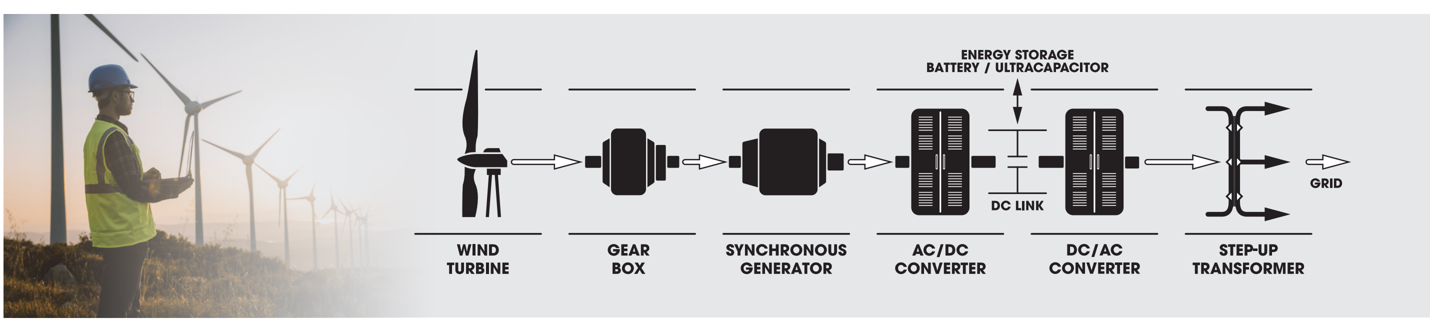
Programmable Sources and Loads Augment Wind-Turbine Development and Test

Wind power is rapidly advancing as a source of renewable energy. The United States Department of Energy recently reported that a record 16,836 MW of land-based wind capacity was installed in the US in 2020, bringing the cumulative total to 121,955 MW, with wind-power installations outpacing solar installations. In addition, the DoE said, the US offshore wind pipeline grew 24% year-over-year, with 35,324 MW of capacity now in various stages of development. And Lawrence Livermore National Laboratory recently reported that wind energy production in the US increased 11% from 2020 to 2021.

Humans have been harnessing wind power for millennia, but today's utility-scale wind installations represent unprecedented levels of innovation as developers strive to maximize efficiency and reliability while minimizing cost. These innovations range from blade design to developing sophisticated control algorithms to provide functions such as turbine blade pitch control and rotor horizontal-axis yaw control.

Wind turbines are available in two basic categories: fixed-speed and variable-speed. Both types typically include a gearbox that increases the relatively slow rotation of the blades (18 rpm, for example) to a much higher speed to drive an AC generator (such as 1,800 rpm for a four-pole synchronous generator operating at 60 Hz). Fixed-speed turbines employ synchronous or induction generators and can interface directly with the grid. However, they often include soft-start circuitry to minimize current surges on connection and disconnection from the grid. The soft-start circuitry can consist of two thyristors in anti-parallel in each phase, with firing angles adjusted to control current levels during connection and disconnection.

Fixed-speed wind turbines provide maximum efficiency at just one wind velocity. Because wind seldom remains at any particular rate, fixed-speed turbines spend most of the time operating sub optimally. To capture the maximum wind energy at any given wind speed, developers turn to variable-speed turbines. The AC output of a variable-speed turbine's generator varies in both frequency and amplitude and therefore cannot directly connect to the utility grid. Instead, a power converter rectifies the AC generator's output, producing a DC link, and the resulting DC level is inverted to match the grid frequency. Optionally, a bidirectional DC/DC converter can connect to the DC link and charge a local storage battery or ultracapacitor. Finally, transformers match the inverted AC output voltage to the level required by the grid.



Programmable Power

Evaluating the various tradeoffs in wind-turbine design requires extensive evaluation in simulation and measurement. A wind turbine's various aspects—blades, gearbox, AC generator, rectifier, inverter, transformer, DC/DC converter, battery, and control algorithms—must work together seamlessly for optimum performance. However, they may be designed and manufactured by different entities and must be extensively tested in isolation before final installation at a wind-farm site. AMETEK Programmable Power AC and DC power supplies and loads play a crucial role in developing and testing wind-turbine applications' hardware and control algorithms. Programmable supplies can be used in test setups for the motors providing pitch and yaw control. They can simulate batteries to provide for the test of DC/DC converters used in applications that include local battery storage. A three-phase programmable AC source can simulate the generator, providing variable output voltages and frequencies. A programmable DC load can help test the rectifier circuitry and assist with the test of any DC/DC converters used in the application. And finally, bidirectional AC sources can provide grid simulation to assist with the inverter and output transformer test as well as simulating AC and DC transients.

AMETEK Programmable Power offers a wide range of programmable power supplies and electronic loads that can serve in the development and test of wind-turbine systems. An AC source such as the RS Series, for example, can simulate a turbine's AC generator to help support the test of the downstream rectifier, DC link, and inverter. RS Series sources are available in standard ratings from 90kVA to 1MVA. In addition, PLW Series programmable electronic loads can assist in the test of DC link components, including DC/DC converters and associated battery-charging circuitry, if applicable. And finally, because the RS Series supports regenerative bidirectional operation, it can provide the grid-simulation capability to test a wind-turbine's inverter.

Whatever aspects of wind technology you are working with, AMETEK Programmable Power stands ready to apply its decades of experience in power technology to meet your needs with reliable, stable standard systems and custom-engineered solutions.

California Instruments RS Series

Sorensen PLW