Southwest Power Pool
Annual Looking Forward Report

Strategic Issues Facing the Electricity Business
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As an Independent Advisor to
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Executive Summary

This is the seventh year in which we have prepared a separate *Annual Looking Forward Report* for the Southwest Power Pool ("SPP") Board of Directors ("Board"). As with the first six, this report is intended to contribute to the longer-term strategic planning by the Board. To that end, we focus on broad market and regulatory events that (a) could potentially have a significant impact on SPP's markets and/or (b) could require the Board's special attention. Bates White Economic Consulting ("Bates White") greatly appreciates the input to and guidance for this report provided by the Board's Oversight Committee.

The topics addressed in these strategic reports have only grown in attention and complexity over time, which is evident by the breadth and depth of the analyses from which we draw this year. Given this, we have become even more convinced that the Board must use a wide-angle lens when trying to anticipate the future. For example, to anticipate the future of electric vehicles it no longer is enough to conduct head-to-head cost comparisons of electric vehicles to those powered by internal combustion engines. Now the future of electric vehicles must also be judged in the context of the future of shared, autonomous vehicles – popularly termed driverless cars. Similarly, the prospects of a carbon tax must be judged in a much broader context including its use in funding income tax reform and its use if the courts require a replacement for the Clean Power Plan, rather than simple repeal. Our topics presented herein represent some of the most important and emerging issues in the U.S. electricity business, and we do our best to provide the necessary context surrounding each issue to best assist the Board in its strategic planning.

A. The Shale Gas (and Oil) Revolution

Since natural gas often sets the price in SPP's electricity markets, we have always asked whether the shale gas revolution is continuing. Once again, the answer is yes: the low price and abundance of shale gas has kept natural gas spot prices low. This year, however, we report evidence that there is a limit to how low natural gas prices can go and for how long low prices can persist. Reports this year show significant declines in natural gas prices. From 2014 to 2015, EIA reports that Henry Hub spot prices fell from $4.55 to $2.62 per MMBtu – a 42.4 percent decline. These prices were expected to fall an additional 6.1 percent in 2016.

However, accompanying the decline in natural gas prices was a decline in proven reserves of natural gas – by 16.6 percent from 2014 to 2015. Proven reserves reflect not only the physical abundance of natural gas reserves but also estimates of whether those reserves can be produced at prevailing market prices. This triggered a discussion of a possible *de facto* floor for natural gas pricing in and around $3 per MMBtu.

To judge the staying power of the shale gas revolution it is worth assessing the parallel revolution in shale *oil*. Prices fell for oil, too, from $94.56 per barrel in 2014 to $50 in 2015, a fall of 47 percent. And estimates of proved reserves of oil were also lowered – by 11.8 percent due mostly to the price decline. This triggered the discussion on whether $50 per barrel was a *de facto* floor price for oil.

We assess once again what we termed "underground" and "above-ground" uncertainty or risk. Underground risk is all about whether the technological progress with shale production will continue so that the low prices can continue. Evidence is that technological progress continued in the sense that new wells this year produced more shale gas than new wells the previous year. As for the more distant future, as was explained last year in our Report, the bet is that big data analytics of the massive amount of data captured on actual gas and oil wells will be what sustains the technologic improvement needed to keep prices moderate.

Last year the big news with respect to above-ground risks – mostly the risk of tightened regulation – was that such risk had been lowered when the EPA published its much-anticipated draft of its assessment of the impact of shale gas production on drinking water. The somewhat surprising headline for the draft was that EPA found no widespread, systemic risk. In the final report, however, no such statement was made and, therefore, in our view this above-ground risk has been restored.

Earthquakes are another significant concern for waste water injection associated with oil and gas development. The good news is that some claim that the frequency of such earthquakes will decline in number, especially in Oklahoma. Leaders in the state reported that the cooperation among all those addressing the issue, including both industry and government regulators, had been exceptional.

B. EPA's Environmental Campaign

Last year this section of our *Looking Forward Report* provided a detailed look at President Obama's Clean Power Plan, said to be America's first significant step to combat global climate change. Things have changed, however, with President Trump's Executive Order on March 28, 2017 calling for a process to be put in place for the "Review of the Environmental Protection Agency's 'Clean Power Plan' and related Rules and Agency Actions."

Some have argued that eliminating the Clean Power Plan ("CPP") would be more difficult than might be expected at first glance. This is because, as we have discussed in previous reports, the Supreme Court (in a 5 to 4 vote) has already ruled that the EPA has the authority under the existing Clean Air Act to regulate carbon emissions, and regulations implementing that authority have already been proposed. This has led some to conclude that the situation with the CPP might best be characterized as requiring repeal *and replacement*.

While there are a wide range of alternatives for replacement, one market-based alternative that has gotten a fair amount of attention is a carbon tax. For example, while far from garnering unanimous support, two well-respected leaders of the Republican party – George P. Shultz and James A. Baker – proposed a carbon tax in an Op-Ed for the Wall Street Journal on February 24, 2017.

Standing alone, a carbon tax would be unlikely to gain momentum and win Congressional approval. However, it might win such approval in a broader context, and we see two such broader contexts. The first context is income tax reform. The carbon tax could be a way to finance serious corporate and personal income tax rate cuts. The second context is concern that artificially low spot market prices in RTO energy markets could mean that baseload power plants do not earn enough revenue to stay in business. Low natural gas prices are a central reason spot market prices are low, but the tax subsidies for wind and solar also contribute to low spot prices.

A carbon tax would bring a fundamental change in how America promotes low- or zero-emission technologies and operating changes. By raising electricity prices – rather than artificially lowering them as tax subsidies do – a carbon tax would address the concern with market prices being too low. More broadly, a carbon tax would enlist all producers and consumers in the battle to address global climate change, not just those with specific technologies.

Because it brings such a fundamental change, a carbon tax is worth some study by the Board. To make a carbon tax tangible, we have included here an analysis of a carbon tax proposal assessed by the U.S. Department of Treasury in January of this year; it also served as the analytic basis for the carbon tax proposal from Secretaries Shultz and Baker.

Again, while a carbon tax is far from having universal appeal, momentum for a carbon tax is possible from three perspectives: (a) if the CPP must be repealed *and replaced*, a carbon tax would be a widely-discussed, market-based replacement; (b) in the heat of battle over tax reform a carbon tax might emerge as a compromise for those who want to address climate change and those who want tax reform; and (c) a carbon tax would address the concern about keeping the lights on by offering a market incentive for baseload plants to stay on line.

