

A Fine Couple They Are (Wind and Solar Power)

The pairing of wind and solar is emerging as a smart strategy to implement renewable energy sources with better economic feasibility.

By Jim Romeo

The pairing of wind and solar power is an advantageous complement; the two benefit each other. The synergistic combination is an emerging trend in renewable energy and power generation as costs drop. The pairing of sustainable sources is in early stages, however. And the configuration still has challenges regarding return on investment (ROI), ease of implementation, and storage.

In western Minnesota, a 2-MW wind turbine and 500-kW solar installation—wind-solar hybrid project—is an early entrant to the wind-solar market and one of the first of its kind in the U.S. It was introduced at a cost of about \$5 million with high expectations and the goal that Lake Region Electric Cooperative in Pelican Rapids would acquire the power for its 27,000 members.

The pioneering project got a boost amid the lower costs of solar. The power generation from both renewable sources is calculated to provide dividends on its investment.

According to market researcher Global Market Insights, hybrid solar-wind projects are expected to grow by 4% in the U.S. over the next five years to join a \$1.5 billion global market. Some attribute the growth to the 2015 United Nations Climate Change Conference objectives, combined with lower costs of development and materials, and a keen interest by many nations to rely more on renewable energy sources. Because wind turbine power and solar both have excess capacity, together they offer far greater possibilities.

Lucrative but Limited

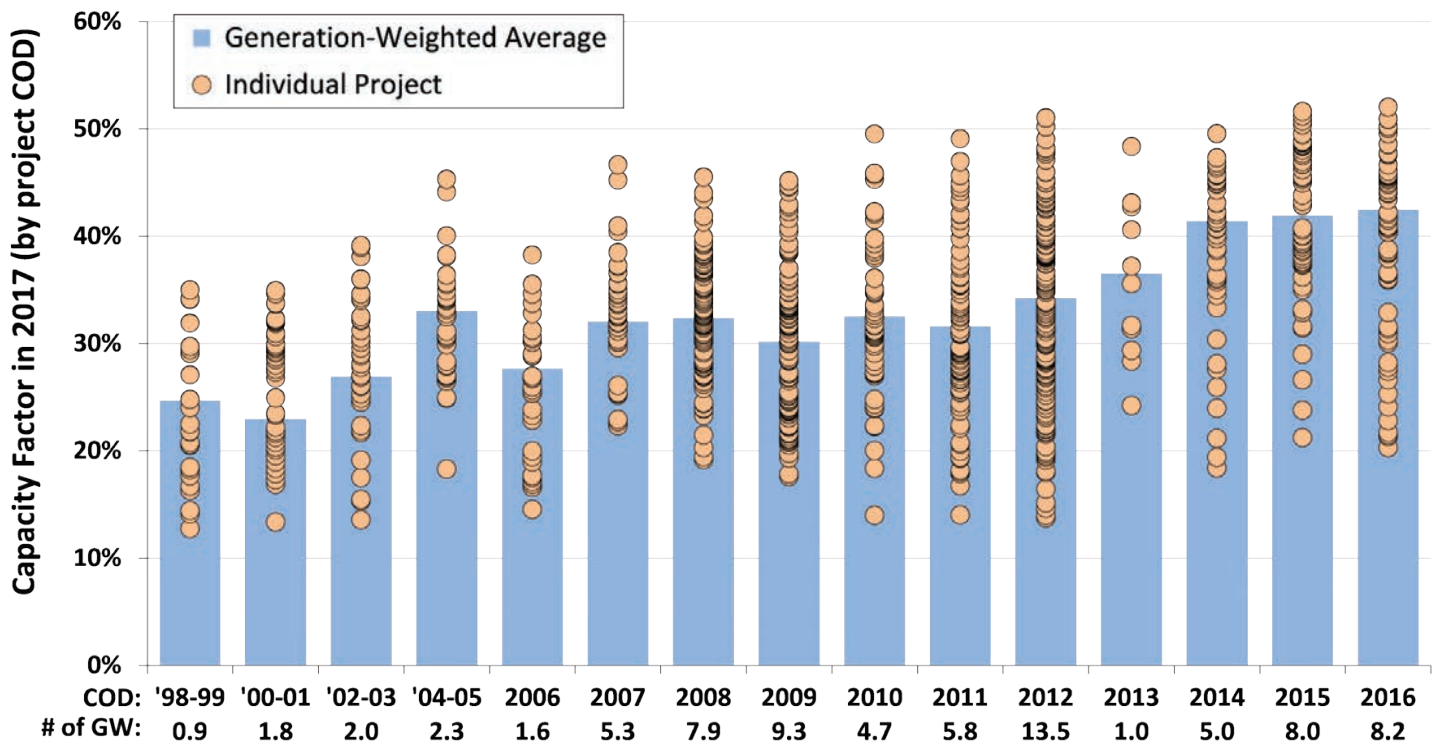
Renewables especially make economic sense in non-urban areas, where costs per kWh are higher, said Mike Voll, principal and sector lead for Smart Technologies at Stantec. “So, rural communities and remote locations, where energy prices often reach \$0.40 to \$0.45 per kilowatt-hour, ac-

