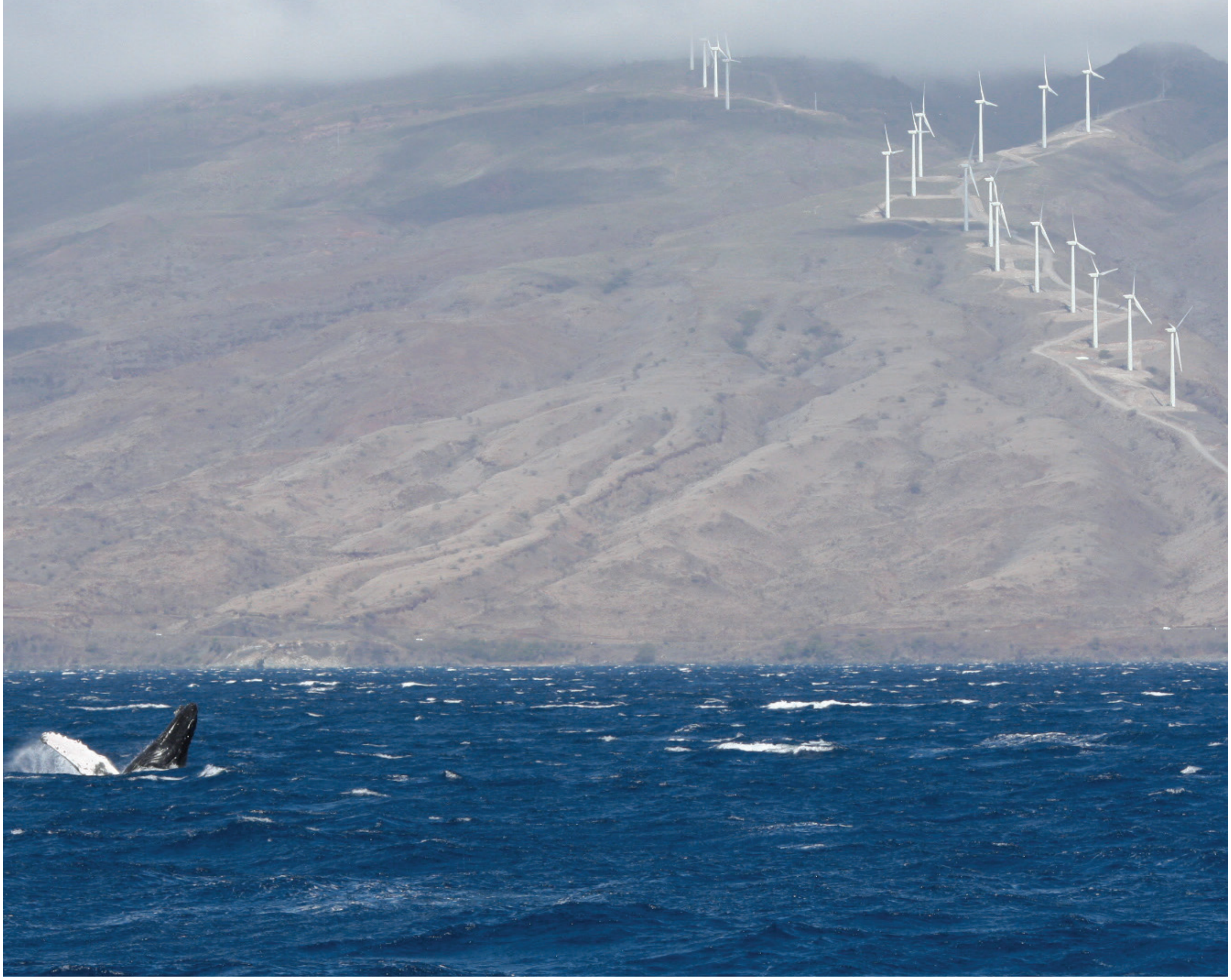
White paper

Five keys to wind farm bankability

The Levelized Cost of Energy (LCOE) of wind power is rapidly gaining equilibrium with other energy sources, making it one of the most attractive options for entities looking to increase their use of energy from renewable sources. However, the LCOE of wind can vary widely from project to project, and developers need to keep a sharp eye on those factors that influence project viability.