C. Distributed Energy Resources, Decentralization, and the Changing Utility Model

Since we first introduced the topic in 2013, we have been seeking to answer what is becoming one of the most important questions for grid planners, regulators, market participants, and ratepayers: are distributed energy resources (a) an existential competitive threat to the grid, or (b) a potential complement that may require efforts to plan and integrate, or (c) both of the above? This is a topic worthy of the Board's attention, and we present five emerging themes that help define the status of distributed energy resources.

First, the topic is a timely one. Acting FERC Chairman Cheryl LaFleur recently suggested that decentralization is "really happening" and may have already passed a "tipping point," while the chairman and CEO of Hawaiian Electric recently stated his belief that distributed energy resources will transform the power system faster than cell phones remade the communications sector because customers will demand it.

Second, the transmission grid remains essential. While distributed energy resources are already having an impact on the existing utility model and the electricity industry in general, they are not yet pushing consumers to go "off-grid," and in most cases, remain reliant on the grid for backup power and/or access to markets to sell excess power.

Third, utilities and grid planners and operators are facing the challenge of flattening demand, which is caused in large part by increased energy efficiency as well as, to a smaller degree, distributed energy resources. To demonstrate this point – and its potential impacts on RTOs, such as the risk of overbuilding transmission – we note two case studies. One is Google, which used proprietary "artificial intelligence" to control its energy use at one of its data centers, leading up to a 40 percent reduction in energy consumption. This caught our attention because it shows just how sophisticated demand-side measures have become. The other is the California ISO, which, in its most recent transmission plan, cancelled several planned transmission projects and put several others on hold due to changing circumstances, but in particular declining load forecasts and increased penetration of distributed energy resources. This shows how the impact on transmission investment is already being felt.

Fourth, distributed energy resources are emerging not as an existential threat to the grid, but as a potential alternative to grid investment. Studies from MIT and ICF argue for the benefits of targeted deployment of distributed energy resources in deferring or even eliminating the need for some traditional grid investments. We provide case studies from New York and California where distributed energy resources have successfully competed in open procurements to help meet reliability and resource adequacy needs.

Fifth, the changing U.S. generation resource mix is benefitting distributed energy resources because it is driving down the cost of solar PV and energy storage. It may further benefit distributed energy resources as states reconsider the "indiscriminate procurement" of renewable energy generation, which some argue have contributed to congestion and negative power prices. Some experts are arguing for renewable generation procurement to account for the location, timing, and impact on congestion of the renewable generation. Others, including Illinois, include distributed energy resources explicitly in their renewable portfolio standards procurements.

We close this already lengthy chapter with three case studies highlighting parties at the forefront of the challenge to the existing paradigm. They include (a) California ISO's new tariff for distributed energy resources, (b) an example of a small town in Ohio building its own mini-grid in Midcontinent ISO's footprint, and (c) the introduction of "blockchain" technology to the electricity industry.

D. Jurisdictional Issues in the Electricity Industry

In past *Looking Forward Reports*, we have brought to the Board information about significant and impactful litigation concerning the jurisdictional split between federal and state regulators in the electricity business. We focused in particular on the issue of federal preemption of state actions on power plant investments, especially two cases from their beginnings in 2012 when generator owners in PJM challenged both New Jersey and Maryland for their separate efforts to build new capacity in response to in-state reliability needs. We noted that decisions in U.S. District Courts in both cases ruled that, by effectively "setting" a wholesale price for capacity and energy – which is federal domain under the Federal Power Act – the state actions violated the Supremacy Clause of the U.S. Constitution.

Over time, this issue has only become bigger and more complex. For example, in 2016, the U.S. Supreme Court ruled on two pending electricity cases. The first – *EPSA* – which involved demand response's participation in wholesale markets, the Court held that the Federal Power Act provides FERC with the authority to regulate wholesale market operators' compensation of demand response bids. Then, in the *Maryland* case, the Court sided with the plaintiffs, finding that Maryland had invaded FERC's regulatory territory by ordering new generation to be built, and thus, its actions were preempted under the Supremacy Clause and the contracts were invalidated.

Since the *Maryland* Decision, legal experts have weighed in on their expectations for the decision's implications. While some have concluded that the *Maryland* decision was very focused and left states with sufficient tools to ensure resource adequacy in their states, others have argued that the Supreme Court failed to establish a bright line between state and federal jurisdiction. This, such legal experts argue, means that there will be significant litigation going forward as courts further define the split between federal and state jurisdiction on a case-by-case basis.

We have noted in the past that, if the Court sided with the plaintiffs in the *Maryland* case – as it did – the implications could have broader implications for state jurisdiction and could create a slippery slope. We suggested that other state programs in all states, such as renewable portfolio standards, utility rate-base generation, and full requirements electricity service for default customers, could be construed to violate the tenets of the *Maryland* decision. One example of such litigation is ongoing in Connecticut, where a party challenged a procurement for renewable generation ordered by three New England states. Moreover, in both New York and Illinois, parties have challenged state actions to secure out-of-market payments to existing nuclear generation that may be at risk of early retirement. Notably, the complainants in all three cases cite the *Maryland* decision in their petitions.

E. Electric Vehicles

Electric vehicles ("EVs") potentially represent new sources of demand for and supply to the grid, a point we have made in past Looking Forward Reports. To date, however, EVs have not achieved a significant market share in the U.S. transportation market. Despite being a record year in terms of EV sales, just 0.82 percent of the cars purchased in 2016 were electric, including plug-in hybrids.

To anticipate the future of EVs, however, we must look well beyond a simple head-to-head cost comparison with traditional cars. As we have noted before, the future of EVs may well be tied to a fundamental shift in the auto industry. That shift, according to some analysts, would take America to driverless cars, not owned by individuals, but, rather, shared through services such as Uber and Lyft. As we explain in this chapter, the so-called "SHEAM" model – shared, electric, autonomous – has the potential to greatly reduce the payback period of an EV investment.

Should this shift occur, the biggest factors that drive autonomous vehicles will also drive demand for EVs. EV proponents argue that factors pushing the development of autonomous vehicles include safety: each year, 30,000 people die and 2.5 million more are injured in car accidents in the U.S., the vast majority of which are caused by human driver error. Other factors such as more efficient driving of a vehicle, optimized traffic throughput, and lighter vehicle designs with fewer safety features could increase demand for driverless vehicles, and thus EVs. The reverse is also true: what holds back development of autonomous vehicles will also hold back demand for EVs, such as a lack of legal infrastructure to support driverless vehicles and headline-grabbing accidents involving autonomous cars.

