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Power gridlock – The challenge of rebuilding the US power grid

The U.S. power grid is millions of miles long, contains countless pieces of equipment, serves nearly 230 million people and is magnificently deficient in upkeep. Analysts are engaged in multitrillion-dollar debate whether the grid needs rebuilding or replacement. And every day, new power sources are coming online that need to be incorporated into the grid – many of them renewables like wind and solar, never envisioned as becoming a "democratized" feature of the power grid. But now one thing is a certain, the power grid needs attention and it will be costly, the largest project and likely most expensive "project" in U.S. history.

By Matt Miller, AJOT

Fixing America's power grid is a monumentally difficult and expensive task. Three years back, Joshua Rhodes, a researcher at University of Texas, Austin's Webber Energy Group, estimated a complete grid replacement would cost nearly $5 trillion. "I'm sure it would be more now," Rhodes recently said.

Joshua Rhodes, University of Texas, Austin's Webber Energy Group

The grid is comprised of three parts: generation, transmission and distribution. Transmission and distribution lines, many of which have passed their life expectancy, are already operating at capacity. Transformers are failing. Hundreds of the aged and uneconomic plants that generate power must be replaced.

Add to this an overall deficiency in the grid's maintenance. That's become especially apparent in particular pockets. However, the entire country suffers. "There is a need to invest and create infrastructure just to keep [the US grid] up and keep it going," said Florian Mayr, a Berlin-based partner at Apricum— The Cleantech Advisory.

Florian Mayr, a Berlin-based partner at Apricum – The Cleantech Advisory

Complicating matters, the US has three separate grids — Eastern, Western and Texas — that aren't even connected. Rick Rys, a senior consultant who specializes in energy management with ARC Advisory Group, calls this "ridiculous for a modern country."

In 2017, the American Society of Civil Engineers released a "report card" on US infrastructure, in which it slammed the state of the country's power grid. "Electricity delivery in the US depends on an aging and complex patchwork system of power generation facilities, transmission and distribution grids, local distribution lines, and substations," the report

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Vulnerability of the grid and climate change

By Matt Miller, AJOT

As wildfires rage throughout the Western United States, they destroy everything in their path and imperil all in their range — life, property, health, natural habitat. Add light and power to that list.

"Flames knocked out transmission lines and generators from the Sierra Nevada to the San Diego backcountry," The *Los Angeles Times* reported in September, adding that utilities begged residents to conserve electricity during the hottest times of day because of stresses on the system.

An Oak Ridge National Laboratory study last year detailed the devastation, obvious and not, that wildfires can unleash on the grid: destruction of power lines, towers and poles. "The transmission capacity of a line can be affected by the heat, smoke, and particulate matter from a fire even if there is no actual damage to the physical structure," it emphasized.

The fires highlight the dangers of climate change. They also underscore the vulnerability of power grids to natural disasters and weather extremes, both of which will increase in scope and frequency because of our warming planet.

"Climate hazards and extreme weather affect all components of the electric grid system, from generation to end use," the Oak Ridge study warned, adding that these systems, decades old, weren't designed to handle new environmental realities.

Bigger and more frequent wildfires, hurricanes, blizzards, floods and drought all call for more renewable energy, but more distributed power as well. These natural disasters "impose the need for another type of flexibility, and that is flexibility in the grid to make it more resilient," said Florian Mayr, a Berlin-based

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said. It awarded energy infrastructure a dismal "D+."

It's getting worse.

State of the Grid

Recent events in California provide dramatic warning signs of what could happen if nothing is done. In the past two years, extreme weather triggered blackouts, a downed power line ignited one enormously deadly fire and the mere danger of wildfires caused a major utility to cut power to millions *(see box on page 4)*. Utilities these days are scrambling to keep their lines and equipment safe from the fires that are now ravaging the West.

"Utilities are already more vulnerable to extreme weather events than in the past," wrote McKinsey & Co. in a report last year calling for utilities to adapt to new environmental realities. *(see box on page 4)*

It's not just utilities. It's vital for those in logistics to understand what could be a seismic shift in the grid and the various components involved. Building a new grid — or even upgrading the current one — will impact vessels and the ports, rail and road, cargo handlers and 3PLs. New equipment, new handling methods, new transport solutions will all be required. Power, which already plays a major role in project cargo, will become ever more important.

Everyone with an interest in project cargo should be aware of the state of the grid and what changes are on the horizon. Billions of dollars will be at stake.

"People gloss over the massive amount of logistics required if you go from having dozens of power plants to tens of thousands of power plants," said Rhodes in an interview, "the managing all of that, upgrading the distribution system to handle that, upgrading the transmission system to handle all that. It is a lot."

A modern grid becomes ever more vital as we attempt to move away from polluting energy sources, embracing everything from electric vehicles to rooftop solar panels. "As electricity consumption is growing through electrification efforts, there is going to be a need for more robust transmission and distribution infrastructure," said Eric Wanless, director of technology and innovation at the Rockefeller Foundation, where he focuses on the power industry.

