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The Transition to Natural Gas: A Roundtable Discussion

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Billed as one of the most energy efficient and responsive power plants in the U.S., the new 550-MW, gas-fired El Segundo Energy Center illustrates how far the power generation industry has come in the last 50 years. Photo courtesy: Siemens

The Shift to Natural Gas: Steady but SLOW

BY RUSSELL RAY, MANAGING EDITOR

Across North America, more than a handful of natural gas-fired power projects are in some stage of development amid low-priced gas created by a boom in the production of unconventional gas supplies.

According to most projections, gas prices will hover between $4 and $6 per million Btu for several years. According to ICF International, gas production from the Marcellus and Utica shale plays will continue to increase. The company raised its production projections for both plays to a combined 25 billion cubic feet per day by 2020.

"Despite a slight downturn in the Marcellus rig count over the past year, output has grown as producers reduce drilling time and increase the production per well," said Frank Brock, senior energy market specialist for ICF. "The Utica, which was originally expected to have higher oil production, has had a significant growth in gas production."

As a result, natural gas-fired generation is projected to grow 3.1 percent a year through 2038, adding 348,000 MW of gas-fired capacity to the U.S. grid, according to a report released earlier this year by Black & Veatch.

Most, if not all, of that capacity will be met with combined cycle gas turbine technology (CCGT). Natural gas-fired combined cycle plants are expected to account for 50.5 percent of U.S. power production by 2038, up from 25 percent this year, according to the report. By 2038, coal's share of the generation pie will drop to 21 percent, down from 39 percent in 2014.

In its 2014 outlook, the Energy Information Administration said natural gas will overtake coal as the dominant source of power generation by 2035. That's a significant change compared with EIA's 2013 outlook, which projected coal would account for most of the nation's power production through 2040.

The transition to CCGT technology is being driven by low gas prices, stricter regulation for coal plants, and the integration of growing amounts of renewable power. Combined cycle plants compliment wind and solar power because they can start and stop quickly, and thus are capable of offsetting the fluctuations in renewable power.

In addition to rapid-response times, combined cycle plants emit significantly fewer emissions of carbon dioxide (CO_2), sulfur dioxides (SO_2), nitrogen oxides (NOx) and other air emissions. CO_2 emissions from power plants using combined cycle technology are about 50 percent lower than most coal-fired plants. Emissions of NOx and SO_2 are 80 to 90 percent lower.

What does the future of gas-fired generation in North America look like? I

recently moderated a roundtable discussion with executives from GE Power & Water, Dominion, Bechtel, and the Electric Power Research Institute (EPRI) to address that question. The participants were: Scott Austin, business development manager for Bechtel's thermal generation business; Mark Dennis Mitchell, vice president-generation construction at Dominion; Revis James, director of Generation Research and Development at EPRI; and Scott Parent, Engineering Leader for GE's Distributed Power business.

What follows is a transcript of that discussion.

POWER ENGINEERING: Several new combined cycle projects are in some stage of development throughout North America. But the construction boom most were expecting did not take place. The construction of new gas-fired projects has been well below the industry's early expectations. Why?

AUSTIN: We all know electricity demand in the U.S. has been relatively low. In addition to that, you're seeing a lot of the energy efficiency measures and demand response being very effective. They're producing better-than-expected results. Those two things together have really reduced the demand for electricity. In 2013, electricity demand was still below the 2007 peak. Then you look at the supply side. While we saw quite a few coal plants retire, the capacity factors of those plants were on the low end. The effect of those plants retiring didn't result in the need for additional capacity to the extent that was predicted.

JAMES: I think there's risk aversion not only from the merchant standpoint but also a little bit of discomfort getting overinvested in an asset that if there were changes in fuel prices, there might be some added exposure there. Even though they're very cost effective and very flexible, it's getting more expensive and more difficult to build inside a gas-fired turbine than it was 10 years ago. We've heard some interesting stories about people taking a little more time and little more effort to get sites permitted and approved than they used to be.


REVIS JAMES, EPRI

MITCHELL: There are a number of factors which influence demand for new power projects, including economic development, unit retirements and other factors such as renewable generation growth and demand-side management. At Dominion, we've been very fortunate to enjoy continued growth in our regulated markets even during the economic downturn. The PJM load forecast indicates the Dominion Zone has the highest projected growth rate at 1.8 percent a year. We have actually been building quite a bit of new generation. We completed a coal plant in 2012 and have converted some of our older, smaller coal units to biomass or gas peaking units. We currently have two 3x1 combined cycle power plants under construction. That includes our 1,329-MW Warren County project, expected to be in service late this year, and our 1,358-MW Brunswick County project, expected to be in service in mid 2016 In addition, our integrated resource plan projects a similar size unit would be required by 2019.


MARK MITCHELL, DOMINION


SCOTT PARENT, GE POWER & WATER


SCOTT AUSTIN, BECHTEL

PARENT: We see this regionally in the U.S. We see the Northeast up. We see the Southwest up. We see the rest of the country kind of flat. They're not up by huge ticks, so the question would be are we seeing a big enough gap around capacity that people are going to make those investment decisions? Or are they going to hold them off a little longer? In the Northeast and the area around the Gulf, where there is a lot of economic activity, we think those decisions might be made a little sooner.