Nevertheless, we have seen a remarkable level of investment in businesses that offer shared, electric, and/or autonomous vehicles. For example, in March 2017, Intel acquired Mobileye, a chipmaker for autonomous vehicle technology, for $15 *billion*. We note several other examples from leading automotive and technology companies.

F. Lessons from the (Failed) 2016 Electricity Policy Modernization Act

Late in 2016, the Senate and House tried to win approval for a comprehensive energy bill. Each house of Congress had passed its own version of an energy bill earlier in the year, and it was up to the conference committee to combine the bills into a single version that would represent the first major energy legislation in almost a decade. That effort failed; the bills were declared dead in December. However, for SPP, the two bills are worth strategic study for two reasons.

First, they renewed public and Congressional concern about the catastrophic consequences of long-term power outages. In this, they were aided by Ted Koppel's recent book, *Lights Out*. Second, if Congress proposes another comprehensive energy bill in 2017 –

and that is a big if, given the change in administration – such a bill could lead to a significant amount of planning and analysis by RTOs, including SPP. To get an idea of what might be included in the next energy bill, we reviewed both the House and Senate bills for key provisions related to SPP. The most notable and potentially relevant to SPP are provisions related to grid hardening and security and provisions related to markets and distributed energy resources. For example, the House version of the 2016 energy bill would have required a "strategic reserve" of spare power transformers and emergency mobile substations to restore the grid after physical or cyberattack, electromagnetic pulse attack, geomagnetic disturbance, severe weather, or seismic events.

G. RTO Spot Markets and the Early Retirement of Existing Nuclear Generation

Early in our Looking Forward Report this year, we tee up the changing U.S. generation resource mix, which includes significant new investment in natural gas-fired combined cycle resources (driven by shale gas' impact on gas prices) and renewable generation resources, particularly wind and solar, which are often subsidized through tax credits and other incentives. These factors, especially shale gas' impact on gas prices), plus flattening demand for electricity driven in part by energy efficiency and (to a lesser degree) distributed energy resources, have led to low market prices for electricity.

Low market prices have consequences for existing resources: across the U.S., baseload generation is retiring before the end of its useful life. In this chapter, we focus on existing nuclear generation, since it provides reliable, emissions-free electricity. According to the EIA, 28 percent of all U.S. nuclear generation has recently retired or is at-risk of retirement by 2030.

This development has led to another manifestation of the honest debate about wholesale power markets themselves: are they working as they should, or are they failing to keep needed generation online? Is the early retirement of existing nuclear generation an efficient result, as older, more expensive generation makes way for lower cost resources? Or is the market failing because nuclear generators' zero-emissions, reliable power is not adequately compensated, particularly in markets with only short-term capacity payments available and where they must compete against subsidized renewable generation?

By no means is this debate resolved, and across the U.S., state governments, FERC, and the private sector are at work on this issue. Some states are seeking to provide existing nuclear generation with out-of-market payments, while FERC is considering ways to revise the way wholesale prices are calculated, which will likely increase prices. The private sector is focused on a longer-term fix in the form of new nuclear technology – like small modular reactors – which could be the future of the U.S. nuclear industry, albeit with many significant hurdles to clear before it is.

I. The Shale Gas (And Oil) Revolution (An Update)

The shale gas revolution has been a prominent focus of the SPP Looking Forward Report since its inception because the abundant, low cost natural gas it brings benefits electricity consumers throughout SPP in three ways: (a) low natural gas prices mean low spot electricity prices in the SPP markets; (b) flexible, natural gas-fired combined cycle power allows SPP to accommodate the full potential of the region's renewable resources; and (c) natural gas-fired power gives SPP Members an option for environmental compliance.

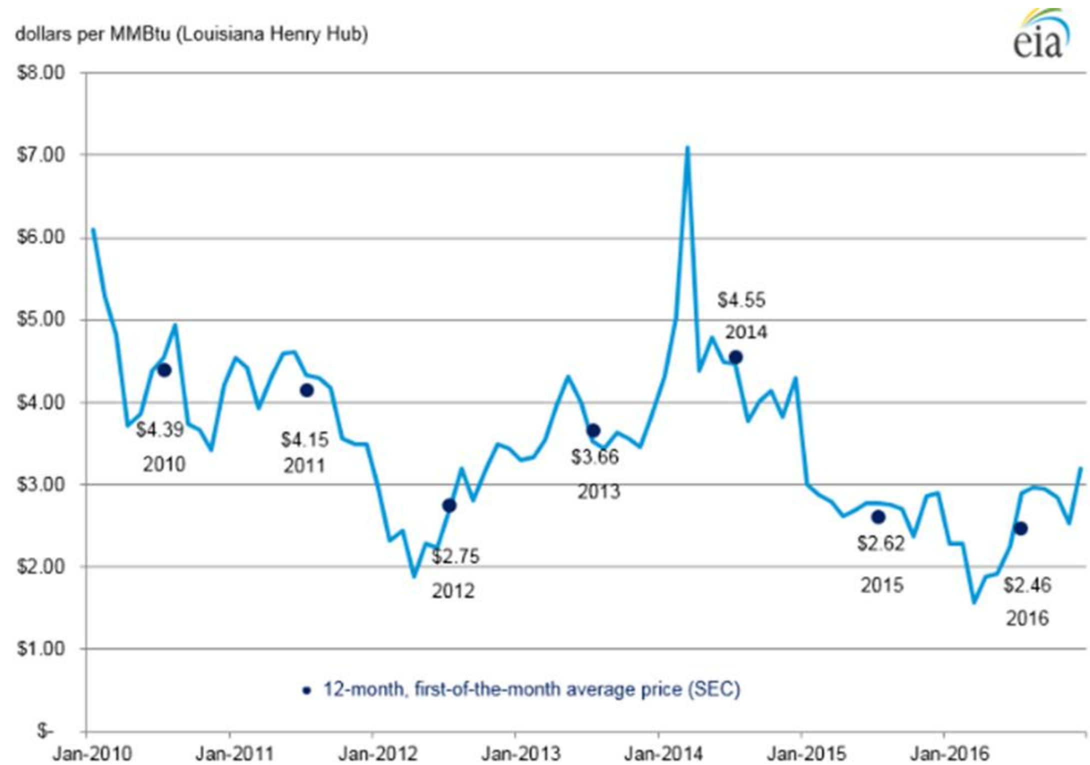
The central question continues to be 'will the shale gas revolution continue?' We begin with evidence that the low prices continue today, but we draw out the point that proved reserves – our typical metric for abundance – declined in the face of significantly lower prices thus suggesting a limit to how low natural gas prices can go in the long run. We also draw out the point that the revolution is not only in natural gas but also in oil – indeed the shale oil revolution garners more of the headlines – and that the two revolutions are linked. The links between shale gas and shale oil have been important to natural gas prices in the past and will continue to be in the future.

