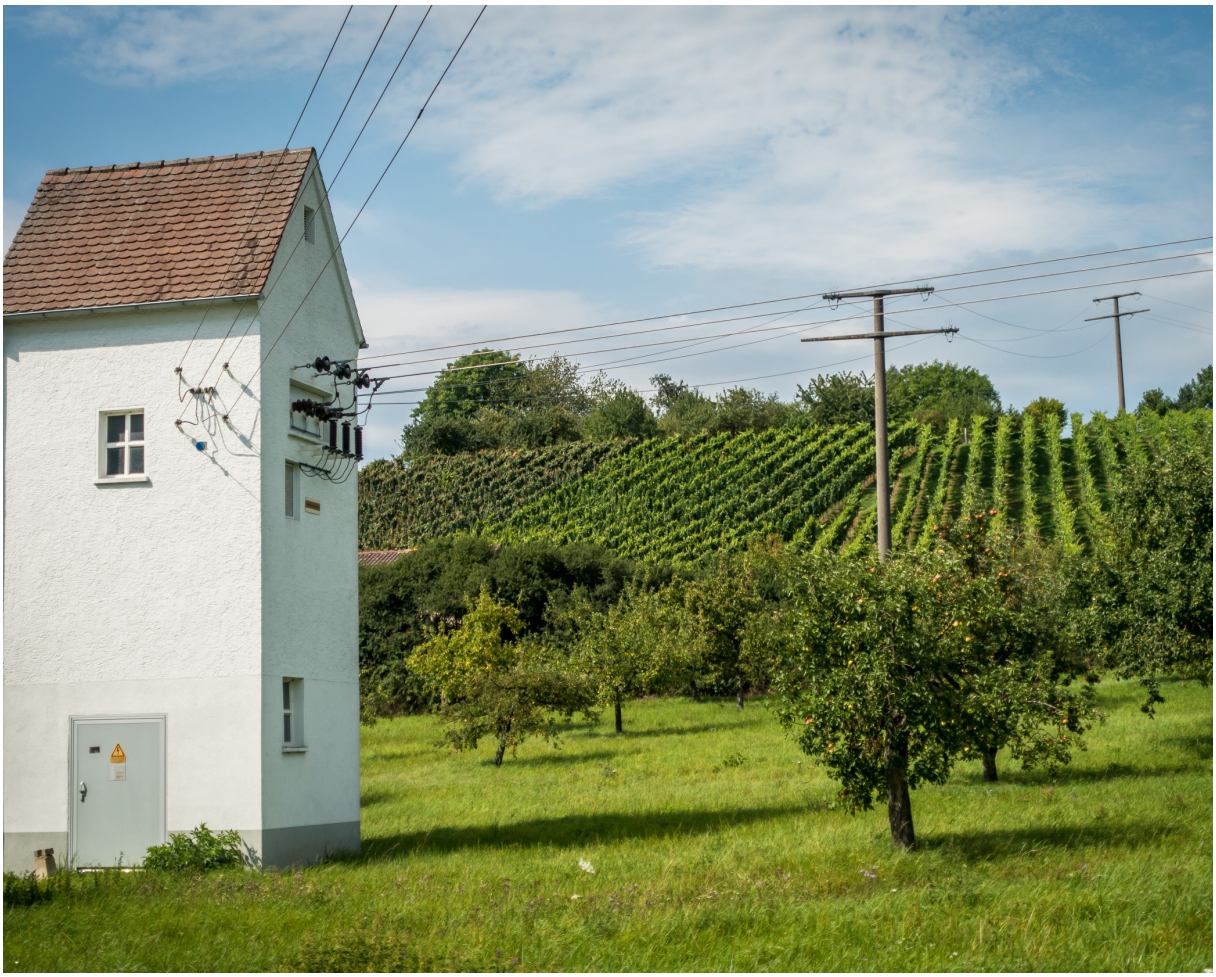
To allow more solar power to flow into the electricity grid in future, adjustments are needed to deal with the irregular fluctuations of this energy source. One possibility is to make better use of the voltage restrictions in the distribution grid with the help of a new type of transformer. Researchers from the University of Applied Sciences Northwestern Switzerland show how the advantages of new and existing transformer technologies can be combined.



Will this little house soon have a new inner life? An upgrade of the transformer technology would be a cost-effective way to make the electricity grid fit for the energy turnaround. *Source:* AdobeStock

At a glance

- Current electricity grids cannot accommodate any number of solar energy systems as fluctuating production would lead to voltage restrictions being violated.
- The new power electronic transformers can make the grid more tolerant to voltage fluctuations. However, this is at the expense of efficiency.
- Hybrid transformers combine the flexibility of power electronics with the efficiency and reliability of conventional transformers.

