Changing Currents: Turbulence for the Electricity Industry?



THE ASPEN INSTITUTE

Energy and Environment Program

2011 Energy Policy Forum

Phil Sharp, Chair
Gernot Wagner, Rapporteur

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Foreword

A series of issues and opportunities identified in past Forums led to the choice of topics for the Aspen Institute's 35th annual Energy Policy Forum. An invited group of energy leaders and policy experts discussed "Changing Currents: Turbulence for the Electricity Industry?" from July 3-7 in Aspen.

As in previous years, the Forum relied on dialogue to explore commercial and public policy issues at the intersection of energy, the economy and the environment. Each half-day session started with short introductory presentations, and a spirited, off-the-record dialogue followed.

Following the failure of cap-and-trade legislation in the previous Congress, the Forum discussed other options to mitigate climate change such as state and regional initiatives, enhanced energy RD&D, EPA regulation, clean electricity standards, and carbon taxes. Aging infrastructure, along with the possibility of rapid retirement of older coal plants, led to discussions about the security, reliability and adequacy of electricity infrastructure and the enhancement and replacement of generation and transmission facilities.

The introduction of two mass-market electric vehicles in the past year gave greater immediacy to questions about electrification of the

transportation sector, and mandates and proposals to increase the use of renewable energy led to discussion of various policy changes to achieve this goal.

Following the crisis involving the reactors at Fukushima, a session on the future of nuclear power in the United States was added to the agenda. It included questions of safety, economics, policy incentives, and public support. China's rapid electrification poses a host of questions for its own and global energy markets, and in the final session the group discussed what is happening there and what lessons it may offer for U.S. policies.

The dialogue was chaired by Phil Sharp, President of Resources for the Future and former Chair of the House of Representatives Energy and Power Subcommittee. His experience, broad perspective, and good humor gave him the ability to focus the discussion on key issues. The highly qualified session chairs and speakers provided a wealth of information and a variety of perspectives, and the diverse expertise of the well qualified participants added to the richness of the dialogue.

The Institute acknowledges and thanks the following Forum sponsors for their financial support. Most have been participants and supporters for many years. Without their generosity and commitment to our work, the Forum could not have taken place.

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On behalf of the Institute and the Forum participants, I also thank Gernot Wagner, who served as rapporteur. He identified important themes from a rich and varied discussion and prepared a vivid summary. Timothy Olson managed the administrative arrangements for the Forum, and I am grateful for his support. As many participants have noted, his thoroughness and dedication were responsible for a smoothly run meeting. Nikki DeVignes ably and cheerfully assisted in the advance arrangements.

This report is issued under the auspices of the Aspen Institute, and the chairs, speakers, participants, and sponsors are not responsible for its contents. Although it is an attempt to represent ideas and information presented during the Forum, all views expressed were not unanimous and participants were not asked to agree to the wording.

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Changing Currents: Turbulence for the Electricity Industry?

Gernot Wagner
Rapporteur

Policy Uncertainty Meets Uncertain Politics Meets Often Painful Certainties

The question is never whether the United States has an energy policy. It has dozens. They come with various decision-makers at overlapping levels of authority, ample numbers of stakeholders, and generally lots of confusing and often contradictory signals.

Congress has been the locus of decision-making over the past half a decade, but by now most attention has shifted from legislation to regulation. The Environmental Protection Agency, in particular, has garnered significant attention—both positive and negative—with its long-delayed rulemaking in various areas. These rules cover everything from tighter ozone standards, the transport rule involving local and regional air pollutants and their effects on neighboring states, as well as greenhouse gas regulation prompted by the 2007 Supreme Court decision in *EPA v. Massachusetts*, which requires EPA to address global warming pollution.

Often the only question is whether Congress will act to overturn or delay EPA's regulatory efforts. That seems unlikely, given Congressional paralysis and threats of Presidential veto, but political doubts remain nonetheless. The ongoing debt discussions, in particular, could add another level of uncertainty related to EPA's authority.

Five current major uncertainties and at least one recurring certainty—the important role of China—govern the world we live in.

First, where is consumer demand going? If electricity use does, in fact, decline as either bearish economists or bullish energy efficiency enthusiasts would prescribe, the energy landscape will be very different than if demand were to increase in the decades to come.

One certainty here is that while U.S. demand may be stagnant, Chinese demand is clearly going up, with equally profound implications for everything from electric vehicles to global coal supplies and the price of solar technology.

Second, are new shale gas supplies here to stay? Citizen concerns over fracking may yet cause massive uncertainties in the supplies of shale gas, but they are not all that is at stake. How will coal supplies develop? How will renewables be affected? What new new technology will eventually displace gas as the coal replacement of choice?

One certainty here is that China will play a large role in coal markets for the foreseeable future, driving up global coal prices even further relative to natural gas.

Third, where is U.S. climate and technology policy heading? Carbon pricing looms large, but it is unlikely to come on a federal, economy-wide level soon.

One certainty is that other countries, including China but especially Europe, are moving ahead of the United States, and may well gain competitive advantages that will be difficult to match later on.

Fourth, what has EPA wrought, and what does it have in store? Long-delayed old rules and new rules are on the horizon. But the when and how are still a big question. Moreover, will new rules be far-reaching enough to tilt the balance toward renewables on a national level, or will we continue to build coal and natural gas, just with a steeper price tag?

One certainty is that China is moving ahead with its own set of ambitious renewable targets. It will be building massive amounts of new coal plants, but it's also bound to take a global leadership role in renewables.

