

a major player

renewables are now mainstream

FOR THE PAST 25 YEARS, THE Utility Variable-Generation Integration Group (UVIG) has focused on the integration of wind, and more recently solar, power into electric power systems. I remember the arguments in the early days about what the maximum penetration limit of wind power could be before the power system would go unstable and fall apart. Now the conversation is around how to integrate inverter-based power plants into weak grids and, indeed, how to design a grid for 100% nonsynchronous generation. My, how the times do change! I think it has been at least a year since anyone has asked me the maximum penetration question.

There is still work to do, but the nature of the conversation has clearly changed. Renewables are now mainstream. People no longer laugh at you when you talk about wind and solar as major sources of energy. As I am writing this, I just saw an Energy Information Administration (EIA) report saying that wind and solar provided over 10% of the electricity for the United States in March 2017, the first monthly period in double digits. The cumulative total for 2016 was 7%. The focus is no longer on how to integrate those alien forms of generation from Mars into the grid but how to integrate the energy systems of the future, of which renewable energy systems are a major part, into a coherent whole. So how did we get here?

Dramatic Cost Reductions

One of the major drivers has been cost reductions. Both wind and solar have seen dramatic cost reductions in the past five years. Lazard has been releasing a cost of energy comparison report for at least the last five years. In it, a range of busbar costs for all major sources of energy is shown, calculated on a levelized cost of energy basis. I think it offers a good, although certainly not perfect, comparison. The report presents ranges of costs for each technology, based on clearly stated assumptions.

In the latest report, from December 2016, wind has the lowest cost of energy of any source, with a range of US\$32–US\$68/MWh, followed by utility scale thin-film solar photovoltaics (PVs) at US\$46–US\$56/MWh. The least-cost fossil option is a natural gas combined cycle at US\$48–US\$78/MWh. Coal comes in at US\$60–US\$143/MWh and nuclear at US\$97–US\$136/MWh. The wind and PV numbers are unsubsidized costs, and the fossil numbers do not reflect any environmental costs. I have seen wind power purchase agreements (PPAs) at US\$14/MWh, and PV agreements under US\$35/MWh, when the current incentives are included. These are some eye-popping numbers.

Corporate America Has Taken Note

Clean and sustainable energy has become a goal of corporate America, by which I mean the Fortune 500 companies such as Apple, Google, Tesla, Microsoft, Disney, GM, IBM, and

Walmart. The list goes on and on. Most major corporations now have a corporate sustainability officer and corporate sustainability goals. These are being met by some combination of purchasing renewable energy credits, entering into PPAs, and private project development. They are driven by pressure from shareholders, employees, and customers; people want clean energy. This has not historically been a partisan political issue, having gathered strong support across both major political parties. The extent to which this will continue is an open question.

The U.S. president's action in taking the country out of the Paris climate agreement has called into question the traditional support for clean energy policy in the United States. This action has been met with strong objection both abroad and at home. Abroad, we have only to look at such developments as the new website of the French government, Make Our Planet Great Again. At home, most utility chief executive officers (CEOs) speaking at the annual meeting of the Edison Electric Institute (EEI), the trade association of the nation's investor-owned utilities, came out strongly in favor of clean energy policy, including support for the carbon reduction objectives of the Clean Power Plan (CPP) that is under attack from the new administration.

What a difference two years makes. At the EEI convention in 2015, the message was that the CPP was going to increase costs and jeopardize system reliability. As mentioned earlier, the message this

year is quite different. Gerry Anderson, CEO of DTE Energy (I still call it Detroit Edison) and environmental chief at EEL, spoke about his company's recent carbon planning. "I really feel in many ways that our sector would be well served to get out in front of this and let the world know that we've got this one—we will deal with this issue," he stated.

He said that DTE discovered, during their planning process for the CPP, that it could affordably cut carbon 80% from 2005 levels by 2050. "We learned there's no sucker's choice here," he said. "You can have a healthy economy and a healthy environment at the same time." This is a very powerful statement coming from a spokesman for a very traditional industry known primarily for its conservative philosophy. And Anderson also said that his position is not an outlier in the electric

power sector. We have a carbon policy, whether we say we do or not.

The days of coal are numbered. And the funny thing is that it has little to do with regulation and a lot to do with economics. The age of coal is simply coming to an end. As recently as 2006 we were still getting 50% of our electric energy from coal; by 2016, just ten years later, it had dropped to 31%. According to EIA projections, a further decrease to 15–20% by 2025 is possible as renewables and gas continue to make strong inroads. The situation is trending in the same direction in Europe, while the outlook for coal consumption in the major economies of India and China is a little different. Current projections show them peaking in their coal production by the mid 2020s and declining thereafter. In just a year's time, from 2016 to 2017, global preconstruction activity on coal plants

was down by 48%, from a pipeline of 1,090 GW to 570 GW. Coal has powered the economies of the past, but it is being replaced by renewables and natural gas for the future.