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Five keys to wind farm bankability

The time is now for wind energy

LCOE, or Levelized Cost of Energy, is an assessment of the economic feasibility of an energy source that incorporates costs over the lifetime of the project. Major cost categories include capital, fuel, and maintenance. While being touted for low fuel costs (wind is essentially free) wind energy often requires significant capital expenses that raise its LCOE. Furthermore, the variability of wind energy can be hard on equipment, making it one of the more maintenance-intensive of the renewable sources.

The good news is that advancements in technology as well as focused efforts to control carbon emissions during energy production have brought wind costs in line with other sources. The following chart, adapted from the U.S. Energy Information Administration's Annual Energy Outlook for 2013, compares the LCOE of new generation sources coming online in 2018. For a full understanding of the assumptions in this analysis, access the EIA report at http://www.eia.gov/forecasts/aeo/electricity_generation.cfm

Only natural gas offers a significant LCOE advantage over onshore wind development. However, while natural gas has some unique advantages over other fuel sources and is likely to be a strong contender for the foreseeable future, it has drawbacks as well. Perhaps the biggest is that the fuel requires an extensive network of pipelines and refinement facilities to bring the energy from the ground to point of use. In comparison, wind is converted into useable energy at the turbine. With the appropriate connectivity and available grid capacity, even small wind farms can "ship" their goods almost anywhere, using the vast array of power lines already available.

Many energy experts don't necessarily see the race to grid parity as a competition between sources of supply. According to Alfredo Parres, Head of ABB's Wind Sector Initiative, "[Providers] should look at optimizing the energy mix. Given the current state of technology and the variable nature of many renewable sources, natural gas and wind are more partners than competitors."

U.S. average levelized costs (2011 $megawatthour) for plants entering service in 2018

Plant type	Capacity factor (%)	Levelized capital cost	Fixed O&M	Variable O&M (including fuel)	Transmission investment	Total system levelized cost
Dispatchable technologies						
Conventional coal	85	65.7	4.1	29.2	1.2	100.1
Natural gas, conventional combined cycle	87	15.8	1.7	48.4	1.2	67.1
Advanced nuclear	90	83.4	11.6	12.3	1.1	108.4
Geothermal	92	76.2	12.0	0.0	1.4	89.6
Biomass	83	53.2	14.3	42.3	1.2	111.0
Non-dispatchable technologies						
Wind	34	70.3	13.1	0.0	3.2	86.6
Wind-offshore	37	193.4	22.4	0.0	5.7	221.5
Solar PV1	25	130.4	9.9	0.0	4.0	144.3
Hydro2	52	78.1	4.1	6.1	2.0	90.3

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It's important to remember that the LCOE of different energy sources is highly variable from region to region and installation to installation. Achieving grid parity requires that wind farm developers focus on the factors that impact performance. ABB groups these factors into five categories: risk, deliverability, efficiency, reliability/maintainability, and safety.

Risk

Of all the issues that keep wind farm developers up at night, risk has to be the biggest. From site selection to project development to operations, producing energy from wind is not as easy as it might appear to the general public. Gunnar Ohras, Senior Financial Advisor at ABB, stresses the importance of controlling risk. "We talk about bankability quite frequently when reviewing projects. You can't get financing or funding for a potential wind project unless you can prove that the project is bankable."

Thankfully, there are ways to reduce the risks inherent in wind development. Whether offshore or onshore, site studies can help developers create profitability models and select the most appropriate location for new wind development. However, a developer must also take into account grid connectivity when considering the suitability of a location. A Grid Integration Analysis can help the developer understand issues such as whether system upgrades will be necessary and what challenges might occur downstream. According to Dennis McKinley, Director of North American Wind Power for ABB, "Helping a developer build a viable wind farm is about far more than just selecting the right components and designing the right configuration. Time spent up front studying potential sites can make all the difference in the world."