This year we also update our assessment of the risks for shale technology. We consider both the underground risk – the risk that shale technology will continue to improve – and the above-ground risks – from environmental regulation and the increased frequency of earthquakes.

A. Yes, the Shale Gas Revolution Continues

The good news about natural gas prices for consumers got even better in 2015 and 2016. As seen in Figure 1 natural gas prices on average, as measured at Henry Hub, declined by 42.4 percent from \$4.55 per MMBtu in 2014 to \$2.62 per MMBtu in 2015. From 2015 to 2016 prices declined by an additional 6.1 percent from \$2.62 per MMBtu in 2015 to \$2.46 per MMBtu.

Figure 1: Henry Hub natural gas spot prices, first-day-of-the-month, 2010-16



Source: Thomson Reuters, EIA, *U.S. Crude Oil and Natural Gas Proved Reserves, Year-end 2015,* 1. Available at https://www.eia.gov/naturalgas/crudeoilreserves/.

However, in large part due to the decline in prices, our oft-referenced metric for abundance – proved reserves – declined by 16.6 percent from 2014 to 2015.[1] EIA states further:

> Sustained low prices for oil and natural gas continued through most of 2016, and downward reserves revisions are likely in EIA's next report for year-end 2016, but probably not to the same degree as in 2015. Lower prices have curtailed drilling and made the economics more challenging in 2016. Although technically recoverable resource estimates are not necessarily reduced by lower prices, the calculation of proved reserves is sensitive to price changes.[2]

In the face of the price declines, shale gas proved reserves declined by far less than conventional gas reserves. Shale reserves fell 12 percent while more conventional reserves in the Lower 48 onshore declined by 21.4 percent; see Figure 2. This indicates, as expected, that

[1] EIA, *U.S. Crude Oil and Natural Gas Proved Reserves, Year-end 2015,* 1. Available at https://www.eia.gov/naturalgas/crudeoilreserves/.

[2] EIA, *U.S. Crude Oil and Natural Gas Proved Reserves, Year-end 2015,* 2.

shale is a lower cost source of natural gas. In 2015, shale accounted for 54 percent of total natural gas reserves in the United States.[3]

Figure 2: Changes in Proved Reserves of U.S. Natural Gas by Source, 2014-2015

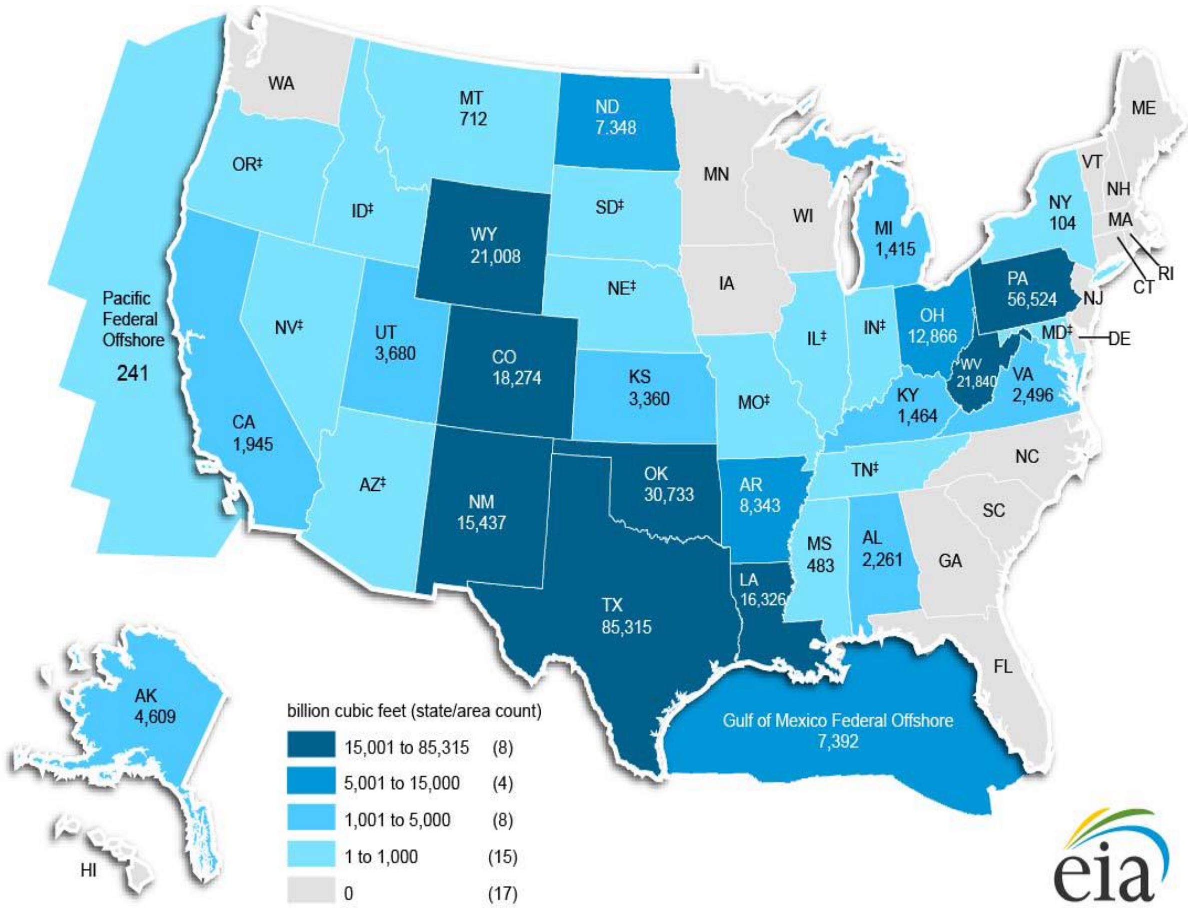
Source of natural gas	Year-end 2014 Proved Reserves	2015 Discoveries	2015 Revisions and other changes	2015 Production	Year-end 2015 Proved Reserves
Coalbed methane	15.7	0.1	-2.0	-1.3	12.5
Shale	199.7	25.9	-34.8	-15.2	175.6
Other U.S. natural gas					
Lower 48 onshore	157.2	8.4	-30.8	-11.3	123.6
Lower 48 offshore	9.4	0.3	-0.4	-1.3	8.0
Alaska	6.8	0.0	-1.9	-0.3	4.6
U.S. TOTAL	**388.8**	**34.7**	**-69.9**	**-29.3**	**324.3**

Source: EIA, Form EIA-23L, Annual Report of Domestic Oil and Gas Reserves, 2014 and 2015. Available at https://www.eia.gov/naturalgas/crudeoilreserves/.