Large, renewable energy projects have already been identified as important drivers in a global economic recovery following the Covid pandemic. And the shift is underway – GE the largest builder of coal fired plants,

Eric Wanless, director of technology and innovation at the Rockefeller Foundation

announced last week that it will no longer build coal fired plants and shutter or sell existing facilities to concentrate on renewables. With a change like this, project cargo specialists should anticipate a significant upturn in business.

Points of Improvement

Despite its crumbling infrastructure, the grid displays some points of improvement. Advanced software systems, for example, can now more accurately monitor equipment wear and tear, better match supply and demand and more precisely control usage. Utilities are already devouring these systems. "The more fundamental change is on the software and controls basis," said Wanless. "It's already happening. You just don't know it," said Wanless.

"Our grid is getting smarter, but it has a long way to go," added Rys. "Homes are getting smarter, but they have a long way to go. And the grid interactive home doesn't exist yet."

Although there's universal agreement that a better grid is a much smarter one, it's less certain exactly what shape a new power grid would take. Among those who see the basic outlines the same way, important details differ. For example, some maintain that highly localized power production and consumption will become vital, while others believe this so-called "micro grid" will remain of marginal importance.

Then, there's politics. "The whole marketplace is a political battle in terms of government and rules and regulations and tax law skewing which source of energy is going to win," said Rys.

Even advocates of a complete grid transformation don't see some sort of magic switch being thrown. It's not as if the old grid will one day be shut down and a new one powered up. Too much is at stake. "You don't want to invest billions of dollars on the grid maintenance and then have it not actually work for a future that we're moving toward," said Wanless. "It's not two pots of money."

It will take time. "This is not an easy infrastructure to change," said Rys. "Many of these products take a decade to build."

Rick Rys, ARC Advisory Group

Analysts have identified several elements of a new grid. Here are eight:

1. A smart grid. The grid itself becomes a more active player, and at every juncture. Information becomes increasingly more detailed and actionable, making both production and consumption

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partner at Apricum— *The Cleantech Advisory*.

Old power sources, which produce C02, exacerbate climate change. The current power grid — with centralized power generation and distribution — makes the severity of the problem that much worse. Utilities are dependent on electricity coming from limited sources, often over long distances, with equipment that is either inadequate or unreliable in a crisis.

"There's going to be an increased desire to build out a more distributed grid particularly in terms of power generation, because if lines go down or if there's something happening on the transmission and distribution side, a distributed grid is more resilient because you don't have to get power from A to B, the power is everywhere," said Eric Wanless, director of technology and innovation at the Rockefeller Foundation, where he focuses on the power industry.

In August, consumers discovered just how tenuous the situation can be. California utilities Pacific Gas & Electric and Southern California Edison were forced to initiate rolling blackouts for four days because extreme heat spiked demand, while supply was unexpectedly curtailed. The utilities assumed they could import power from Nevada and Arizona. However, those states needed the power for themselves as they were experiencing record heat as well.

For PG&E, the state's largest utility, the linkages between cuts to the supply of power and fires are becoming all-too-common. In 2017, a downed transmission line triggered the worst wildfire in California's history, killing more than 80 and destroying the town of Paradise. Last year, the utility cut the electricity to millions of customers without warning, fearing strong winds could blow down trees, which in turn could down power lines or other equipment.

Getting the grid to be more weather-responsive is one side of the equation. Reducing carbon dioxide levels in power production is the other. Boosting renewable energy sources is on the rise, although not as quickly as planners believe necessary.

"First on our priority is de-carbonizing the electric grid," said Rick Rys, who specializes in energy management as a senior consultant with ARC Advisory Group. "We haven't moved particularly fast compared to how fast we need to go."

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more efficient. "Data can be just as valuable as the energy that's flowing across the lines," said Rhodes.

2. A two-way grid. Customers will produce energy as well as consume it. (They are known in industry jargon as "prosumers.") Homes, vehicles, offices, schools, shops and factories will all become sources of power, with both electricity and data flowing back and forth. Mayr calls this the "democratization of generation."

"There will be two-way flows of information, two-way flows of power. It will be a much more integrated systems approach to the power grid, which is a fundamental shift from the power grid of today, which really is the same grid of 100, 120 years ago," said Wanless.

3. A distributed grid. Power will be increasingly decentralized or distributed, rather than the traditional model, which is a centralized system of generation, storage and distribution. Andrew Meyer, a Southern California clean energy advocate, talks of six advantages: Efficiency, reliability, modularity, flexibility, economy and environmental responsibility.

Customers have a greater role in not only consuming, but in generating and trading electricity. The relationships between consumption, production, and storage become redefined, according to the equipment manufacturer Siemens.