Fifth, what does Fukushima mean for nuclear power, new and old? Reactions around the world have been markedly different. In Germany, nuclear energy will soon be a thing of the past. In the United States, new nuclear power seems to be as uncertain after Fukushima as it was before.

One certainty is that China is building more new nuclear plants than the United States has to date, and is bound to take a global leadership role here as well.

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The subsequent sections will address these five uncertainties, the uncertain politics of it all, and the certainty of a rising China. Even there, though, uncertainties are all around us: Where will China's rise lead—especially in a carbon-constrained world? That's our first stop.

Alternative Approaches to Climate Change

With the failure of comprehensive, national climate legislation, most of the policy and regulatory action has left the halls of Congress and instead found willing takers in federal agencies and states.

Over half of U.S. states have renewable portfolio standards, almost two-thirds have state climate action plans, over twenty have state-wide greenhouse gas emissions targets, and a full dozen have started or already completed adaptation planning efforts to be able to respond to the inevitable effects of climate change.

Moreover, states have taken on the task of creating comprehensive cap-and-trade systems that the federal government has so far failed to do. California is leading the pack with its AB 32 legislation that will establish a comprehensive, state-wide cap-and-trade system by 2013. It is also part of the Western Climate Initiative, a coalition of seven states, which comprise almost 15% of U.S. greenhouse gas emissions, and four Canadian provinces.

Other regional initiatives include the Regional Greenhouse Gas Initiative. It is currently under severe assault, not least because Governor Chris Christie has decided to pull New Jersey out of the initiative and repeal initiatives and legal challenges are under way in other states. Nevertheless, RGGI has generated over $800 million in

revenues from auctioning greenhouse gas emissions credits, and that despite a loose overall emissions cap resulting in very low allowance prices.

It is clear that a plethora of state laws will inhibit efficient regulation of greenhouse gases in the United States, but failing federal action, state-level legislation and regional initiatives have the potential to make a significant difference in overall reductions. States together with EPA regulatory efforts could achieve as much as half the greenhouse gas emissions reductions federal legislation would have promised to do.

While climate policy driven by a cap or price on carbon is a key pillar of reducing emissions and jump-starting the green economy, support for clean energy innovation plays a similarly crucial role. It can lower the cost of achieving any particular emissions reduction target, and it can help make goals more ambitious by lowering cost barriers.

More fundamentally, we know we have two massive market failures: one is the negative environmental externality, which is best combated by capping greenhouse gas emissions or putting a price on them—cap-and-trade or a carbon tax. The second is a positive technological spillover externality. Inventors don't consider the fact that they will eventually provide shoulders for others to stand on. That's a social benefit to private innovation that's not considered in individual decision-making.

It's also where public support for clean energy innovation comes in. The need for subsidies for development and deployment is clear; the political will for it is much less so.

One political justification is international competitiveness. A key question there is whether we can have a robust energy innovation

system without a robust domestic manufacturing sector. The answer may well be no, if we believe that innovation tends to follow manufacturing. In that case, direct subsidies for targeted industries may play an important role.

We do already have some ready support in the form of research and development tax credits. The challenge is to make them permanent, or at least extend them far enough into the future to create a predictable policy environment.

Another important dimension is direct government support for innovation. That includes basic research as much as targeted research for the development of clean technologies and, ultimately, their deployment. The Department of Energy is leading many of these initiatives, although it, too, lacks funds and often focus. Many initiatives are under increased pressure from Congress just as demand-driven greenhouse gas policies like cap-and-trade and a carbon tax are off the table for the time being. That, of course, doesn't make supply-side policies less important.

To the contrary, the central policy and political question is in how far supply-side policies can substitute for a lack of demand-side options. Or more poignantly, how to jump-start a green economy and achieve emissions reduction goals now that comprehensive, federal cap-and-trade is dead for the foreseeable future?

Three possible alternatives to cap-and-trade are EPA regulation, Clean Electricity Standards, and a carbon tax.

EPA regulation is the most realistic of the three options, mainly because it requires no Congressional action and is already largely underway. It is also rather complex. For one, there is considerable concern around market-based approaches related to interstate and other rules. The more flexible the system, the trickier is EPA's legal authority.

There are also other, more fundamental challenges. The Clean Air Act, on which all present rules are based, states explicitly that anyone with annual emissions larger than 250 tons needs a permit. That threshold is sensible for sulfur dioxide, nitrous oxides and other criteria air pollutants. It is not practical for carbon. EPA has recognized this and passed the so-called "tailoring rule," which sets the threshold at 100,000 tons. Critics, however, are challenging the legal grounds for the rule. If EPA is forced to follow the letter of the law, regulation would not just be impractical but also extremely costly to administer and comply with.

EPA has an obligation to implement the best system of emissions reductions, which may well be to let states take the lead in pursuing cap-and-trade approaches in compliance with federal clean air statues. However, there are clear disadvantages to a state-by-state pollutant-by-pollutant approach, which would limit the reach of the program and also its cost-effectiveness.

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Hence a lot of hope is still put into Congressional action. One possible approach could be a nation-wide Clean Electricity Standard that sets a maximum level of greenhouse gas emissions per megawatt hour of electricity produced. Such a standard would remove the necessity for state-level renewable portfolio standards, currently in place in over half of states. "Keep it simple" is generally one of the key design principles, given how important simplicity and predictability are for those making investment decisions. Another key component is price or cost certainty.

Ideally, such a standard would employ a technology-neutral metric that is agnostic as to how companies ultimately comply. Another key characteristic is that CES credits ought to be tradable. That might open up the system to charges that it is really just a back-door cap-and-trade system, but it also makes it significantly more cost-effective than a static approach. Trading makes compliance cheaper and also allows for a more ambitious target in the first place.

