Where solar and wind energy share the same infrastructure

Feeding wind and solar energy into the grid using a common connection point enhances the yield, saves money and helps to avoid bottlenecks in the project planning

Words: Michael Lange, Senior Due Diligence Manager, TÜV SÜD Industrie Service

In many wind farms, the ground space between the turbines remains unused. Densification with photovoltaics (PV) offers operators the opportunity to feed more electricity into the grid via the same grid connection point. This is particularly interesting when considering that grid connection often represents a bottleneck in the energy transition. However, the combination poses technical, regulatory and economic challenges. TÜV SÜD utilises the Halbturn project in Austria to exemplify what is important from a technical point of view.

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The discussion about scarce grid connection points drives the integration of additional feed sources, e.g., PV modules into the wind farm. The basic idea is simple enough: wind and solar energy complement each other in terms of energy generation profiles. While wind turbines tend to supply their electricity mainly in winter and at night, PV is more fruitful during the daytime in spring and in summer. Both sources combined could mean a steady feed-in, which utilises the existing grid infrastructure much more efficiently.

In practice, photovoltaics can be installed in and next to a wind farm with up to 100% of the existing wind turbine capacity without requiring a new grid connection and without the yield losses making such a project uneconomical. This not only saves material and engineering resources but also reduces grid fees.

What are the challenges for the development of such hybrid parks?

While the technical capabilities are generally already in place in many parks, or can be set up with manageable measures, organisational and bureaucratic obstacles can stand in the way of additional densification. Installations of photovoltaics, when carefully planned, can significantly improve returns and grid stability through smoother generation profiles. There is, however, often still a lack of awareness of these economic advantages.

Around 68 GW of onshore wind capacity is currently installed in Germany. Adding PV with, for example, 90% of wind capacity would result in an additional capacity of up to 60 GW; roughly half of the PV capacity installed today. With additional battery storage, surplus electricity can be temporarily stored and fed into the grid in a more grid-friendly manner.

In order to avoid misunderstandings during planning, the terms should be precisely clarified: the term hybrid park can encompass wind plus PV, wind plus battery or all three technologies. Each constellation has its own requirements in terms of control, marketing and approval.

Grid conformity as a technical sticking point

The greatest technical challenge in densifying an existing wind farm with PV lies in the grid conformity of the overall system. Individually, both technologies are mature enough. However, combining them at a common grid connection point requires a coordinated control architecture. The existing wind farm controller must be compatible with a new PV controller and a higher-level overall system controller, of which the latter regulates feed-in time and quantity of the individual systems. It ensures that the relevant parameters are adhered to and frequency specifications are met. It also implements regulation and control requirements from the grid.

In practice, configuring these controllers almost always requires readjustments. Practical experience with the interaction of wind and PV controls in operation is also still somewhat limited. The correct operation parameters, however, are a prerequisite for the certification, which proves the proper interaction of all components and without which grid operators will not grant a feed-in permit. This causes delays in implementing the grid connection.

TÜV SÜD offers independent grid compliance tests to ensure grid conformity. These tests assess whether simultaneous feed-in can be contained in a technically safe manner and whether the control architecture meets the requirements of the grid operator. Simulations of the plant before commissioning can significantly reduce the need for subsequent adjustments in the field.

Technical Due Diligence

Hybrid park projects are usually financed by external sources. Before committing to financing, the lending bank or an investor requires a comprehensive technical risk analysis, known as Technical Due Diligence (TDD). As part of this assessment, TÜV SÜD examines the following technical aspects: Is the plant design correct? Are the yield forecasts plausible? What risks does the operation entail and what financial provisions are required?

The TDD of a hybrid park goes beyond the assessment of a single generation technology. In addition to classic yield reports for wind and PV plants, it also includes the evaluation of generation profiles.

Added to this are both the analysis of overbuilding factors and the calculation of curtailment risk. Each given battery storage system's operating mode, charging cycles and marketing opportunities are also included in the assessment. Are the technical investment and operating costs, CapEx and OpEx, realistic? Applicable operating data, for example, from a SCADA (Supervisory Control and Data Acquisition) system, will also be evaluated.

In addition to the typical risks in project business, such as cost overruns, delivery delays and material damage, hybrid parks face a specific risk: delays at the grid connection point due to the integration of control systems. TÜV SÜD not only identifies such risks but also designs suitable solutions, such as the renegotiation of contracts which have fallen below market standard, or pointing out equipment that was overlooked during procurement.

Practical experience: Halbturn project

The Halbturn project in Austria is a vivid example of a large-scale redensification. With 79 wind turbines and an installed capacity of 237 MW, the already existing wind farm there is one of the largest onshore installations in Central Europe. Its annual electricity generation corresponds to the electricity requirements of around 155,000 households.

As part of the redensification process, a section of the wind farm with a capacity of 72 MW is being supplemented by a PV system with a capacity of nearly 70 MWp.

The PV modules are mounted on a single-axis tracking system. This ensures that the modules always align vertically to the sun, increasing the yield compared to a fixed mounting system. The row spacing of around nine metres allows continued agricultural use of the land, a key difference to densely built open-space installations, where the land under the modules is rendered unusable.

Modules that are too close together are also difficult to maintain or may cause overheating of electrical components, yet another reason why sufficient spacing is being taken into account.

The issue of ice throw also requires attention. As the PV modules are installed in the immediate vicinity of the wind turbines, there is a risk of falling ice damaging the modules. This must be accounted for during the construction phase to protect people and equipment. Proper planning includes sufficient safety distances.

Nevertheless, occasional module damage cannot be completely ruled out and must be considered for the operation and maintenance of the plant.

Another effect that is apparent in practice concerns the shadows the wind turbines cast onto the PV modules. The tower's shadow slowly moves along with the sun. At the same time, the rotor blades periodically sweep across the modules, depending on wind speed.

Thermographic images document which modules are temporarily in the shade and switch off. Whether or not the repeated switching on and off will affect the service life of the modules needs to be kept under surveillance in the coming years of operation.

Michael Lange

Conclusion and outlook

The redensification of existing wind farms with photovoltaics increases economic efficiency, ensures smoother generation profiles and utilises the existing grid infrastructure more efficiently. Careful planning is crucial for success, especially with regard to the control architecture and grid conformity of the overall system. Early, independent technical testing reduces risks for operators and banks or investors alike.

With every hybrid project implemented, knowledge about the interaction of these technologies grows. This enables more accurate project planning, reduces risk premiums and encourages banks or investors to finance projects. In order to exploit existing potential for redensification, project developers, banks, investors, operators, independent auditors and authorities should exchange information as early as possible to minimise interface problems and friction losses.

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There is a lot of potential in the redensification of existing wind farms with PV