As seen in Figure 3, six states in the SPP are significant players in terms of their top ranking for natural gas reserves within their state boundaries: Texas, Oklahoma, New Mexico, Arkansas, North Dakota, and Kansas. These SPP states account for 46.4 percent of total natural gas proved reserves.

[3] EIA, *U.S. Crude Oil and Natural Gas Proved Reserves, Year-end 2015*, 17.

Figure 3: Natural Gas Proved Reserves by State/Area 2015



Note: * denotes data withheld to avoid disclosure of individual company data.
Source: Source U.S EIA, Form EIA-23L, Annual Report of Domestic Oil and Gas Reserves, Available at https://www.eia.gov/naturalgas/crudeoilreserves/pdf/usreserves.pdf.

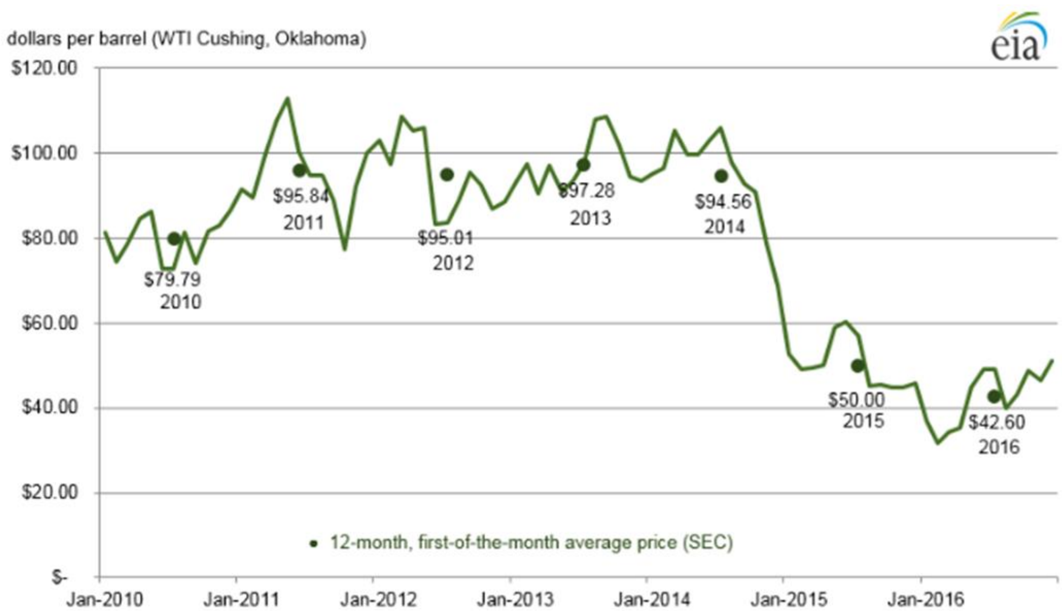
B. The Shale Oil Revolution

One other milestone was reached due to the shale gas revolution: The United States became a net exporter of natural gas in November 2016.[4] As the United States becomes a larger player in liquefied natural gas ("LNG") exports, the world oil market will become a bigger factor in natural gas prices in the U.S. Natural gas and oil will be linked in this broad world market because in some markets they will compete head-to-head. As we have discussed in previous Looking Forward Reports, the two fuels are linked even more directly; a previous Looking Forward Report suggested that high oil prices were affecting natural gas price because of associated gas and because of natural gas liquids production.

[4] Stephanie Yang and Alison Sider. "New Milestone: The U.S. Is Now a Net Exporter of Natural Gas." *Wall Street Journal*. November 28, 2016. Available at https://www.wsj.com/articles/new-milestone-the-u-s-is-now-a-net-exporter-of-natural-gas-1480258801.

But there are other links between these two fuels. The shale oil revolution was sparked by the same technology and has had a similar, significant impact on oil prices and proved reserves. As seen in Figure 4, the price of a barrel of oil at Cushing, Oklahoma fell 47.1 percent from $94.56 per barrel in 2014 to $50 per barrel in 2015. The price fell by another 14.8 percent from $50 per barrel in 2015 to $42.60 in 2016.

Figure 4: WTI Crude Oil Spot Prices, first-day-of-the-month, 2010-2016



Source: Thomson Reuters, EIA. Available at https://www.eia.gov/naturalgas/crudeoilreserves/pdf/usreserves.pdf.

As with natural gas, the decline in oil prices led, at least in part, to a decline in U.S. oil reserves. U.S. oil reserves declined 11.8 percent from 39.9 billion barrels in 2014 to 35.2 billion barrels in 2015.[5] Also as with natural gas, this decline in oil reserves indicates to some that, at present, it takes a price somewhat above $50 per barrel to cover the cost of substantial shale oil production. CNBC quotes Wood Mackenzie, the highly-regarded energy commodity experts, that investment in oil projects will increase in 2017. The firm believes that U.S. shale investment will lead the way because it is "relatively cheap and quick to develop, in some cases it can take only six months."[6] And, further, Wood Mackenzie reports that the more efficient production areas, including the Permian basin in Texas, production can be profitable with an oil price in the $40-$60 per barrel range.[7]

[5] EIA, *U.S. Crude Oil and Natural Gas Proved Reserves, Year-end 2015,* 2.

[6] Ron Bousso. "New oil projects to double in 2017, WoodMac says." *CNBC*. January 11, 2017. Available at http://www.cnbc.com/2017/01/11/reuters-america-new-oil-projects-to-double-in-2017-woodmac-says.html

[7] Ron Bousso. "New oil projects to double in 2017, WoodMac says." *CNBC*. January 11, 2017.