A possible benchmark could be a system that starts with a target of 0.4 tons of carbon dioxide per megawatt-hour of electricity produced in 2015, declining to perhaps 0.2 tons by 2035. This standard would bring about a significant change in the power sector. It could also be combined with a cap on the price of credits traded in the market. Higher prices would trigger the sale of further credits, with the money raised spent on clean energy research.

A smartly designed—yet still simple—CES might be a credible alternative to EPA regulation. It would likely be both cleaner and more cost effective, and it would avoid the risks of Congressional and legal challenges that EPA faces. It would, of course, face formidable opposition to passage in the first place.

A more ambitious alternative to EPA and state-level action would be a carbon tax. The rationale for pricing carbon is simple and will surprise no one: carbon has a social cost; it ought to have a price. The policy: set such a price via a nation-wide, top-down carbon tax, and get out of the way.

The politics of such a venture are trickier. "T-a-x" is a four-letter word in Washington. That said, the political urgency is clear, and climate is only one reason. Another is to raise additional revenue and help achieve fundamental tax reform.

One could imagine taking all carbon tax revenue and devoting it to a trust fund whose sole purpose is to reduce corporate income and payroll taxes, while at the same time removing as many tax credits and other exemptions as possible.

Like a CES, an ideal tax would be uniform across fuels. The goal is not to pick winning technologies, the goal is to decrease carbon and greenhouse gas emissions. Almost every form of energy has some side effects that we may not like for one reason or another.

Why would this possibly work?

It's not cap-and-trade; it's fundamental tax reform. The corporate income tax is the worst tax when it comes to international competition. However, it's impossible to imagine corporate tax reform without raising revenue somewhere else. A carbon tax could fill that hole.

Moreover, we now have a test case in British Columbia. The province has a carbon tax, and the government is sending a monthly check to households, refunding revenues in a lump-sum fashion. In many ways, it is the ideal economic design, and we should pay close attention to how the politics play out.

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Regardless of whether the federal policy outcome will look more like a Clean Electricity Standard, a carbon tax, or perhaps even cap-and-trade, the reasoning behind federal action is clear. The more we let state policies get ingrained, the longer they will stay in place. We don't need fifty different climate policies.

Infrastructure Reliability and Adequacy

Electricity is one of the essential services driving economic growth and human progress. It is also often taken for granted.

That puts electric utilities and especially regulators and policy-makers in a difficult position, given that electricity also shares several other, competing characteristics: it must meet customers' (and the economy's) demand for reliability, it's unbelievably regional and local, it's very capital intensive and thus hard to change rapidly, and it has a large environmental footprint.

All of these characteristics and competing priorities are important and present real trade-offs for regulators and policy-makers. Electricity policy, to no small extent, is often muddled precisely because it's being pulled in many different directions.

One priority that often gets short shrift, at least from the general public, is reliability. It is more often than not simply taken for granted, with few wanting to pay extra for more reliable service.

A key question in this context is the trade-off between conventional fuels—chiefly coal, natural gas, and nuclear—and newer, lower-carbon (or non-nuclear) alternatives. But before we look at both, let's look at an area that's all too often dismissed but is pos-

sibly even more central than power generation: transmission and distribution of electricity.

The grid is vulnerable to crippling disruptions that can cause real economic and human havoc. FERC itself—its main building in Washington, DC—was without power for 3 days not too long ago. One would think that this would have lead to an investigation of sorts looking into grid stability. Alas, no such luck.

Investment in grid technology is absolutely crucial. However, transmission investment is lagging electricity demand increases, and the effects are being felt. Half a million Americans experience power outages of two hours and more per year, largely due to interruptions in the transmission and distribution grid. Any interruption, of course, comes with enormous costs.

An apt comparison here is to the interstate highway system. It was clear from the beginning that the highway system was crucial for the economy and national security, and that's how it was sold: as part of an integrated plan that included national security as a crucial justification. The Federal-Aid Highway Act of 1956 is popularly known as the "National Interstate and Defense Highways Act of 1956," and for good reason. Grid modernization should be presented in the same way: elevated to national security level.

In this context, the gaps in federal regulatory authority are deeply concerning. Transmission, in many ways, is a national and regional issue, whereas transmission siting policy is often done on the state and local level. States also have authority over pricing, with regulators in one state often deciding whether a utility can charge customers within a state for transmission elsewhere.

A possible sleeper issue is local distribution and its relationship to transmission. One of the key questions is whether it is possible to address the challenges inherent in traditional investor-owned utility models, where utilities invest in generation but little in transmission

and distribution. Once again, it may well be necessary to have a program led by the federal government, perhaps linked to national security.

But we ought to plan for all eventualities. Right now we are identifying massive needs for new transmission investment. Will that be truly necessary as the world moves toward a distributed model of electricity generation? Would we be putting too many assets into something that's inflexible and not reversible? Uncertainty is a real caveat here, too.

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Fossil fuels—in particular coal and natural gas—play a key role whenever discussion moves to stable supplies. (Nuclear energy is similarly important. More on that in a later section.) Coal has clear environmental problems, and EPA regulates it for good reason. Still, there are considerable challenges to replacing coal.

Coal currently provides the largest single share of stable, baseload electricity, and this will be the case for some time to come. But the electric utility industry is clearly in an era of transformation—chiefly, of course, a transformation away from traditional coal to cleaner forms of generation.