In order to realise the vision of a clean energy supply without nuclear power, Energy Strategy 2050 not only focusses on hydropower, but also on photovoltaics. However, the electricity grid in its current form is too rigid for a massive expansion of this decentralised and erratic energy source. This is because the power lines could be overloaded by the temporary feeding in of larger quantities of solar power into the grid. Furthermore, there are strict restrictions in place with respect to the permitted voltage in the low-voltage grid, i.e. the part of the electricity grid to which sockets and solar energy systems are connected. In many places today, it is this voltage range that limits the potential of photovoltaics.

The voltage restrictions in the low-voltage grid are related to the transformers that provide the power to the socket. The tried-and-tested transformers made from copper coils and iron cores work extremely reliably and efficiently. However, they can only transform the current in a fixed voltage ratio. Therefore, voltage specifications for the next higher grid level, namely the medium-voltage grid, also have a restrictive effect on the low-voltage grid.

Loosening the reins

More flexible electricity transmission would be possible with the so-called power electronic transformers. This new type of transformer is based on electronic components made from silicon carbide (SiC) and can not only change the voltage, but rather also the frequency and phase of the alternating current. This would allow the range of permitted voltages to be extended or the permissible range to be better exploited – and more solar energy systems could be connected. Researchers from the Institute of Electric Power Systems at the University of Applied Sciences Northwestern Switzerland (FHNW) have calculated how much photovoltaic energy could be added to a distribution grid thanks to the new transformer technology. They also investigated how efficient and environmentally friendly various transformer types would be in operation.

For their calculations, the researchers used the electricity flows measured over the course of a year in a Swiss supply area with more than 100 transformers. They also considered two scenarios with significantly more photovoltaics: the first scenario corresponds to the target of Energy Strategy 2050 with a solar power output of 11 terawatts across Switzerland. The second is a scenario of the solar energy industry association Swissolar, which quantifies the overall potential of photovoltaics in Switzerland and assumes 30 terawatts of solar power.

Expansion at the expense of efficiency?

The result of the study confirms the expectations of the new technology. The replacement of the transformers between the medium- and low-voltage grid alone would almost suffice to add a quantity of photovoltaics in the investigated grid area that corresponds to Swissolar's extreme scenario. This capacity would be more than sufficient for the plans under Energy Strategy 2050. The costs would be comparatively low, as it would not be necessary to reinforce the power lines.

However, the calculations also show that the benefits of the power electronic transformers have to be accepted with a considerable loss in efficiency. Energy losses during current transformation are almost three times higher than with conventional transformers. The new technology also performs relatively poorly in the life cycle assessment as it uses environmentally harmful materials.

However, the trade-off between efficiency and flexibility is not the final result of the study. The researchers also looked at another variant – a hybrid transformer that combines a conventional and a smaller power electronic part. This hybrid system has a variable voltage ratio within certain limits, but is almost as efficient as an ordinary transformer.

You can’t have your cake and eat it

Despite the smaller dimensions of the power electronics, hybrid transformers can be used to realise similarly ambitious photovoltaic scenarios as the full version. This requires interaction with the solar energy systems, however. This is because the inverters, which convert the direct current from the solar modules into alternating current, must ensure that the current and voltage do not oscillate synchronously, but rather with a phase shift. This additionally reduces the voltage difference between the photovoltaic system and the mains transformer and ensures that the permissible voltage range is not exceeded. Another advantage of hybrid transformers is their safety. If the power electronics should ever fail, the old-fashioned part made of iron and copper will continue to work reliably.

Due to the above-mentioned advantages, the researchers’ recommendation is clearly in favour of the hybrid transformer. Like the power electronic transformer, the hybrid solution allows for the use of photovoltaics on a large scale but without any noticeable loss of efficiency or reliability.

Produkte aus diesem Projekt

- Solid-State Transformer Modeling for Analyzing its Application in Distribution Grids
  Date of publication: 01.01.18
- Potential of solid-state transformers for grid optimization in existing low-voltage grid environments
  Date of publication: 01.01.18
- Was können leistungselektronische Transformatoren in Niederspannungsnetzen bewirken?
  Date of publication: 01.01.18
- Werden Trafos zukünftig zu Multifunktionstools?
  Date of publication: 01.01.18

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