Once a project begins, environmental concerns can still delay a project, but advancements in underground cabling can reduce this risk. When Sweden wanted to connect the island of Gotland with the mainland, the developer had difficulty getting the necessary permits for overhead transmission. ABB's HVDC Light® technology allowed them to deploy two 70 kilometer cables underground, eliminating concerns from those who objected to the overhead lines and minimizing the impact to the sensitive marine environment.

Every wind farm has its challenges, and additional analysis may be necessary to preserve viability after commissioning. "Sometimes project owners and developers are more concerned about keeping costs down than they are about ensuring the new wind farm won't cause issues on the grid," said McKinley. "A transmission and distribution root cause analysis can identify trouble spots, such as increased harmonics that affect power quality and stability, and recommend solutions that weren't considered during the initial design."

Deliverability

Of course, once a site is selected, funding approved, and environmental permits in place, the race is on to develop the wind farm within the scheduled timeframes. For wind farms, this is especially important as developers often rely on pre-negotiated Power Purchase Agreements (PPAs) to secure funding for the project. These agreements specify milestones that must be met in order for the PPA to remain effective.

"The PPA is critical because it sets the date on which the wind farm is to first deliver power to the grid," says Melvin Brown, ABB's Manager of Substation Business Development for Renewables. "That date is set in stone. If it changes, the entire development suffers because the wind farm owner does not know when, or even if, he will be given a new date. Worse, still, if the developer misses the PPA dates, the owner says ‘goodbye’ to treasury grants and production tax credits.”

Selecting the right supplier is key to ensuring the project is commissioned as scheduled, and global equipment suppliers offer significant advantages. Some power equipment, such as high voltage transformers, come with relatively long lead times. Factoring in design, manufacturing, and delivery, it can be as long as a year. That time can be cut drastically by working with a supplier who has experience in all aspects of wind farm development, including transformers.

Lead times can be cut even further, often by months, when working with a supplier who can manufacture the equipment regionally. Wind farm development also benefits from using suppliers whose people live and work in the region.

Mainstream Renewable Power, Ltd. develops, finances, builds, and operates wind farms all over the world. According to Mainstream’s Head of Technology, Joe Corbett, “All development is local. That’s why we always work with local developers. Regulations governing energy generation vary widely from region to region. A developer with experience in the region is more likely to understand the regulations – those already in place as well as those coming down the pipe.”

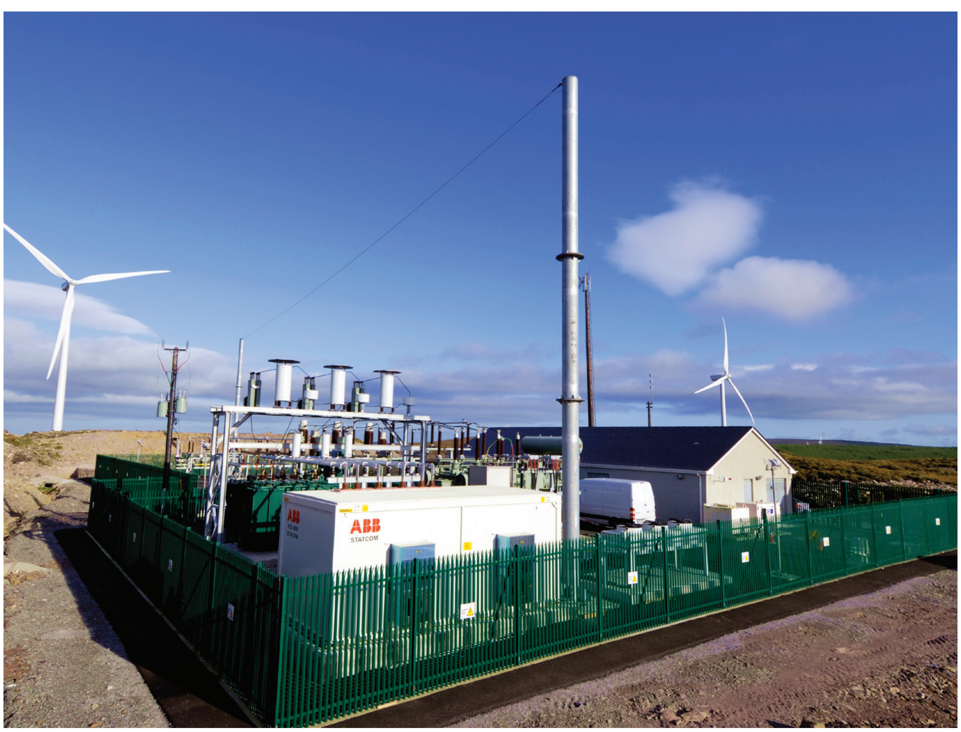
ABB’s Parres agrees, “Having a global footprint allows ABB to serve customers anywhere in the world. However, supplying equipment is only half the battle. Having local ABB people who understand the political and cultural environment is crucial to getting things done.”