4. Behind the meter. These are customer-generated energy resources, rather than utilities. It includes the obvious, such as rooftop solar panels and batteries, and the not-so-obvious, including electric vehicles and smart thermometers.

5. Renewable energy. Solar, wind and hydro will account for a larger and larger percentage of total power and some analysts such as Rhodes believe renewable energy will account for 40% to 50% of total in another 15 to 20 years. Not only is it environmentally necessary, it's now the cheapest source of power in many areas and will become more and more economical as time goes on. (California, for example, already depends on renewables for one-third of its energy consumption and pledges to be 100% carbon-free by 2045.)

"A clean energy portfolio is cheaper to build today than certainly coal and in a lot of cases, new natural gas plants," said Wanless, who predicts this kind of cost advantage will only grow in time. "This has been like a relatively huge paradigm shift in the power sector."

6. Batteries. They will be a key component for much of the change, especially as the price of lithium-ion batteries is falling dramatically, although other battery technology is being developed as well. Some batteries will allow residences and businesses — as well as vehicles — to store power. Others, called grid-scale batteries, provide onsite storage for power production. The issue for the grid is energy variability. The sun doesn't shine at night. Wind doesn't blow all day long. "With renewables, there's much more fluctuation," said Mayr, who adds that energy storage enables "flexibility in the grid."

7. Smaller power plants, and many more of them. The days of the mammoth 1GW power plant lording over a city are over. The size of one plant isn't key, overall production is. "The size of power plants recently has shrunk, and technology has also allowed them to do that," said Rhodes.

This, however, means a greater emphasis must be placed on more efficient power transmission, both locally and over long distances.

8. Microgrids. Shrink power generation, transmission and usage down to a neighborhood or a single complex of buildings, such as a university. That's the concept behind a microgrid, which is usually connected to the main grid, but can disconnect and function independently through an autonomous power source. This is called "islanding." Ports of Long Beach, LA and San Diego have microgrid projects underway while the Port of Baltimore

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Dutch subsea cable installer, Blue Offshore, fashioned a unique "double basket" carrousel barge to move 8,000 tons of cables from the manufacturing site in Greece to Rotterdam

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is studying the concept. Some microgrids are already operating, although there's some skepticism that they can be widely used. "People romanticize the idea of locally produced power, just like they romanticize the idea of locally produced food," said Rhodes. "It's a lot harder when it's 100 degrees outside and you and all of your neighbors want air conditioning."

Impact of Grid Transformation

The grid's transformation will impact logistics handlers in sometimes contradictory ways. For example, as *AJOT* has written about extensively, wind turbines are becoming ever more powerful, which means they're larger and heavier. Transportation and handling become proportionately more challenging. For Instance, LM Wind has developed a blade that reaches 107 meters in length [351 feet].

Offshore wind can be especially difficult, with purpose-built vessels and advanced handling techniques. In July, for example, the Dutch subsea cable installer, Blue Offshore, fashioned a unique "double basket" carrousel barge to move 8,000 tons of cables from the manufacturing site in Greece to Rotterdam.

On the other hand, both batteries and solar panels are modular. They are built to be containerized. An array of photovoltaic cells stands in stark contrast to a coal plant.

As power is decentralized and distributed, the physical attributes of the grid change. "You need less grid infrastructure and you also need less centralized power generation," said Mayr.

On the other hand, ultra-high voltage power lines can more efficiently send electricity from, say, a rural source to a population center hundreds of miles away. One $6 billion project in China, completed last year, constructed a 1,100-kV (1.1 million volts) direct-current line that stretches more than 2,000 miles. Transformers weigh 800 metric tons each and are 37 meters long (121 feet).

Finally, just keeping the old grid working is a tall order. Rhodes calls it "a trillion-dollar problem," adding, "even if the grid stays the exact same as it is today, just on maintenance, we're going to be spending trillions of dollars."

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to supporting the development of a wind energy industry in New Jersey and off its coast. *(See box on page 10)*

The state estimates the new wind port will cost between $300 million and $400 million to fully develop. NJEDA is leading the development efforts and is considering a range of public, private, and public-private partnership financing options. The precise financing scheme for the wind port has yet to be announced but observers note that the governor's office would not have announced a construction start in the second quarter of 2021 unless there was a clear path to financing.

"Planning and permitting work is certainly well under way," Sabina allowed.

Similarly, the process of leasing port parcels to interested entities has not started yet, but Sabina anticipates that further developments on that front will be announced "in the coming months."

When the wind port is fully developed, Saporito expects it will be serving wind projects well beyond New Jersey waters, to include projects off New York, Delaware, and Maryland. "Parcels like the wind port are not readily available," he said. "When you look at the Connecticut State Pier," which is also vying for a slice of the wind business, "you are talking about 30 acres. We are talking about 200 acres of property that we're developing. This is virgin land that the state wants to dedicate to offshore wind generation. It's different in size and scope," when compared to other facilities that are being developed to serve the wind energy industry.