Three Important Things we Don't know About Electricity Innovation

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Innovation is about things we don't know, which makes it really hard to discuss and predict. Today I would like to talk about three aspects of innovation that could have a huge effect on the shape of the electric industry. In all three of these areas we aren't thinking properly about the driving forces and likely impacts of innovation. These aren't the only three, but they are near the top of the list.

First is the cost of large engineering projects. Innovation isn't just about new ideas and individual technologies. It is also about how those ideas fit together into systems that are workable and cost effective at scale. For the electric power industry, especially, it is reliability and affordability at scale that matters. We don't lack for cool ideas, but when we think about real innovation that could transform the electric power system to deal with challenges like energy reliability and affordability and climate change it is practicality and scale that matters. Doing things at scale with central power stations requires engineering and construction of whole systems—not just individual technologies. Construction costs dominate in any practical vision for technological transformation of the industry. My first topic concerns innovation and cost in construction.

[slide 2]

This slide shows the *Chemical and Engineering News* index for large chemical plant costs—an index that is germane for projects such as IGCC with CCS or gas with CCS. Thanks to George Booras and Jeremy Platt for sharing this slide, which those of you in the coal council saw last week. Other indexes, relevant to other kinds of advanced plants in the industry, show similar trends. We are in the midst of a boom in construction costs that hasn't much abated during the world financial crisis—in large part due to continued strong growth in Asia.

And the conventional wisdom is that future costs will keep on rising. We are looking to a future where construction and systems engineering is a lot more expensive than during the period when most of the power systems in the western countries, such as the US, Europe and Japan, were built.

It is plausible to imagine a future that is exactly the opposite—big plants with extremely high performance built with very low capital costs. The opportunities lie with innovations in robotics and systems integration, innovation in materials, smarter regulation, and competition. I run an EPRI-funded lab that has just started to look at the interaction between regulation, competition and innovation in this space and it is pretty extraordinary what can be achieved through innovation of this type.

[slide 3]

In fact, you can see this at play today by looking at the variation in capital costs for plants we already know how to build. This next slide shows the capital cost of nuclear plants worldwide. There is almost a threefold variation. The places that are building new plants in large numbers such as China have the lowest costs—in particular, I highlight what Korea has done on this front. This pattern of huge variation in building equivalent plants around the world indicates the potential for improvements in system innovation through competition. And it isn't unique to nuclear power. My group has looked at this same issue in advanced coal plants and we see a similar pattern, with the Chinese now setting the world standard. For a long time analysts thought this was something unique to working in China or Korea and those skills weren't portable. I don't think that is true. We are now seeing the spread of these lower cost engineering skills globally. A few years ago the IMF took a close look at how Chinese engineering firms were competing globally, which is hard to do because that competition is taking place on the periphery of the world economy, such as in Africa. Yet when you strip away all those differences you see, as the IMF concluded, that Chinese competition has in fact lowered the cost and accelerated the spread of innovations in large plant construction. You see some similar things with Korea's role in the Abu Dhabi nuclear plant. And that's just the beginning.

My first point is that innovation and competition in construction will have a huge impact on any future vision for this industry. It is an interesting topic to think about on EPRI's 40th birthday because a lot of what EPRI's first boss, Chauncey Starr, originally imagined for the industry—large, centralized plants interconnected with continental supergrids—sinks or swims on the cost of building large-scale engineering projects. If you think the cost of large engineering projects will be extremely low then the future of this industry is akin to what Chauncey imagined. If you think those costs are high then the future for this industry is in demand response, decentralized power supplies, and probably a lot of gas burned in conventional turbines.

We don't know the answer to this question, but the answer really matters. Almost everything else we study in the electric power industry depends on whether it is cheap or costly to do big engineering projects.

The second point I would like to make concerns the role of the federal government in innovation. Talking about the federal government's role in anything these days is hard to fathom. Yet it is hard to escape the conclusion that innovation is a public good and nobody will supply that good at scale. That's why government exists. The actual experience with government providing these kinds of public goods varies; often it does quite well, as we are seeing today, for example, with ARPA-E.

[slide 4]

This next slide is a warm chestnut in our industry. It shows the perilous decline in federal support for energy RD&D—from the peak around 1980 to today's level, which is about half. There was a brief peak linked to the stimulus program—a hiccup we are still digesting—but that wasn't sustainable and we have largely reverted to historical patterns with a modest amount of growth. One of the big accomplishments of this administration is its serious effort to turn this picture around. Yet it is hard to avoid the conclusion that we still under-spend for energy R&D—not just in total dollars but also as a fraction of GDP. (See slide 4, inset.)

On this slide I also show the various proposals—from the Gates/Immelt commission to the Climate Group—for boosting federal RD&D. These are striking numbers. People are talking about doubling (or more) federal spending in this area over a decade. This is fun to talk about, but it isn't connected to reality for two reasons. One is that, for far too long, there have been bold proposals that focus on spending and not enough on how we could spend such resources wisely. The energy industry isn't alone in such dreaming, and we can look to other industries to see what might happen. The US doubled federal spending on biomedical research over roughly a decade and we didn't double productivity in that field—instead, a lot of that new money just bid up the cost of research. The other reason, of course, is that the politics of securing $15b or more for federal energy research is getting a lot harder and is probably impossible for the foreseeable future.