POWER ENGINEERING: We've seen a substantial increase in capacity factors for gas-fired power plants for a number of reasons. Clearly, power producers are counting on gas to supply a larger share of baseload capacity. As these plants run longer and harder, how important is it for power producers to revisit and adjust their O&M strategies to reflect the actual operation of these plants?

JAMES: The amount of money power companies want us to spend on research related to preventive maintenance activities to extend the life of components and life extension activities of various sorts has increased steadily

over the last several years for combined cycle and gas turbines. I think that's a response to people trying to operate these assets longer or in different ways. We have a program focused on heat recovery steam generators. We've certainly seen some challenges related to reliability to those components related to thermal transients. There's an increased focus on diagnosing those problems, anticipating those problems and modifying your operational and maintenance approach to try to mitigate those problems.

MITCHELL: Based on reduced gas prices relative to other fuel types, we have seen shifts in some of our stations' capacity factors from one fuel source to another over certain periods. This includes our combined cycle plants running as base load units. As with any of our units, we do monitor and adjust O&M strategies as needed to support these changes as the market demands. For our newer combined cycle units, they are expected to run as base load units with O&M forecast based on that expectation.

AUSTIN: You can look at this issue in two ways. You are running these units longer and harder. But if you look at a combined cycle plant, one of the biggest O&M challenges result from frequent starts and stops. When you're running at these high temperatures and you're using a advanced nickel based alloys and coatings, that could lead to some of the more significant O&M issues. Running these units as a true baseload operation may, in fact, not be negative from an O&M perspective. Having said that, we work closely with our combustion turbine suppliers and advise clients they put in rigorous training programs during the commissioning stages to get that hands-on experience prior to going into the operations phase of a project.

PARENT: We're seeing both the interest in uprating equipment to squeeze another 5 or 10 percent load capability, which could have significant lifting effects on all of these products. People are looking at their fleet and saying "Is there a way I can manage to squeeze a little bit more life or capacity?" That would be the first piece. The second piece is, I think in terms of age/mission knowledge of the equipment, going to see a doctor for the first time when you're 55 is a mistake, you can't get a trend. You get information, but it doesn't give you an understanding of how the equipment was performing or has been used historically. We need to wire and collect historical data to better estimate and optimize a product's remaining life. We find folks willing to say I may change the application of this piece of equipment based on knowing more about the history and how that can affect the longer term performance.

The third thing, and it's a big push for us in our services business, is this push for advanced gas path solutions to all hardware coatings and materials. As we work our way to the turbines and our reciprocating engines, how do we enhance the key life components and re-extend the life of a product? There is obviously huge interest in this space. It's a way to get more megawatts sometimes and it's a way to potentially get more availability and reliability.

JAMES: As we have spent more time developing some of the maintenance research results, one of the side effects is that more work is being done on our instrumentation and controls program to develop capabilities to measure things that are really important for longer periods of time. Even if we are seeing higher capacity factors and more cycling of combined cycles, those mission profiles could change, depending on economic conditions and other externalities.

POWER ENGINEERING: According to one report, gas-fired combined cycle plants will account for a little more than half of U.S. power production by 2038. As more gas-fired facilities come online and more coal plants are retired, are there concerns about maintaining a diverse fleet of generation?

MITCHELL: History has shown that a diverse fuel source is very important over the long haul and it is certainly important to understand the implications of moving too much toward a single fuel source or any single criteria which could impact a large portion of your generation fleet. As I mentioned, we have a number of projects in construction now which represent several thousand megawatts. If you look at our Integrated Resource Plan, we recognize the need for fuel diversity and continue to develop other generation sources to make sure we maintain a balance over the long term. This includes early development and licensing of a new nuclear plant and development of Offshore wind which is a resource in Virginia. We recently secured a wind lease area offshore of Virginia and we're participating in a demonstration project for the advancement of offshore wind. Fuel diversity is something we monitor very closely.

JAMES: We've done a number of analyses over the last decade looking at the impact of various sorts of policies and what kind of technology implications they would have. There's a monetary value to a diverse fuel mix that manifests itself in more economic growth. We're pretty much convinced that every technology – even gas with all of its strengths – has vulnerabilities. You have to hedge that risk. A diverse fuel mix helps with that. That will be a risk to manage as we move forward with gas. There is a lot of evidence that says there is quantitative economic value to generation diversity.

PARENT: The age of such inexpensive gas in the U.S. is driving people to think very differently about not only the application but the distribution of gas. It could potentially bring with it an incredible increase in manufacturing and other things as energy prices overall go down. I

GE recently introduced its 9HA gas turbine, an air-cooled high efficiency turbine with firing temperatures exceeding 2600oF for 50Hz and 60Hz combined cycle power generation. Photo courtesy: GE Power & Water

wouldn't suggest today that gas goes from 30 percent to 50 percent and coal goes from 50 to 30. But I do think it's something everybody's going to look at more opportunistically moving forward.