Efficiency

According to the U.S. Energy Information Administration, about seven percent of energy generated is lost in transmission and distribution. While that may not seem like a lot, it’s important to understand the benefits of reducing that loss. According to the American Wind Energy Association, a single 1.67 MW turbine can produce over 5,000 MW/h of electricity per year and reduce CO2 emissions by over 3,000 tons.

The greatest losses often come when energy has to be transmitted over long distances. By its very nature, utility-scale wind energy is a long-distance energy source. Offshore development holds great promise for utility-scale projects because of the strength and the reliability of offshore winds. Onshore wind development is often more attractive because of the lower LCOE, but can entail wrangling with individual groups who object to the development due to noise, a perceived lack of aesthetics, or a potential environmental impact.

Once again, technology holds the key to increasing efficiency and addressing environmental concerns. High Voltage DC (HVDC) cables are a primary solution



for lowering energy losses over long distances. ABB's Borwin Alpha project uses HVDC Light® to connect one of the world's most remote offshore wind developments to the German grid. To minimize the environmental impact and reduce line loss, 130 kilometers of HVDC cables were laid from the North Sea to the German coast.

Companies like ABB are investing in other technologies to increase the efficiency of wind farms as well. ABB worked with Areva, a manufacturer of wind turbines for offshore installations, to develop a series of liquid-cooled IGCT (Insulated Gate Commutated Thyristor) converters that could operate in high stress conditions. The use of medium voltage technology results in lower currents and therefore in less space, less cabling, and reduced system losses.

Reliability and maintainability

Quality of energy is perhaps one of the biggest concerns expressed by developers looking at increasing the penetration of wind power on the grid. The variable nature of wind energy leads to a highly unstable output that can have a negative impact on grid frequency and voltage, tripping protection relays, and leading to blackouts. The benefits of increased renewable penetration can easily be offset by increased reliability concerns unless stability issues are properly addressed.

"As turbines and wind farms get larger and generating capacity increases, grid operators have been forced to establish more stringent grid connection rules, commonly called 'grid codes', to ensure fluctuations don't disrupt the main grid," says Michelle Meyer, Senior Product Manager, Power Conversion, ABB. "Wind farm developers need to find a way to compensate for variability."

That's where ABB's STATCOM (static synchronous compensator) comes in. Whitelee, Europe's largest onshore wind farm, has more than 200 turbines with a generating capacity of more than 530 MW. "Not only does ABB's PCS 6000 STATCOM stabilize the power injected into the grid, it also enhances power transfer and quality, ultimately increasing the power factor of the wind farm which equals more revenue for the plant owner," adds Meyer.

Variability can also be addressed with backup sources of power such as the diesel generators used in smaller scale developments such as a microgrid. However, the use of diesel power defeats the goal of the utility or institution looking to increase the penetration of renewables on the grid and decrease their CO2 output. Flores Island in the Azores is remote from the central grid in Portugal. For years, they relied on power generated by heavy fuel oil (HFO) generators and a hydro power plant. In an effort to reduce the cost of diesel power generation, the utility installed a number of wind turbines. The solution wasn't perfect, and they soon discovered they had to limit the amount of wind power injected into the system to avoid power fluctuations and blackouts.