tually see an ROI from these projects. When it comes to combining both wind and solar with storage, however, the list of locations is even smaller still. In a perfect world, we’d have a place that has excellent radiance with enough wind and low cloud cover, but the reality is there are very few locations that meet the geographic requirements. So even as the price continues to drop, there will still be significant limitations to pairing solar and wind.”

Despite limitations, renewables can work well in locations where everything clicks. A storage option is an essential component. “Adding energy storage can reduce intermittency of output, reshape the generation profile to match to load, and enable dispatch of the renewable energy to maximize revenue generation through ISO market participation or utility programs,” said Todd Tolliver, senior manager at ICF, a global consulting and technology services company headquartered in Fairfax, Virginia.

Tolliver said the economic viability of these systems is constrained by equipment, costs of storage, and limited or irregular revenue streams. But he explained that the most common combination today is solar plus battery storage, thanks to investment tax credit and incentive programs in certain markets that provide clear lower costs and better revenue streams. Still, wind power energy storage has challenges.

“Wind plus storage is more challenging as the intermittent nature of the wind resource makes it difficult to guarantee the storage system can be charged,” Tolliver said. “Without that stored energy, the storage system may be underutilized and limit the economic benefit. Additionally, wind projects benefit from the production tax credit and cannot take the investment tax credit at the same time. Therefore, the equipment cost of the storage system will not be offset if paired with wind in this manner, again, limiting the economic viability.”



1. Average wind turbine capacity factors for projects built in 2016 improved about 79% from those built in 1998. Source: U.S. Department of Energy's Office of Energy Efficiency & Renewable Energy

According to the U.S. Department of Energy's (DOE's) Office of Energy Efficiency and Renewable Energy, wind power's usable capacity is growing. It says: "Improvements in design engineering and manufacturing have led to higher hub heights and larger rotors, which are comprised of turbine blades and the hub. The increased size of these components has contributed to the trend of higher capacity factors. Turbines with larger rotors have higher capacity factors because the spinning blades sweep a larger area, resulting in greater energy capture. Using a taller tower to increase hub height at sites with positive wind shear, those where wind speed increases with height, helps lower the cost of wind energy by providing greater access to higher wind speeds."

According to DOE, the average capacity factor for units operating at projects built from 2014 to 2016 was 42%. This compares to an average of 31.5% among projects built from 2004 to 2011. That's a 33% increase since 2004–2011 and a 79% increase since 1998–2001 (Figure 1).

One cost-saving factor is the integral inverters, which convert DC power to AC and are built into the wind turbines. Because they're part of the wind turbine, the solar panels didn't need their own inverters and could instead use those on the wind turbines. This shaves about 10% off the project's total cost.

Tolliver notes that a common application for solar-plus-storage power generation configurations is for load shifting from midday to evening. In such a scenario, consumption of power generated may be matched at the local level to a specific load, whether a building or region. A solar-plus-storage system, he said, can be "economically dispatched" to

available markets weekly, daily, or even hourly to maximize revenue potential.

Growing Pains?

Projects are sprouting up, but utilities and other stakeholders of energy power generation tend to struggle with aspects of the pairing and its energy supply. Dillon Elizabeth Filion is the CEO of Sundamental, a firm that works with hospitals, universities, and other smart collectives. According to Filion, the most-common combination of solar, wind, and storage is done at the utility level.