So this is my second point. We need to lay out a practical vision for innovation for the federal role in energy RD&D in light of these new realities. My view is that that vision will rely more heavily on industry self-funded RD&D through organizations like EPRI in part because such investments are less visible on the federal budget. It should make more strategic use of institutions like ARPA-E. It should rely on arms-length institutions such as the proposed CEDA.

A practical vision for energy innovation should put greater emphasis on international coordination of RD&D agendas because new knowledge is a global public good. We here in America should care a lot more about the effectiveness of the RD&D programs in the rest of the world—including the emerging markets such as Brazil and China. The last decade has seen a radical shift in global innovation—notably with the rise of Chinese spending on energy R&D and even more importantly the transformation in the organization of the Chinese R&D system,

which appears to have radically increased the performance of the Chinese R&D system.

We in the EPRI community need to lay out this kind of practical vision for energy innovation in our new era. Not because it is defeatist about what is achievable in Washington but because it is realistic. And simple, bold visions like those shown on this chart are passé. The numbers matter a lot less than the practical vision for innovation. EPRI itself can't do that because it will be seen as self-serving. But it's friends can.

[slide 5]

Third, I would like to talk about gas. Gas is, of course, at the center of innovation in the electric industry. Big innovations in gas supply and utilization could secure a future for that fuel in electric power supply. And the failure to innovate adequately in other fuels will make gas the default option. We have a whole panel on gas chaired by Jen Snyder later today, but I would like to make just one point about innovation in gas.

We are in the midst of one of those periods where the gas supply and electricity industries have radically different visions for the future of the same fuel. In January I ran a poll of CEOs from both of these global industries on their vision on questions such as the share of gas in electric supply over the next two decades. There were striking and systematic variations, with gas suppliers a whole lot more bullish about how much of their fuel would get used when compared with the electric companies that are expected to be the big buyers of this fuel.

For the gas supply industry, shale gas is the new new thing that will change everything else For the gas users this is a movie we have seen before.

We in the electric industry need to pay very close attention to innovation in gas. The innovations in fracking, of course, are important. They are real and they are a big deal. But the innovations in regulation and the environmental footprint of the shale gas industry are equally important. They could have a huge effect on the amount of shale gas that is practically available and the cost of that gas to you.

One way to think about this industry is that it is a race between two forces. On one side is the ability of the shale gas industry, especially the independent producers, to inflict wounds on itself. Those wounds, which are rooted in the whole business model of the independents, have put blood in the water. They have raised questions about the financial sustainability of this growth model and, more importantly, the environmental footprint. All kinds of interest groups have flooded in, pressing for different kinds of regulation in response to legitimate worries about the industry's effects on water quality, air pollution and other concerns. The result is regulation that, in effect, will take sections of the shale gas resource out of play.

You know things are bad when an expose documentary about the industry is nominated for an Academy Award, as *Gasland* was last year.

On the other side of this race is innovation—not just in technology for cutting the environmental footprint but also regulation, which could unfold in many different ways.

How should we think about the likely evolution and impact of regulation in the shale gas industry? Our group has started on that question by looking at water regulations related to surface runoff and deep injection. The governing statutes in this area make it relatively easy for pressure groups to mobilize against fracking at "veto" projects—in effect, to block development of certain kinds of projects or whole geographical areas such as New York state or the Delaware river basin. There is a set of theories about this—called "veto point" theory—and we have for the first time taken those theories from political science and applied them to shale gas.

You can do this for the Marcellus shale—where the rubber meets the road on water regulation. By our estimate maybe 40% of the Marcellus resource won't be available due to water regulation. That's not a guaranteed outcome—regulations could be developed in flexible ways (especially if industry self-regulation leads the way) or they could emerge in ways that encourage veto points, which will lead to higher regulatory costs and larger acreage made unavailable.

You can do this simple veto points analysis for the rest of shale, which we have done here—using the IEA regions. And then you can do it for the whole USA, with the result that maybe one-quarter of the shale resource will prove unusable. This is a crude first effort; more sophisticated efforts, which we are now planning, would link this to gas prices. And still more sophisticated efforts would apply the same methods to air pollution.

I have focused here on innovations in regulation and how they interact with gas supply. As analysts we can study the innovation—good and bad—in this regulatory environment and we can help sharpen our discussion about the future of gas. Obviously regulation isn't the only factor at work; one other that is important to highlight is the interconnection between the US market and the world. Low gas prices here in the US come from many factors, but one factor is that after a decade of growing interconnection between the US gas market and the result of the world the arrival of shale gas (along with economic recession) decoupled America from the world. I doubt that is sustainable as other countries turn to LNG and as people look, even, at LNG exports from the US. That will inevitably reconnect US gas prices and the rest of the world and it will change how gas prices are formed. In short, that probably means higher gas prices and price formation that reconnects, at least partly, with oil prices since so much of LNG in the rest of the world is priced partly with reference to oil.

So that's my list of the top three topics in innovation. They are the dull but important issues surrounding construction and systems engineering. Second is a practical vision for an innovation strategy and the role of the federal government. And third is the innovation in shale gas supply, where our vision for the future hasn't adequately reflected the likely role of regulation.

All three have the potential to reshape the industry in material ways, and in all three I don't think we have outlined the right way to think about how innovation will unfold.