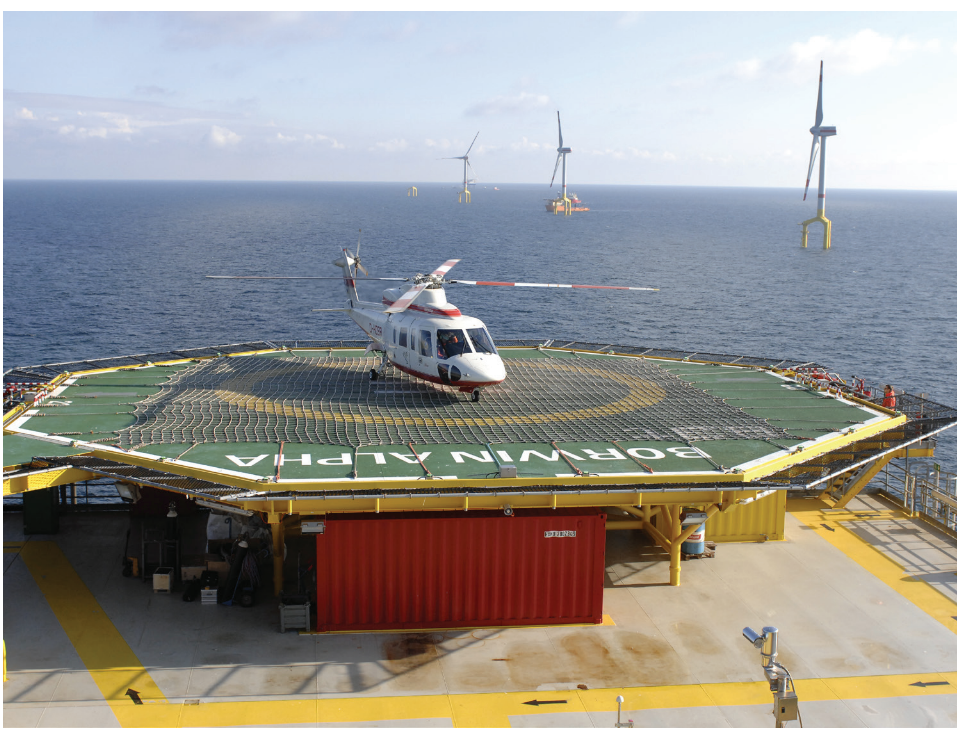


ABB solved this dilemma for the Flores Island microgrid with an innovative storage solution called PowerStore™ that uses a compact and versatile flywheel-based grid stabilizing generator to protect the grid against fluctuations in frequency and voltage. High-speed software controls the power flow into and out of the flywheel, absorbing and injecting real power within an isolated power network as needed. "It functions somewhat like a high-inertia electrical shock absorber," says Brad Luyster, Head of ABB's North American Microgrid Execution Center. "PowerStore's ability to smooth out both voltage and frequency fluctuations makes it an ideal solution for wind farms developments that need to connect to the main grid or simply control power quality at the local level."

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Other technologies such as ABB's FACTS (Flexible AC Transmission System) allow the grid operator to maintain and even improve grid function, enabling an increase in power transmission over existing lines and ensuring that irregularities in voltages do not disrupt the primary grid.

…if the design is wrong for the application, something's going to break.

Reliability goes hand in hand with maintainability. As with any power generation, equipment that stands the test of time is key to ensuring viability. If equipment lasts longer, the wind farm will last longer. Just as importantly, if you design a wind farm using equipment that requires less maintenance, operating expenses can be better controlled. The variable nature of wind energy makes it especially hard on equipment, but maintenance takes on a uniquely troubling aspect for offshore wind installations. "You can't just expect to use the same technologies offshore that have been used onshore for decades," says ABB's McKinley. "The conditions are harsher. The demands are greater. And the cost, if something should go wrong, is much higher. It's not like a couple of technicians can drive out in their truck to make repairs. Offshore maintenance involves transporting technicians by helicopter or boat in seas that can be rough. Once they get there, they have to do the job in some pretty brutal conditions. In wind, reliability is something that really has to be built into the product during the design phase. You can have the best manufacturing operations in the world, but if the design is wrong for the application, something's going to break."