In large utility-scale projects, it's rare to have all power sources linked to one meter or one development. But Filion said companies are starting to see fault with this, noting two proposed projects in Southern California and one in Texas where wind, solar, and storage are all planned to be tied together on one site.

"The most common example is the utility with the necessity to make good on their renewable generation promise while trying to upgrade their operating system," she said. "Trying to run solar and wind on the grid [can] be compared to running iTunes using Windows 95. Of course, the utility never planned for this to happen. But never underestimate the ability of one developer on a mission."

The pairing, as Filion explained, is usually an outgrowth of a solar farm. In her comparison, it "works perfectly with the grid, and the utility is happy because Windows 95 works with Solitaire just fine," she said. "Then another company comes in and develops a wind farm 100 feet down the road

on the same transmission line. This happens often because developers are able to save a ton of money and have a greater chance of success with the second project. The most notable reasons being that the developer is able to use old surveys and studies, [and] may know [what] the transmission line needs and that it can hold additional power, and the soil or pre-development conditions are favorable.”

But in Filion’s view, this can be a problem for the utility unaccustomed to the somewhat unpredictable nature of power generation. She said the utility is accustomed to a single generation point that can be turned higher and lower.

“When working with wind and solar, you get what Mother Earth gives you. Don’t get me wrong, there are many intelligent measurement capabilities that we have been able to create to allow us to forecast the exact amount of power produced, but at the end of the day, this still costs the utility companies more money.”

Storage Enhances Hybrid Projects

Jacqueline DeRosa, vice president of Battery Energy Storage Systems for Ameresco in Sacramento, California, said that for intermittent resources, such as wind and solar, energy storage can smooth the output, thus creating a more predictable energy solution. With more and more renewable penetration on the power grid, added energy storage paired with wind and solar can also adjust output to demand. The storage can also boost the capacity value of the intermittent resource.

“While adding energy storage to renewable resources creates tremendous worth, there is a lag in the regulatory and market structures, thus making it more challenging for the developer to monetize the multiple values provided by the storage resource,” she said. “Today, pairing solar PV generation with storage is more commonplace in comparison to wind and energy storage. This is because solar developers can take advantage of the investment tax credit (ITC) when adding energy storage to the solar resource. While the value proposition for wind developers is not as pronounced as solar plus storage, it is becoming more apparent.” DeRosa said storage can boost the wind project’s value by reducing curtailments, mitigating congestion, adding to the capacity value, and providing reliability services (see sidebar). It can also be used to alleviate periods of overgeneration.

DeRosa said batteries with lithium ion chemistries are the most common solution today for pairing with solar resources. “This is primarily due to the pronounced drop in price, as well as the advances in technology to provide both instantaneous response and a longer duration discharge,” she said. “While this is the current trend, other types of energy storage technologies, such as flow batteries, fly wheels, and thermal storage, can be successful for different types of applications. We are also seeing interest in larger bulk storage resources to provide a grid-scale solution for addressing renewable integration.”

Powering Up Illinois Institute of Technology’s Data Center in Chicago Illinois

Azimuth Energy worked to improve backup power for the Illinois Institute of Technology’s campus data center. An existing diesel generator set serves as backup power along with small rack-mounted uninterruptible power supplies to support short-term data-processing loads as backup.

Azimuth worked with the institution to further protect the data center by installing a 90-kW solar array on the roof, a 10-kW wind turbine next to the building, and a 500-kWh Tesla battery plant (Figure 2). The solar, wind, and battery plant can support the data center loads for an entire day without starting the generator set. The pre-existing generator set runs now only if the primary grid fails, and the Tesla battery plant is not recharged by the wind and solar.



Integrating into an existing electrical system requires finding a “point of common coupling” that doesn’t disrupt ongoing operations, provides adequate capacities, and allows easy operations and maintenance access. In this case, the project landed on an existing automatic transfer switch (ATS). Project managers had to replace the old feeders because they were not code-compliant. Furthermore, the new feeders also have the correct color-coded jackets.

The battery plant can be recharged from solar, wind, or the utility grid. This can be tailored and controlled based on expected loads, weather forecasts, or other potential critical-needs situations. The microgrid site controller is programmed with daily routines, which can be overridden remotely based on weather or other priorities.