For utilities that rely largely on coal, one key issue with coming environmental regulations is the higher cost associated with an earlier compliance deadline. Regulators must weigh these costs against the public health impacts of less stringent deadlines. Another issue is the interaction between plant location decisions and the transmission grid. It's important to look at specific areas within the grid to see why units are located where they are located. That often contradicts other rational ways of looking at plant decisions, including decisions on plant closures to comply with environmental regulations. For example, minimizing local environmental impacts would entail building plants away from population centers, while minimizing transmission losses would call for the opposite.

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Another challenge to coal comes from natural gas. It's now viewed as a safer bet than building new coal plants, for several reasons. For one, gas is perceived to be better environmentally than coal. Domestic supplies are plentiful. Moreover, there is considerable excess capacity that will allow for a relatively cheap expansion from current levels. Lastly, it is essential to have flexible backup technologies for many renewable energy sources, and natural gas plants are more flexible than coal.

It is true that the electricity sector is dominated by long-lived assets and the so-called "lock-in" effect, but large-scale fuel switching has happened before. The shift from coal to gas could be a similarly far-reaching switch.

Consistently low natural gas prices, of course, will come with their own challenges. For once, gas has the potential to be a cleaner-burning fuel. However, it still has local environmental and greenhouse gas impacts and will thus also be impacted by climate policy down the line.

Another big challenge comes from the ruckus caused over the environmental impact of fracking technologies. Whether objectively safe or not, significant disruptions and associated price volatility could occur because of drilling moratoriums and other regulatory interventions.

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The fact that the electricity industry is in upheaval is evident by the plethora of options suddenly available. The latest capacity auction in the PJM region, centered on Pennsylvania, New Jersey and Maryland, included 1 gigawatt of energy efficiency being offered. That kind of offer would have been unthinkable only a few years ago, yet in this case it even cleared the auction—i.e. it underbid other forms of electricity supply to truly show that "negawatts" can be the cheapest electricity source.

Similarly dramatic changes are happening on the demand side with increasing frequency. Zero-emissions buildings are no longer a pipe dream. They are being built at increasing rates. It will take decades to change the U.S. housing stock, but we can clearly no longer take it as a given that every building will be an electricity user. Many will be independent. Many may, in part, turn into electricity suppliers.

That has enormous implications for traditional utilities as well as for transmission, distribution, and especially also electricity regulators. The latter may no longer be faced with dozens of utilities but possibly millions of possible suppliers. One of deepest challenges is to restructure regulatory systems to service net-zero buildings.

Electric Vehicles

Electric vehicles are bound to change the way we move. They could also have some surprising impacts on how we generate, distribute, and use electricity more broadly.

EVs aren't exactly new. A full third of cars on the road in 1912 were powered by electricity, but EVs lost out to the internal combustion engine for several reasons—chiefly that of reach. A century later, we have a chance to approximate the market share EVs held back then. Battery technologies have largely caught up with our increasingly mobile lifestyle and most uses. That doesn't yet mean that a switch to EVs will happen automatically or quickly, but EVs clearly have all the markers of a "disruptive technology," challenging beliefs about transportation we have held for generations.

It's clear that EVs are cheaper to operate than cars using internal combustion engines. A typical user spending $2,000 a year on gas would incur electricity costs of no more than $500 per year, and that assumes charging the vehicle exclusively during peak demand times. With off-peak charging, assuming differentiated rates are available, costs could drop to as low as $250 per year.

The EV itself will be more expensive than cars powered by internal combustion engines, but costs are coming down fast and will soon approach a point where combined capital and usage costs are comparable. Costs for energy storage technologies have decreased

dramatically over the years and are projected to come down substantially for at least the next five years. Some projections don't see gains beyond 2020, but there is always room for surprises.

Even now, EVs pay for themselves in under 10 years, and the payback period is projected to decrease to 5 years within the decade. This reflects large jumps in battery technology. Even 5 years, though, is long relative to how average consumers make their purchasing decisions. Consumers typically expect 3-year payback periods for investments in efficiency.

None of this yet reflects additional monetary incentives. Tax credits and other incentives currently in place decrease the payback period now from just under 10 to under 5 years.

A key component in this equation will be carbon pricing. With federal gas taxes at 18.4 cents per gallon and slated to decline to 4.3 cents per gallon at the end of September, EVs, of course, have a much harder time competing than at prices that would reflect the true cost of a gallon of gasoline.

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But regardless of payback periods, learning curves, and other price projections, it's clear that the EV is here and seems to be here to stay.

One indication is demand, which is clearly there. General Electric alone has ordered 25,000 EVs, a number far in excess of current supply. This marks a clear inversion of the 1990s, when supply was there, demand wasn't.

The shift to EVs may also be coming hand-in-hand with other shifts in car ownership such as vehicle and fleet sharing. For one, rental companies with their rapid fleet turnover are a prime target. Most buy and turn over cars every year. Hertz alone buys $5 billion worth of cars per year. Other fleet companies such as FedEx and UPS, by contrast, turn over their truck fleet on average every 20 to 25 years. It was no accident that the Prius got its start with Hertz, where it was

tested before it went to the public market. Larger-scale shifts in car ownership models may well aid the transition to EVs and could, by themselves, represent major changes to transport systems.

It's still important, though, to look at the broader policy context. If the primary objective is reducing oil consumption then there are several other technologies that could complement or possibly even substitute for EVs. Biofuels for traditional internal combustion engines, natural gas vehicles, or fuel efficiency efforts could all fall into that category. It's perhaps difficult to see how one technology—EVs—can displace all others. Not all will be winners, but perhaps it will be more than one.