Austin: The question is what is the balance and how do you strike that balance? Most of our customers are moving forward with gas plants. We believe technology will help drive where those choices go. We believe offshore wind has a role to play in the future. We're building up our capability in the offshore sector. We can't ignore that the role energy storage will play as we move forward.

POWER ENGINEERING: Modern-day gas turbines and combined cycle systems operate at higher temperatures and higher efficiencies. The energy conversion rates for combined cycle plants range from 50 to 60 percent. Is there room for more efficiency improvements?

JAMES: We have a history of being able to improve efficiency. The higher firing temperatures and higher pressure rates would enable us to reach higher efficiencies, maybe as high as 65 percent. That would lead to new materials requirements. We are certainly spending some time and money on high temperature materials at EPRI. The balance of plant for combined cycle has to come along with that. Demand growth and higher gas prices overseas might help drive the continued development of improved technology and more efficient technology. An uncertainty, though, would be where the break-even point is in terms of improving efficiency versus the cost. That's a function of fuel prices, demand and other market factors.

MITCHELL: We have seen efficiency gains and would expect to see efficiency gains to continue. In our large combined cycles, we highly value efficiency because we expect these large units to run at baseload. The higher firing temperatures typically associated with higher efficiencies are a concern which

we evaluate as the OEMs continue to advance their designs.

PARENT: We believe there's more room for improvement in that space and the balance of plant, where further investment in technology would be needed if we wanted to bring the whole system up to higher efficiencies. Software will play a huge role moving forward, a bigger role than the hardware in the short term. We say we want to move average efficiency to a higher level of capability. We're starting to see opportunities to bring efficiency to our customers. We're basically following a curve. But we have a lot more information to work with to optimize that curve. We have a 10-MW gas reciprocating engine - the J920 FleXtra - that has 20 cylinders. Each cylinder's peak pressure is controlled individually. Therefore, we can get the overall efficiency of the engine higher by making sure all cylinders are optimized for their as-built variations.

AUSTIN: I agree with working with the customers to chase the average efficiency. How do you operate the plant and design a plant to operate in the most efficient way? We ask what is going to be the driver for chasing that efficiency, especially in the U.S., where we have low-cost gas. Is that efficiency, the cost of the new materials, and the risk of introducing new technology worth that investment?

POWER ENGINEERING: To build a combined cycle plant, an investor must be able to make an adequate return on that investment. Right now, does the market provide that kind of surety?

MITCHELL: There has to be some reasonable surety of a fair rate of return to invest millions of dollars to build these new, larger stations. That can be through the rate structure, or a PPA can provide that rate of return. We do have a regulatory system that recognizes the need for a fair rate of return once the project is approved. That is what has enabled us to be successful in building a large infrastructure in Virginia. We have a very good track record of executing projects safely, on time and on budget.

AUSTIN: We're keenly aware of the market dynamics. As Mark just said, we love to see that surety of a PPA. Surety is not the word I would use to describe the environment for investing. Having said that, I think there are certain pockets of opportunity - the area around the Gulf Coast, the Southwest and in the PJM. Scott earlier mentioned the area around the Gulf Coast, the Southwest and in the PJM. We think there are opportunities there. They are increasingly difficult to find, but with the right amount of diligence, there is opportunity to get the return to justify investment.

"Our combined cycles, for the last few years, have run essentially as baseload units."
- Mark Mitchell, Dominion

POWER ENGINEERING: Many combined heat and power (CHP) plants are fueled with natural gas. The Obama administration wants to increase CHP usage 50 percent by 2020. Low gas prices are expected to promote the construction of new CHP plants. Do you agree? Is CHP an emerging market for gas-fired generation?

PARENT: They are small projects, but they are special and very different. An example of that would be a greenhouse project we did recently in California. We delivered a couple of our J624 gas reciprocating engines, and they're providing CO_2 for the greenhouse, they're providing heat, and they're also providing power. Additionally, we're also using condensed water from the exhaust – about 10,000 gallons a day – to go back into the greenhouse.

When we look at these kinds of distributed CHP projects, they make great economic sense and the environmental impact is also quite unique. In this case, the payback was quite quick. I think what we're seeing is really good economics with specialized factories and processing plants that make great sense.

POWER ENGINEERING: What's your outlook for gas prices?

MITCHELL: Predicting gas prices has been a difficult task over the years. Most forecasts will end up being wrong at some point. We're involved in processing gas out of the Marcellus and Utica Shale. I would agree that gas prices should remain stable for some time. With that said, there can be large swings in certain regions or at certain periods, as we saw this past winter where the polar vortex caused extremely large swings in gas prices on a short-term basis.

AUSTIN: Our view is that over next five to 10 years, you're looking at sub $6 gas. That's weighted against the level of gas exports and any environmental restrictions placed on the extraction techniques being used today. We are planning for a continued build out of combined cycle plants over the mid-term.

JAMES: We stay away from those projections. Nobody needs our help with that. pe

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