A similar picture was drawn in an interview by Bloomberg with Fatih Birol, Executive Director of the International Energy Agency. In the face of the promised cut back in production by OPEC, Mr. Birol expected U.S. shale oil producers to "react strongly."[8] While he acknowledged production costs vary by shale play, he suggested a breakeven price for U.S. shale oil in the range of $50-$55 per barrel.[9] At the same time, he suggested that at that price he would expect new supply from other places including Brazil, Mexico, and China. Mr. Birol went on to say that U.S. shale oil is very price-sensitive since it can be "turned on and off" as prices change. He expects the price to be volatile. And he sees no final peak being reached in world oil demand.[10]

Finally, when asked about the impact of the new administration in Washington, he expected that would also increase U.S. oil and gas production in significant terms. Wood MacKenzie also anticipated an increase coming for the polices of the new administration. In a December 19, 2016 Press Release, Wood Mackenzie wrote: "The US Independents will respond first to rising prices. Emboldened by a Trump administration committed to exploiting domestic oil and gas resources, US [lower 48 states] operators have three core competitive advantages: access to capital; cost-advantaged portfolios; and flexibility to scale back spend sharply if prices stay low."[11]

And while the share of proved reserves attributed to shale *oil* is not as large as the share with shale *gas* (which is 54 percent), shale oil, or more broadly "tight plays" account for 33 percent of proved reserves for oil. The EIA states: "As of December 31, 2015, *tight plays* accounted for 33% of all U.S. crude oil and lease condensate proved reserves. Most of these proved reserves (93%) came from six tight oil plays. The Bakken/Three Forks play in the Williston Basin remained the largest oil-producing tight play in the United States in 2015."[12]

C. Underground Uncertainty

The shale gas and oil revolution will continue to bring low prices and abundance if and only if technological improvements continue because producers must turn to more and more difficult resources to expand production. A 2012 article in MIT Technology Review put it well: "The world isn't running out of oil and gas. It is running out of easy oil and gas."[13]

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[8] Francine Lacqua and Javier Blas. "IEA Sees Significant Gains in U.S. Shale Oil as Prices Rise." *Bloomberg*. January 18, 2017. Available at https://www.bloomberg.com/news/articles/2017-01-18/iea-sees-significant-increase-in-u-s-shale-oil-as-prices-rise.

[9] Francine Lacqua and Javier Blas. "IEA Sees Significant Gains in U.S. Shale Oil as Prices Rise." *Bloomberg*. January 18, 2017.

[10] Francine Lacqua and Javier Blas. "IEA Sees Significant Gains in U.S. Shale Oil as Prices Rise." *Bloomberg*. January 18, 2017.

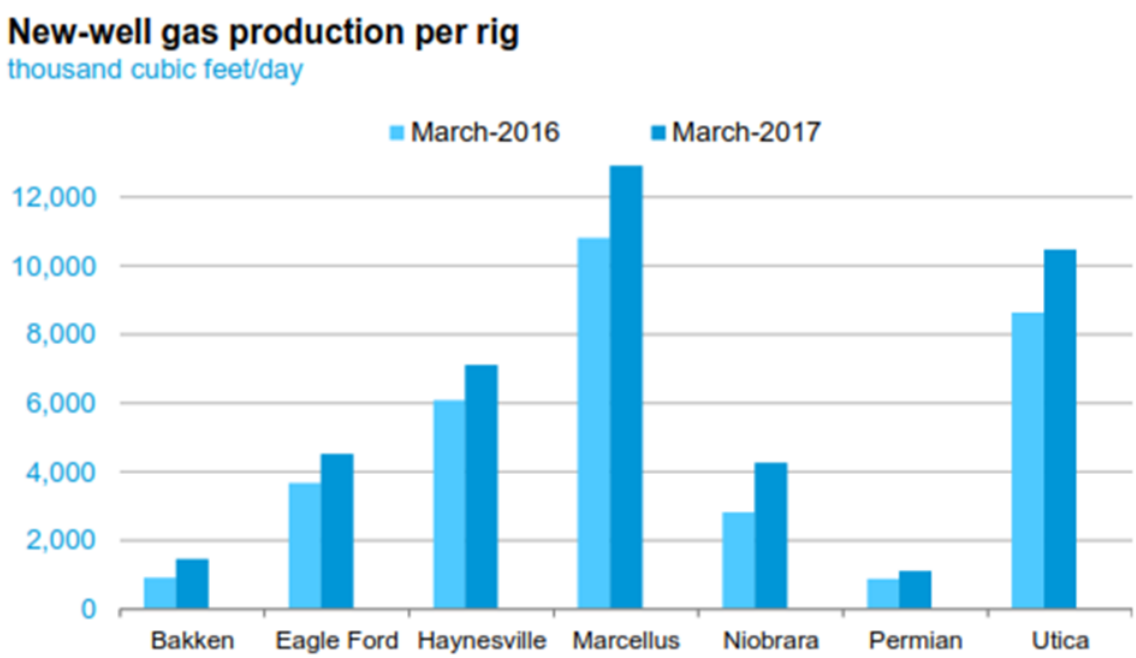
[11] "Wood Mackenzie forecasts 2017 to be a year of 'stability and opportunity' for global oil and gas." *WoodMackenzie*. December 19, 2016. Available at https://www.woodmac.com/media-centre/12534118.

[12] EIA, *U.S. Crude Oil and Natural Gas Proved Reserves, Year-end 2015*, 10.

[13] Jessica Leber. "Big Oil Goes Mining for Big Data." *MIT Technology Review*. May 8, 2012. Available at https://www.technologyreview.com/s/427876/big-oil-goes-mining-for-big-data/.

We start with short-term evidence that the technology has indeed continued to improve, and then turn to evidence on why. The EIA published in February 2017 its *Drilling Productivity Report: For key tight oil and shale gas regions*.[14] EIA starts with the fact that "[t]he seven regions analyzed in this report accounted for 92% of domestic oil production growth and all domestic natural gas production growth during 2011-14."[15] The metric we draw from EIA to document continued technological improvement in the short-term is the amount of natural gas produced by new wells; if that increases year after year, then we say that technology continues to improve. As seen in Figure 5 excerpted from the EIA Report, new well gas production was expected to increase in all seven regions from March 2016 to March 2017.

Figure 5: New-well Gas Production Per Rig (thousand cubic feet/day)



Source: EIA February 2017 Drilling Productivity Report. Available at http://www.eia.gov/petroleum/drilling/.