EVs themselves also harbor various profound policy implications. One question is around gas tax revenue. It's true that part of the reason for the gas tax is to get people to drive less and drive more fuel-efficient cars. On the other hand, federal and state transportation funding to a large extent depends on the gas tax. Granted, taxes are already too low to pay the full bill, but that shortfall is small compared to what we could experience if we saw a large-scale shift to EVs and no fundamental policy shift from taxing gallons to miles driven. Drivers are, of course, already paying a miles-per-gallon fee, just that it comes via the gas tax, and that it is variable. We need to shift that tax to a fixed amount per mile, or perhaps base it on the weight of vehicles to create the right incentives.

A second policy question relates to carbon pricing, which is especially important right now for California. Specifically, who will end up getting credits under its cap-and-trade system for investment in EVs and EV infrastructure? Will it be utilities, car manufacturers, service providers, or ultimately consumers? The answer right now is that consumers get credit in the sense that they are saving money on their gas bills. Who else could or should get credit, or does this simply point to the limitations of cap-and-trade to aid systemic changes like a wholesale shift to EVs?

Subsidies present another important policy question. Is it feasible for us as a nation to expect that we can afford a $7,500 tax credit for EVs at scale? Many early adapters, one would think, would buy EVs with or without a tax credit. In that sense, it may even be possible to wait with the credit. On the other hand, a sizeable tax credit should motivate many to purchase EVs. That, of course, comes with a price tag for the government. How sustainable will that price tag be, and what will happen once it has to be phased out?

Lastly, there are serious policy issues related to the supply chain of EVs. Battery technology, in particular, is an area where early market leadership could help cement a longer-term position. Not surprisingly, Chinese manufacturers are taking a large lead in this area. Beijing's support for this industry comes with costs, but there are clear benefits that only China seems to be able to tap into at the moment. A nascent industry like car battery technology may well call for some kind of industrial policy that would enable an entire country to take a leading role in global manufacturing and innovation.

EVs themselves may also hold the keys to fundamental change. To some, EVs may offer an entirely different value proposition from cars powered with internal combustion engines. Many consumers are willing to spend three times as much on their mobile phone bills as on their bills for land lines, and still, many give up land lines altogether in favor of mobile phones. Do EVs look more like commodities or cell phones in this context? The answer may well be the latter.

Moreover, EVs currently on the market are scarcely representative of EVs we will see even in 18 or 24 months. Change will happen fast—not unlike other high tech areas with early adopters standing in line to get a glimpse of the latest iPhone. EVs surely have some of these characteristics, which make them unique in the utilities space, where innovation usually doesn't come with long customer lines.

Utilities and regulators have a unique role to play in enabling EVs. On the one hand, EVs could become a true resource to the grid itself. EV battery technology is key to making micro-grids happen, which in themselves have large benefits ranging from grid stability to national security. There, utilities and their regulators can play the role of active enablers, encouraging customers to play just such a role.

Utility pricing models could also have an enormous impact, as the simple numeric example with on-peak and off-peak pricing shows. It doesn't even need to go as far as real-time pricing. "Time of day" pricing may already be enough to bring about sufficient differences and, conversely, enable real cost savings for EV owners. In addition, utilities also need to be prepared—or possibly compelled—to pay customers real-time (or "time of day") prices. In other words, if an EV gets charged during off-peak hours and is then able to sell electricity at peak demand times back to the grid, EV owners should be justly compensated and, in this case, be able to make money through their services.

Despite all the hype and justified excitement surrounding EVs, it's also important to note that EVs are still cars. They are much better cars, in many ways, but we may well save many more greenhouse gas emissions by looking at the entire transport landscape rather than a narrow focus on EVs or cars more broadly.

Renewables

The entire electric system is undergoing dramatic changes. We are moving from a large-generator, one-way-grid, passive-customer model to something that is much more distributed on the generation side. Electric vehicles and battery technologies are one element in this equation. Renewables are another crucial component, possibly the most significant one of them all.

There are lots of uncertainties, but a few pieces are clear, especially on the policy side: Eventually, renewables need to stand on their own; we cannot continue to subsidize *ad infinitum*. However, it is equally clear that we cannot compare renewables to fossil fuels without adding in the social cost of carbon.

Another known and ever-present issue is intermittency. Wind doesn't always blow, and the sun doesn't always shine. That stands in contrast to other forms of electricity, which is indeed possible to dispatch almost whenever it is needed. Battery technology—possibly aided by EVs—will play a crucial role, but these additional storage services come at a cost, which need to be built into electricity prices.

Moreover, renewables come with environmental challenges of their own. The carbon impact of operation may be small or zero, but a rapid shift to renewables may still increase carbon emissions in the short-term due to the large investments necessary. Perhaps more important are some other environmental issues linked to

renewables, whether land-use changes or the need for precious metals—domestic or imported—as is the case for solar panels.

Still, the biggest challenge right now is cost, although the balance is changing rapidly. In 1980, wind cost 50 cents per kilowatt hour. Now it is 7 cents per kWh, and all signs point to a further halving of costs by 2020. Looking at these cost trends, it's clear that renewables are still a very young industry, especially compared to traditional fossil fuels.

The true driver of renewables at current cost points is not technology, it's policy. One key element, of course, is carbon pricing to hold coal, natural gas, and oil accountable for their full environmental costs. We know that carbon pricing will come in one form or another. Certainty around when and how that will happen will be crucial for a take-off of the renewable industry.

Failing that, a combination of other policies may well add up to appropriately sized incentives. Once again, though, policy certainty is paramount—for example an orderly and predictable scaling down of subsidies would be preferable to the current situation where production credits for wind get extended on an annual basis and have frequently lapsed from year to year. When they do, new wind installations go down dramatically from one year to the next.