The Road Ahead for Solar and Wind Pairing

DeRosa noted that states have acknowledged that adding energy storage to the grid is cost-effective, and the storage-paired solution ultimately benefits the ratepayers. DeRosa said several states have now implemented targets, mandates, and incentives to help bridge the gap, and more are pending, especially as the cost of using such power generation drops.

“The cost for projects involving solar, wind, and storage have certainly come down in recent years,” said Voll of Stan- tec. “Storage in particular has become much more competi- tive. Two to three years ago, the costs were simply too high and didn’t make economic sense. But while the price tag has gotten smaller, the economic feasibility of projects that combine renewables with storage remains jurisdictionally dependent. As the old real estate adage goes, ‘location, lo- cation, location.’ ”

The Federal Energy Regulatory Commission (FERC) last year implemented a rule to help incorporate cutting-edge energy storage technology into America’s electric grids. The rule requires regional grid operators to update rules for battery systems to allow renewable energy such as wind and solar to meet energy demand. It follows the path of pairing carbon-free solar energy with batteries and is beating out fossil fuel projects.

U.S. Senate Environment and Public Works Committee members Sheldon Whitehouse (D-R.I.) and Edward J. Mar- key (D-Mass.) hailed the rule as not only a step in a green new direction, but also a creator of new jobs and an ambi- tious use of renewable energy.

“We’re already seeing powerful new batteries help renew- able energy beat out fossil fuels. This rule will help contin- ue that success, reducing carbon pollution and providing Americans with dependable, low-cost energy. I’m grateful to Chairman McIntyre and his colleagues for making good on their commitments to treat renewable energy fairly and finalize this rule swiftly,” Whitehouse said in a publicly re- leased statement. “With this rule on the books, I encour- age the commissioners to turn to the second part of the proposal—to help mix power from small renewable energy systems, like rooftop solar, into our grid.”

Cities eager to lead the charge with renewable energy solu- tions are adopting the practice of pairing solar and wind. According to Deloitte’s March 2019 report “Renewables (em)power smart cities,” solar and wind may play a key role for cities and communities worldwide to achieve their sus-

tainability goals. “Solar and wind power are the linchpins to aligning and achieving both sets of goals,” the report says. “To better describe cities that recognize this and harness wind and solar energy, we developed the concept of smart renewable cities (SRCs). SRCs are already powered by so- lar and wind and envision the further deployment of these sources as integral to their smart city plans.”

Such smart cities are all over the world. Deloitte lists about 26, from Sonderborg and Copenhagen, Denmark; Tokyo; Paris; Bangalore; and others abroad; to Denton and George- town, Texas; Chicago; Los Angeles; and Peña Station, Col- orado, in the U.S.

In its report, Deloitte said a city’s integration of more solar and wind power “can directly power their goals to be more economically competitive, sustainable, and livable. In fact, these goals cannot be achieved without a significant share of renewables. Utilities play a key role in their successful deployment as electrification powered by both utility-scale and distributed renewable energy spreads in the building and transportation sectors, unlocking new possibilities for customer engagement.”

Deloitte said these SRCs are the genesis of renewable pow- er for many smart cities. The inclusion of wind and solar as a renewable pairing is a statement in itself. Such a city has engaged renewables, but it’s just the beginning.

The report says: “The purest SRCs have already flipped the equation, presenting smart cities as a component of their renewable energy plans, recognizing that renew- able power is a starting point for smart cities. It behooves both cities and utilities to be bold in their SRC journeys, as growth is not guaranteed. Cities are competing with one another, while utilities may risk losing business and other opportunities to nontraditional electricity providers. The first cities and utilities to achieve 100 percent renewables may reap the most reward as they attract a growing number of like-minded stakeholders.”

The viability of solar and wind pairing, with integral ener- gy storage, is evolving. According to Ameresco’s DeRosa, utility and system operator rules and regulations defining ownership, interconnection, operations, and the rate struc- ture for hybrid storage resources are evolving. As the rules and expectations change, wind plus energy storage will be- come more widespread.

—**Jim Romeo** (www.JimRomeo.net) is a technology writer and speaker.