Why will technology continue to improve? To answer, we return to a central point made in last year's Looking Froward Report: many analysts see "big data analytics" as the primary reason.[16] In the article in MIT Review cited above, the author added that, "as energy companies drill deeper and hunt in more remote regions and difficult deposits, they're banking on information technology to boost production."[17] Are real companies making big bets on so-called big data as the way to keep up the pace of technology improvement? It seems that they are. One good example is the new company formed by an investment partnership of GE and Baker

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[14] February 2017 EIA Drilling Productivity Report, 1. Available at http://www.eia.gov/petroleum/drilling/.

[15] February 2017 EIA Drilling Productivity Report, 1.

[16] Craig R. Roach, PhD. and Vincent Musco, *Southwest Power Pool Annual Looking Forward Report*. April 15, 2016, 17-18. ("2016 Looking Forward Report").

[17] Leber. "Big Oil Goes Mining for Big Data."

Hughes. Several points were made in a CNBC article on November 1, 2016.[18] Per the CNBC article, GE and Baker Hughes first got together "to discuss how Baker Hughes could use GE's Predix big data technology" to increase productivity in the oil fields.[19] It was agreed that "[t]he marriage of big data and new energy technology could be a game changer."[20]

However, despite the extensive, long-standing collection of real-time data, some find that only a small portion of that data was being used. McKinsey & Co. reported that "less than 1 percent of the information . . . they studied reached decision-makers."[21] GE itself had found that "[w]hile the industry has invested for decades in seismic technology, 2D and 3D modeling and is most likely one of the largest data collectors in the world, there [sic] one inconvenient truth to it: We are utilizing only (!) 5% of the data collected."[22]

To illustrate how big data might be used, GE noted that "GE's Predix can, for example, help Baker Hughes determine when a piece of equipment is likely to fail, based on how long it's been in the field."[23] Presumably the equipment would be replaced before failure to minimize any interruption in production. Looking more broadly at the strategy, GE Baker Hughes said that they could become a "molecule to megawatt" company.[24] A market analyst added that the new company could perform across the entire fuel cycle "finding the oil, bringing it on to production, and then also creating the equipment that can generate electricity."[25] GE identified two additional strategic forces driving industry to big data. One was the challenge to earn a profit as oil and gas prices declined. The other was to offset the loss of skilled, experienced workers as they retired.[26]

Schlumberger and Haliburton, two substantial competitors in oil and gas field services, are advancing with their own innovations, some related to big data. For example, Schlumberger announced a data analytics partnership with Chevron in 2015.[27] Such investments in the use of big data analytics can result in higher production and, therefore, lower prices for natural gas and oil.

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[18] Tom DiChristopher. "GE-Baker Hughes: Some call the deal unprecedented; others see a 'competitive nuisance.'" *CNBC*. November 1, 2016. Available at http://www.cnbc.com/2016/11/01/ge-baker-hughes-merger-breaking-down-the-oilfield-services-deal.html.

[19] DiChristopher. "GE-Baker Hughes: Some call the deal unprecedented; others see a 'competitive nuisance.'"

[20] DiChristopher. "GE-Baker Hughes: Some call the deal unprecedented; others see a 'competitive nuisance.'"

[21] DiChristopher. "GE-Baker Hughes: Some call the deal unprecedented; others see a 'competitive nuisance.'"

[22] Matthias Heilmann, Chief Digital Officer, GE Oil & Gas. "Digital Transformation in Industrial – The real thing for Oil and Gas!" *GE*. December 1, 2016. Available at https://www.geoilandgas.com/our-voice/digital-transformation-industrial-real-thing-oil-gas.

[23] DiChristopher. "GE-Baker Hughes: Some call the deal unprecedented; others see a 'competitive nuisance.'"

[24] DiChristopher. "GE-Baker Hughes: Some call the deal unprecedented; others see a 'competitive nuisance.'"

[25] DiChristopher. "GE-Baker Hughes: Some call the deal unprecedented; others see a 'competitive nuisance.'"

[26] The ARC Advisory Group. "Asset Performance Management Overcomes Challenges in the Oil & Gas Industry." *GE*. November 8, 2016. Available at https://www.geoilandgas.com/our-voice/asset-performance-management-overcomes-challenges-oil-gas-industry.

[27] "Chevron and Schlumberger sign data analytics contract." *Oil Review*. March 27, 2015. Available at http://www.oilreviewmiddleeast.com/information-technology/chevron-and-schlumberger-sign-data-analytics-contract.

D. Above Ground Uncertainty

1. Shale Gas Production's Impact on Drinking Water

Chief among the above-ground uncertainties is the regulatory response to highly-publicized concerns over the possible effect of shale gas production on drinking water resources. We have followed this issue in detail since the 2013 Looking Forward Report,[28] and since then, the EPA has published two major documents, each with a different 'tone.'

First, in June 2015, EPA published a draft report on its findings related to shale gas production's impact on drinking water ("Draft Report"). We wrote about this draft report in last year's Looking Forward Report; notably we explained that there was reason to conclude that the uncertainty had been reduced because of the EPA's overall conclusion. Although stated with caveats, the EPA concluded that there was no evidence of "widespread systemic impacts on drinking water resources."[29]

The second major document issued by the EPA was its final report on shale production's impact on drinking water, published in December 2016 ("Final Report"). While some of the data and other evidence has not changed since the Draft Report, the EPA no longer stated the same, calming conclusion. Instead, the Final Report has a different overall tone. It is more about describing the ways shale gas production does and *could* affect drinking water resources, and less a definitive study of the record. The report is offered as guidance for state governments and other stakeholders to help them focus on the most severe possible harm. Because of the change in tone, we believe the Final Report has restored some of the uncertainty about what shale gas producers will be required to do to mitigate potential harm to drinking water resources. (This change in tone in a document from President Obama's administration will, of course, be weighed against the planned change in direction on environmental policy of President Trump's administration.)

Recall that in the *2013 Looking Forward Report* we were impressed with EPA's comprehensive scope of work, especially two aspects: "(a) its comprehensive coverage of the full, five-stage water cycle for hydraulic fracturing and (b) the wide range of evidence to be considered when judging potential dangers to drinking water at any of these five stages."[30] When the Draft Report was published in June 2015, we noted that "EPA identified five 'mechanisms' by which such wells could impact drinking water."[31] EPA described the five as follows: "These mechanisms include water withdrawals in times of, or in areas with, low water availability; spills of hydraulic fracturing fluids and produced water; fracturing directly into underground drinking water resources; below ground migration of liquids and gases; and

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[28] Craig R. Roach, PhD., Vincent Musco, Sam Choi, and Andrew Gisselquist. *Southwest Power Pool Annual Looking Forward Report*. April 23, 2013, 15-17. ("2013 Looking Forward Report").