Regardless of the subsidy structure and other incentives, long-term policy certainty has two elements: carbon pricing, and electricity pricing that reflects the true cost of supplies. Market manipulation is serious business—not necessarily manipulation by market participants, but rather by regulators in attempts to bring short-term prices down without adequately considering the long term. Market prices ought to reflect the true cost of generation as much as of demand response and other elements that can help renewables prosper and can help the grid provide stable supplies in the long term.

A smart grid—especially one driven by increased supplies of renewables—demands smart pricing structures that often have little to do with technology but much more with the regulator.

Another key element in this puzzle is transmission. It's intimately related to renewables, mainly because many new renewable sources will require additional transmission lines to bring electricity to population centers. Current transmission payments are often inconsistent with the beneficiary-pays principle. That leads to many a market distortion, especially when linked to renewables.

Some large-scale projects like the Atlantic Wind Connection are prime examples of projects that all but call for smart policy to be able to evaluate their overall efficacy and, ultimately, be able to implement them. Beneficiaries in this case are offshore wind providers, but also onshore customers, who would benefit from a strengthened grid overall.

Transmission planning, however, has formidable challenges in the current regulatory structure. State cooperation as well as federal participation are critical to any transmission plans and to fair cost allocation. All of that, of course, is often much easier said than done, and utilities often play a crucial role as well. Incumbent utilities don't always see the benefits of supporting new transmission projects, which would more often than not aid new competitors. Still, a crucial step—possibly the most crucial one—is to find ways to monetize current transmission and distribution assets: How to find willing payers for transmission services? That's a key question for utilities as well as for regulators. How else to get wind power from the Great Plains to places where more people actually live? Or to get solar energy from deserts to the coasts?

If renewables aren't yet cost competitive and important challenges remain, what then drives current renewables investments? They cannot be explained by long-term investment decisions or do-goodism alone. A driver—the key driver, in fact—is renewable mandates, primarily state-level Renewable Portfolio Standards that all but mandate higher-cost renewables. Private capital is still remaining on the sidelines because renewables aren't yet cost competitive, and there is no sustained policy driver. Instead, we see utilities that are all but obligated to invest to comply with state laws.

This focus on finances often misses what a true paradigm shift many renewables present. Fuel costs are no longer variable, but essentially zero. Operating cost uncertainty currently plays an important role in energy planning and purchasing behavior. Renewables may well be able to command a price premium simply by virtue of having no uncertainty regarding fuel cost. We already see many existing renewable plants at times bidding their services at close to or at zero. That poses real questions for transmission rights and related policy questions.

Another enormous paradigm shift is distributed generation. The central power-station model may well become a thing of the past. And distributed generation itself may trigger many more policy changes. Localized generation at the point of consumption will likely make more economic sense if it's linked to demand response measures. The ultimate model may not be clear, but it's clear that distribution pricing needs to change, largely driven by technological change in the renewable space.

In the end, one key question is whether the public will be willing to accept higher electricity rates. We need higher rates for reliable and clean service. So much is clear. The question is how far that rate increase can go, and how much will ultimately be attributed to cleaner, more reliable service as opposed to simply the fact that electricity has been underpriced for quite a while.

Nuclear Power Post-Fukushima

Nuclear energy is a wedge issue, and it's not necessarily a partisan divide. Almost every energy model that aims to meet most commonly stated greenhouse gas reduction targets assumes rapid deployment of new nuclear energy, a low-carbon fuel. That stands in stark contrast to some environmentalists' vocal opposition to nuclear energy as the "ultimate non-renewable fuel."

Nuclear energy defies easy categorization.

The Fukushima nuclear accident earlier this year only served to strengthen each position: Nuclear advocates point to it as proof that the dramatic problems that did ensue were avoidable and largely due to poor planning and poor regulatory oversight. Nuclear opponents, of course, had a much easier time justifying their renewed rage.

Chancellor Angela Merkel reacted by announcing a commitment to retire German nuclear plants within a decade. This was a reversal of her government's previous position, although it was something Germany's previous coalition government had already agreed.

The U.S. government, by contrast, reaffirmed its previously stated commitment to nuclear energy and announced that the Fukushima accident would change little other than a renewed assessment of

safety in existing and planned plants. That is only good news for U.S. greenhouse gas emissions, although nuclear opponents predictably had a different reaction.

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Currently, 104 plants are operating in the United States. They constitute around 10 percent of U.S. generation capacity but account for 20 percent of total generation, reflecting a remarkably high capacity factor throughout the fleet. Moreover, today 70 percent of carbon-free electricity comes from nuclear power. That is a remarkable number and one that becomes increasingly important as old plants will retire as their licenses expire.

Existing nuclear plants, with their capital costs largely amortized and low operating costs, also show good financial performance, although that does not imply that new plants are coming online anytime soon. The so-called nuclear renaissance has largely missed the United States, with only four new plants currently under construction.

Still, there are many issues and lessons to be learned both from Fukushima and from our experience with building and operating nuclear plants. Lack of standardization across the existing U.S. fleet is one clear issue, although some tensions remain between standardized design and allowing learning from past experience.

Lots, of course, is still unknown. It took six years for anyone to see the inside of the Three Mile Island reactor. No one yet knows the extent of the damage in Fukushima. In any case, though, the impact of Fukushima on the design and construction of new reactors in the United States will likely be small. First, we are building so few of them. More importantly, however, new plants are likely safer than the design used in Fukushima. There may be some impact on location decisions, but even that seems unlikely. September 11th prompted the U.S. Nuclear Regulatory Commission to require emergency equipment and other changes that cost licensees on the

order of $1 billion. Fukushima may lead to some changes to regulations, but will likely lead to lesser overall costs than those incurred after September 11th.