To decrease the maintenance required for wind farm equipment, ABB follows a philosophy called "Designed for Reliability" that follows three best practices:

Failure Mode and Effects Analysis (FMEA) – FMEA starts with the product and technical specifications and looks for potential failures. After assessing the risk of occurrence, FMEA identifies corrective actions that avoid or mitigate the failures.

Reliability Prediction – Reliability prediction uses commonly accepted standards such as MIL-HDBK-217FN2 and Telcordia to estimate the failure rate of the system or subassembly. This provides feedback to the designer on where the attention should be focused.

Root Cause Analysis – Any field failures are examined to determine the cause of the failure and provide corrective measures to improve system reliability. At ABB, Root Cause Analysis may go as far as recreating the failure in the laboratory to fully understand the true cause of the failure.

ABB continues to invest in the industry as well. "Next to the electrical systems, more than 20 years of data tells us that the auxiliary systems are the most likely to fail in the field," says ABB's Parres. "We recently invested in RomoWind, a service company that is creating innovative solutions for online monitoring of yaw alignment and solutions for corrective action."

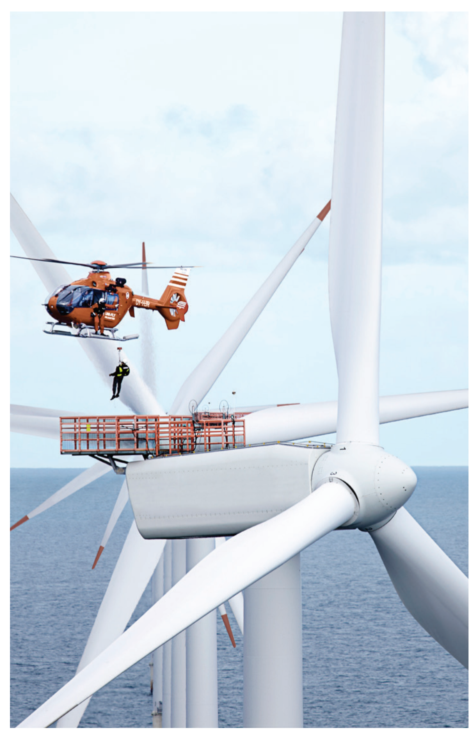
Safety

The energy industry is an inherently dangerous business, and wind energy is no exception. Complicating matters, the entire industry is experiencing a shortage of skilled workers as older workers retire and fewer young people choose technical degrees.

One way to promote safety is to reduce the amount of maintenance needed. "Reducing the part count in components such as the PCS 6000 converter results in a lower predicted failure rate," adds Meyer. "When possible, we'll also design using self-healing components. For example, metalized film capacitors can be designed with insulation systems that restore their original insulation properties after a breakdown."

Another way to reduce the maintenance required is to design around those components most likely to fail. "Decades of field data tell us that encoders and fuses are two components that are most likely to fail due to aging," says McKinley. "The PCS 6000 operates without encoders, using software to calculate the rotor speed and torque. We've also replaced the fuses in the PCS6000 with advanced breaker control algorithms."

When maintenance is required, it's important to minimize the amount of time it takes. ABB arranges power modules



inside the cabinet in such a way that it is easy for qualified personnel to replace them when necessary. In addition, all subassemblies (with the exception of the line reactor) are sized so that they can be carried by one person.

McKinley sums it up: “You minimize the amount of maintenance and the number of people involved, you minimize the potential for accidents. It’s as simple as that.”

ABB also helps their customers create a qualified workforce by providing training on how to safely and efficiently integrate and operate ABB products. These classes are taught by engineers with experience in the unique demands of wind energy and offered at ABB training centers around the world, online through e-learning classes, and onsite at the customer’s facilities.

The future is now

Historically electric grids have been powered solely by fossil fuel-based sources, which meant the cost of electricity rose when the cost of the fossil fuel commodity increased. Wind and other renewables offer an alternative to the ups and downs of commodity pricing.

For wind developers, weathering the ups and downs of the industry requires a sustained focus on those factors that influence profitability. Only then can wind remain on par with other sources and earn its rightful place in meeting the growing needs of an energy-hungry world.

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