The New Baseload Power

As I am writing this editorial, the U.S. Department of Energy, at the direction of Secretary of Energy Richard Perry, is undertaking a review of baseload power in the organized markets of the United States, due to a concern that renewable energy subsidies may be putting baseload power plants (nuclear and coal) at a competitive disadvantage and threatening system reliability. I cannot help but be reminded of a slide shown by Xcel Energy at a UVIG meeting a few years ago, showing the transition from a low renewables scenario, where wind energy provided a small amount of peaking energy at the top of the dispatch



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stack, to a high penetration scenario, where wind and solar provide the baseload power and fossil energy and storage fill in around it. A similar comment was made by one of our utility board members, where he noted that his president now speaks about wind as the new baseload power, and their remaining coal needs to follow the net load! Yes, the times, they are a changin'!

The Articles in This Issue

With this as a background, let me describe the great lineup of authors and articles that we have to address the issues around transitioning from a power system where renewable energy is a minor player to one where it is a mainstream player. We have seven articles with a broad and balanced set of authors from around the world.

The first article is written by a team headed by Aaron Bloom of the National Renewable Energy Laboratory, looking at what we have learned from a diverse set of wind and solar integration activities from the United States, Europe, and Australia. The article is meant to build a consensus on the lessons learned from this work done over a long period of time so that those approaching this for the first time will not have to learn everything all over again.

The next article, on energy storage and system flexibility, is written by a team led by Derek Stenlik of GE. Energy storage is recognized as a useful, but expensive, source of system flexibility that can be helpful under some situations for the integration of renewable energy today. It is expected to become more prevalent in the future as the cost of battery storage decreases with increased production.

The third article is written by an international team from Europe and the United States led by Jan Dobschinski of Fraunhofer IWES, in Germany. Probabilistic forecasts and the use of uncertainty information by transmission and distribution system operators in system operations is the focus of this article. Several practical applications of uncertainty forecasts are provided.

The next article is a very interesting one, dealing with the increasing applications of distributed energy resources and the issues created at the interface between the operation of the bulk power system and the distribution system. This article is led by Debra Lew of GE, with another team of international collaborators from Europe and the United States. The authors review the extensive progress that has been made and the work that remains to be done.

The fifth article, dealing with the increasing penetration of inverter-based generators and the migration toward an inertialess grid, is sure to cause us to reconsider some very fundamental ideas we have about power system behavior. The article is led by Thomas Ackermann of Energynautics in Germany, with participation from some of the leading international luminaries from the United States and Europe who are thinking about this problem from many different angles. It will challenge your thinking!

As the power system evolves, so must the markets that aggregate and distribute the energy and balance the system. The sixth article is written by a team headed by Erik Ela of the Electric Power Research Institute and includes leading market designers from the United States and Europe. Both Europe and the United States offer examples of market evolution and redesign that have been brought about due to the increasing share of energy from renewables.

The seventh and final article is another thought-provoking one, this time dealing with a new approach to the planning of the future system with a high share of renewables. It looks at planning the total generation and transmission system in parallel, subject to meteorology constraints, including both ac and dc transmission networks, and across synchronous zones. James McCalley of Iowa State leads the team of authors, with participation from China, Europe, and the United States.

A very thoughtful "In My View" column is provided by Mark Ahlstrom, the president of the UVIG board and a vice president of NextEra Energy Resources. He writes about the major structural transformation taking place in the in-

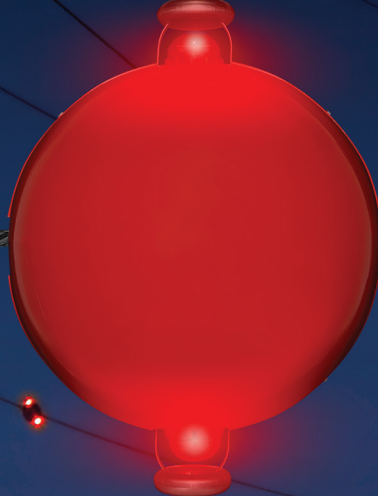
dustry, and that goes well beyond renewables. In his view, the old days are not coming back, but new opportunities are bright for utilities and energy companies that develop the skill sets and services needed for the future.

In closing, I would like to recognize the many years of service provided by the previous editor of the magazine, Mel Olken, and the new leadership being brought to

the magazine by Mike Henderson. Mel provided friendship, leadership, and encouragement to all of us who worked with him, and we will miss him, but we know he is only a phone call away. And I am looking forward to working with Mike, another old friend, to lead us into the future with a fresh vision and energy for the magazine.



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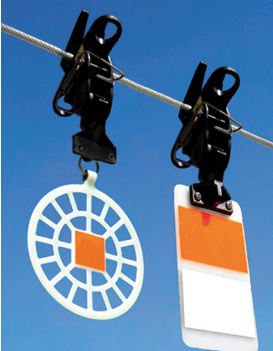


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