The largest obstacle to building new nuclear plants in the United States is not safety or regulation, it is cost of constructing the plant in the first place—in part due to strict regulatory requirements. Loan guarantees offer the most substantial benefits to potential project developers. But it is difficult to see how nuclear energy can compete with new natural gas plants, given the current glut of natural gas.

One important trend in nuclear technology is toward smaller, more modular units. The lesson from the past 20 years—from newly built gas, solar, wind and other plants—is that smaller, more modular plants have certain advantages over large, central power stations. The same could hold for nuclear. Capital financing is much easier for smaller plans. Public perception might be much altered as well.

A big worry remains that although smaller, modular reactors may be easier to build and finance, some costs, such as security and emergency protection, may not scale with size. As a result, the advantages of small, modular reactors remain somewhat uncertain.

The problem as with any new engineering systems is that we will need adjustments along the way. The first reactor will be a prototype. Later reactors will need to incorporate lessons from the prototype and other "demo" reactors. A big question is financing of the first units and especially research funding. In the current budget climate, it may be difficult to sustain a major effort in the United States. The Chinese are a more likely candidate.

China will clearly play a central role in the global nuclear renaissance. While the United States is building four reactors, 50-60 new nuclear plants will be built in China by 2020! The worry there is that most of them have different designs—ranging from Generation II to IV. That also puts safety to the fore once again.

China has no consistent nuclear regulatory program. Since its start in the 1980s, the regulatory regime moved from military to civilian oversight, and now several agencies are vying for the right to administer the program. The only true nuclear safety program is currently housed in one of the weakest ministries, the equivalent of the Environmental Protection Agency. The nuclear oversight program has scarcely 200 employees. That is a real worry, and the chance of implementing an effective independent nuclear agency in China are not good. That said, it's clearly in everyone's interest—France, the United States, and especially the Chinese—for China to maintain a stellar safety record, especially given the breakneck speed of new developments.

China

"Well, you can just stop and think of what could happen if anybody with a decent system of government got control of that mainland. Good God."

President Richard Nixon's infamous words about China still ring true today. Last year China became the biggest manufacturer, a position the U.S. held for a century. In less than a decade, China will almost certainly become the largest economy.

China is experiencing huge shifts in demographics, urbanization, economics, electricity and general energy consumption. There's no denying that major changes are under way.

In energy, the numbers speak for themselves: in 2000, China was half of U.S. consumption; in 2009, China overtook the United States as the number one consumer of energy. China will add generation equal to the entirety of current U.S. capacity in the next 15 years. China's overall electricity demand is expected to triple from today's levels by 2035.

China also has its share of problems. Five strategic industries are driving 50 percent of China's demand for energy, even though they only employ 15 million people, out of a total workforce of around

800 million. These numbers alone point to the importance of China growing its service sector and creating domestic demand for its products rather than relying on an export-led growth of its most prominent sectors.

Beijing has also recognized that energy demand increases point to real strains. China's 11th five-year plan, from 2006 to 2010, included an ambitious target of decreasing energy intensity by 20%. China practically achieved the target, and reaffirmed a similar commitment in its 12th five-year plan. But there is an even more ambitious target looming within the decade: generating 15 percent of electricity from non-fossil sources by 2020. That translates into 230 to 480 GW of non-fossil fuel capacity. Large hydro and nuclear help, but they are clearly not enough. Achieving this target will imply massive deployment of wind, solar, and other renewables including small hydro plants. To put this figure in perspective, even if China meets only half of its non-fossil target, China will constitute 50 percent of the global renewables market.

But even if China meets its entire target for non-fossil fuels, it still needs to add 450 GW of coal at minimum over the next decade. By 2009, China was already a net importer of coal at a scale that commanded quantities equaling the totality of coal exports from the world's two largest exporters, Australia and Indonesia.

How is China paying for its massive investments in industrial policy? In short, it's happening on the backs of Chinese households, which have enormous savings rates but get little in return. Chinese state banks are offering 3 percent lending rates, while inflation is 5.5 percent. That leads to perversities like the fact that Chinese per capita GDP is three times that of India, whereas per capita consumption is only 30 percent above India. Households subsidize a banking system biased toward state-owned, heavy industry. That is a huge potential problem. China cannot get from $8,000 to $24,000 per capita GDP on the backs of households alone, especially since most of these heavy industries do not offer sufficient domestic employment opportunities.

Another crucial problem is that chairmen of the largest industrial firms hold ministerial ranks in Beijing, often above that of their own regulators. That is an important issue in nuclear safety and also for environmental and other regulations throughout many sectors of the economy.

China's demand for coal will drive up global prices and will have massive implications for the United States. But China's reach goes much farther. Government approval for new ventures might be bureaucratic, but the execution—speed and technology—is incredibly fast. Adding the simple fact of China's size and rate of growth to the equation means that China is taking a clear leadership role in the global energy and clean tech agenda.

The fact is clear: China will likely lock the United States out of the clean tech market within a decade.

China employs massive investments in industrial policy to dominate markets. That makes the job of the United States all the more difficult. And we can never underestimate the impact of scaling. China, in effect, is building intellectual property in scaling up infrastructure investments at an incredible rate. But the reach goes much beyond infrastructure markets. Electric vehicles, for example, are bound take off in China: first, because demand clearly exists, with a billion Chinese having never driven a car before; second, because China is increasingly investing in the technologies necessary to dominate the global EV market.

In general, thinking that we can somehow "catch the Chinese" can only lead to U.S. policy blunders. As renewables scale globally, China will derive the most benefits. That much is clear. China is executing a comprehensive manufacturing and incentive plan spanning energy generation, efficiency, and storage. It will likely be messy, but

Beijing will be achieving its goals in this area. That makes it all the more vital to keep open energy markets between the United States and China, to benefit from enormous Chinese growth in this area. The United States doesn't have the ability to accelerate job creation domestically. Using Chinese investments and capital for job creation will be crucial in that respect.

The United States may not want to have an industrial policy similar to China's policy of stimulating growth in renewables. Putting a price on carbon as environmental policy, however, may get us to a similar percentage of renewables, but without putting the burden exclusively on households as in the case of China. The reaction when the economy is bad is often to blame foreign threats, but that is the wrong instinct here. It's a lack of appropriate domestic policy that is aiding China's relative rise in some strategic industries.

Appendices

Agenda

Changing Currents: Turbulence for the Electricity Industry?

Monday, July 4

8:00—11:30 am

SESSION I: Alternative Approaches to Climate Change

The failure of cap-and-trade legislation in the last Congress has turned political attention to other actions to mitigate climate change while meeting the energy challenge. The Forum will discuss options such as enhanced energy RD&D, state and regional initiatives, EPA regulation, clean electricity standards, carbon taxes in the context of deficit reduction, and the benefits, costs and political likelihood of each.

Chair — Phil Sharp, President, Resources for the Future

State and regional action:	**Vicki Arroyo, Executive Director, Climate Center, Georgetown Law**
RD&D and innovation:	**Richard Newell, Associate Professor of Energy and Environmental Economics, Duke University**
Clean Electricity Standard and EPA regulation:	**Joseph Aldy, Assistant Professor, Harvard Kennedy School**
Carbon tax:	**Douglas Holtz-Eakin, President, American Action Forum**

Tuesday, July 5

8:30 am—12:00 am

SESSION II: Infrastructure Reliability and Adequacy

Discussions of energy security generally focus on oil, but continuing electrification, aging infrastructure, and the possibility of rapid retirement of older coal plants raise equally important questions about the security, reliability and adequacy of electricity infrastructure. This session will examine issues relating to enhancing and replacing generation and transmission facilities.

Chair — Sue Tierney, Managing Principal, The Analysis Group

Reliability and security:	**Susan Eisenhower, President, The Eisenhower Group**
Challenges to replacing coal:	**Nick Akins, President, AEP**
The role of natural gas:	**Greg Staple, CEO, American Clean Skies Foundation**
Unconventional answers:	**Sue Tierney, Managing Principal, The Analysis Group**

1:30—5:00 pm

SESSION III: Electric Vehicles

The introduction of two mass market electric vehicles (EVs) has given greater immediacy to questions about electrification of the transportation sector. The Forum will consider utility business models necessary to support EVs, questions about deployment and customer acceptance, and prospects for improvements in energy storage technology.

Chair — Phil Sharp, President, Resources for the Future

Utility business models to support:	**John Russell, President and CEO, CMS Energy**
Utility business models to support:	**Alex Kim, Director, Customer Innovations, San Diego Gas & Electric**
Energy storage technology:	**Barbara Tyran, Director, Washington & State Relations, EPRI**
Respondent:	**Ron Minsk, Senior Vice President, Policy, Electrification Coalition**

Wednesday, July 6

8:30 am—noon

SESSION IV: Renewables

Increasing the use of renewable energy will require consideration of various policy changes. What will be necessary to provide enhanced transmission capacity? What financial incentives, regulatory measures or market structures will be most effective? And what goals are reasonable given expected costs and technological advances?

Chair — Michael Yackira, President and CEO, NVEnergy

Transmission – Midwest:	**Gary Hanson, Commissioner, South Dakota Public Utilities Commission**
Transmission – Atlantic offshore:	**Robert Mitchell, CEO, Trans-Elect**
Obstacles and policy tools:	**Martha Wyrsch, President, Vestas–American Wind Technologies**
Market design factors:	**William Hogan, Professor of Global Energy Policy, Harvard Kennedy School**
Costs and timing:	**Bryan Hannegan, VP for Environment and Renewable Energy, EPRI**

1:30—5:00 pm

SESSION V: Nuclear power post-Fukushima

Concern about climate change has helped reduce opposition to nuclear power, and the availability of federal loan guarantees has encouraged plans to build new reactors. The economics remain challenging, however, and public support is likely to decline as a result of the tragedy in Japan. What will determine the future of nuclear power in the United States?

Chair — Richard Meserve, President, Carnegie Institution

The regulatory system:	**Richard Meserve, President, Carnegie Institution**
The decision to build:	**Cheri Collins, General Manager and External Affairs Liaison, Nuclear Operations and Development, Southern Company**
Financing nuclear reactors:	**James Asselstine, Managing Director, Barclay's Capital**
The challenges:	**Peter Bradford, Adjunct Professor, Vermont Law School; former Commissioner, NRC**
Next generation reactors:	**Michael Corradini, Chair, Engineering Physics, University of Wisconsin**

Thursday, July 7

8:00—11:30 am

SESSION VI: China

China's rapid electrification poses a host of questions for its own and global energy markets. Meeting the challenges may offer lessons for U.S. policies. This discussion will cover China's actions on climate change mitigation, clean coal, renewables, and energy efficiency.

Chair — Clint Vince, Chair, Energy, Transport & Infrastructure Practice, SNR Denton

Overview:	**Trevor Houser, Partner, Rhodium Group, LLC**
Clean coal:	**Jim Rogers, Chairman, President and CEO, Duke Energy**
Renewables:	**Mike Splinter, Chairman, President and CEO, Applied Materials**

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