[29] Office of Research and Development. "Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources (External Review Draft)." *Environmental Protection Agency*, June 5, 2015, ES-6 lines 17-21. Available at http://cfpub.epa.gov/ncea/hfstudy/recordisplay.cfm?deid=244651 ("EPA Draft Drinking Water Assessment").

[30] 2013 Looking Forward Report, 15.

[31] 2016 Looking Forward Report, 19.

inadequate treatment and discharge of wastewater."[32] Most importantly, we quoted EPA's major conclusion: "We [EPA] did not find evidence that these mechanisms have led to widespread, systemic impacts on drinking water resources in the United States. Of the potential mechanisms identified in this report we found specific instances where one or more mechanisms led to impacts on drinking water resources, including contamination of drinking water wells. The number of identified cases, however, was small compared to the number of hydraulically fractured wells."[33]

Again, the tone of the conclusions in the Final Report is very different; EPA suggests that, while it found evidence of impact at the local level, limited data and other information meant that it could not come to a definitive conclusion for the nation as a whole. For example, EPA states:

> The available data and information allowed us to qualitatively describe factors that affect the frequency or severity of impacts at the local level. However, significant data gaps and uncertainties in the available data prevented us from calculating or estimating the national frequency of impacts on drinking water resources from activities in the hydraulic fracturing water cycle. The data gaps and uncertainties described in this report also precluded a full characterization of the severity of impacts.[34]

Moreover, in the Final Report, EPA now offers a detailed description of how drinking water resources could be harmed, but does not offer evidence on the national extent and severity of the harm. For example, EPA states:

> The scientific information in this report can help inform decisions by federal, state, tribal, and local officials; industry; and communities. In the short-term, attention could be focused on the combinations of activities and factors outlined above. In the longer-term, attention could be focused on reducing the data gaps and uncertainties identified in this report. Through these efforts, current and future drinking water resources can be better protected in areas where hydraulic fracturing is occurring or being considered.[35]

Aside from its change in tone and revised overall conclusions, the Final Report does include a lot of useful information. For example, EPA estimates that, between 2000 and 2013, about 275,000 wells were drilled that likely used hydro fracturing technology.[36] As to the level of water use, EPA reports that "[i]n most counties studied, the average annual water volumes reported in FracFocus 1.0 were generally less than 1% of total water use. This suggests that

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[32] 2016 Looking Forward Report, 19; EPA Draft Drinking Water Assessment, ES-6 lines 12 to 16. EPA specifies that the report is in draft form and should not be cited or quoted, however, its conclusions are useful to draw on for this analysis.

[33] 2016 Looking Forward Report, 19; EPA Draft Drinking Water Assessment, ES-6, lines 17 to 21.

[34] Office of Research and Development. "Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States (Final Report): Executive Summary." *Environmental Protection Agency*, December 2016, 2. Available at https://cfpub.epa.gov/ncea/hfstudy/recordisplay.cfm?deid=332990 ("EPA Final Drinking Water Assessment Executive Summary").

[35] EPA Final Drinking Water Assessment Executive Summary, 2.

[36] EPA Final Drinking Water Assessment Executive Summary, 6.

hydraulic fracturing operations represented a relatively small user of water in most counties. There were exceptions, however."[37] Concerning the number of produced water spills and the impact, EPA states that "30 of the 225 (13%) produced water spills characterized were reported to have reached surface water (e.g., creeks, ponds, or wetlands), and one was reported to have reached groundwater."[38] Related to the chemicals used in hydrofracturing, EPA stated that "[s]ome of the chemicals in the hydraulic fracturing water cycle are known to be hazardous to human health. Of the 1,606 chemicals identified by the EPA, 173 had chronic oral toxicity values from federal, state, and international sources that met the EPA's criteria for inclusion in this report."[39] Still, this recitation of facts did not take EPA back to its clear conclusion in its Draft Report.

2. Seismic Activity

Earthquakes have been another major above-ground risk that we have followed since 2014; it is above-ground in the sense that the regulatory response to the concern could increase the cost of shale gas and oil production going forward. Scientists made it clear that it was not hydraulic fracturing *per se* that was linked to the earthquakes, but rather the link was to wastewater injection associated with both conventional and unconventional oil and natural gas production. We presented evidence on that distinction in previous reports.[40]

Oklahoma earthquakes have received rightfully a lot of press coverage ranging widely from the national to the state level. It includes local coverage by the Red Dirt Report with its article on April 23, 2016 titled "Earthquake issue not as easy as flipping a switch, Commissioner Murphy says."[41] Commissioner Dana Murphy of the Oklahoma Corporation Commission is quoted in most of the coverage, a fact which reveals the leadership role she has taken with this important, real, but often politicized concern. Her fact-based presentation about Oklahoma's earthquake issue to NARUC in November 2016 also illustrates her role.[42]

In our 2016 Looking Forward Report we focused on the debate over who should address concerns: should it be the courts or the legislative and executive branches of state government? We favored the latter because of the broader scope of inquiry as well as the broader range of solutions that could be pursued. A recent article in Energy In Depth gives further support for that preference. The article writes about the "collaborative efforts between producers and regulators" in Oklahoma and reports that such collaboration works because earthquakes are down in

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[37] EPA Final Drinking Water Assessment Executive Summary, 13.

[38] EPA Final Drinking Water Assessment Executive Summary, 31.

[39] EPA Final Drinking Water Assessment Executive Summary, 39.

[40] 2016 Looking Forward Report, 20-22.

[41] Tim Farley. "Earthquake issue not as easy as flipping switch, Commissioner Murphy says." *Red Dirt Report*. April 23, 2016. Available at http://www.reddirtreport.com/red-dirt-news/earthquake-issue-not-easy-flipping-switch-commissioner-murphy-says.

[42] Dana Murphy (speech). "Earthquake Impacts from Waste Water Injection from Oil and Gas Production." *NARUC 128th Annual Meeting Committee on Electricity.* November 14, 2016. Available at http://pubs.naruc.org/pub/B244D67D-E64A-06AE-62C7-C2773FF473FA.

Oklahoma in 2016 as compared to 2015.[43] As seen in Figure 6 based on data from the Oklahoma Geological Survey show that earthquakes with measured magnitude of 3.0 or higher earthquakes declined in number from 903 in 2015 to 623 in 2016. Consistent with this trend is the recent Stanford University study, which forecasts that the number of earthquakes in Oklahoma will return to the “normal level” in five to ten years.[44]

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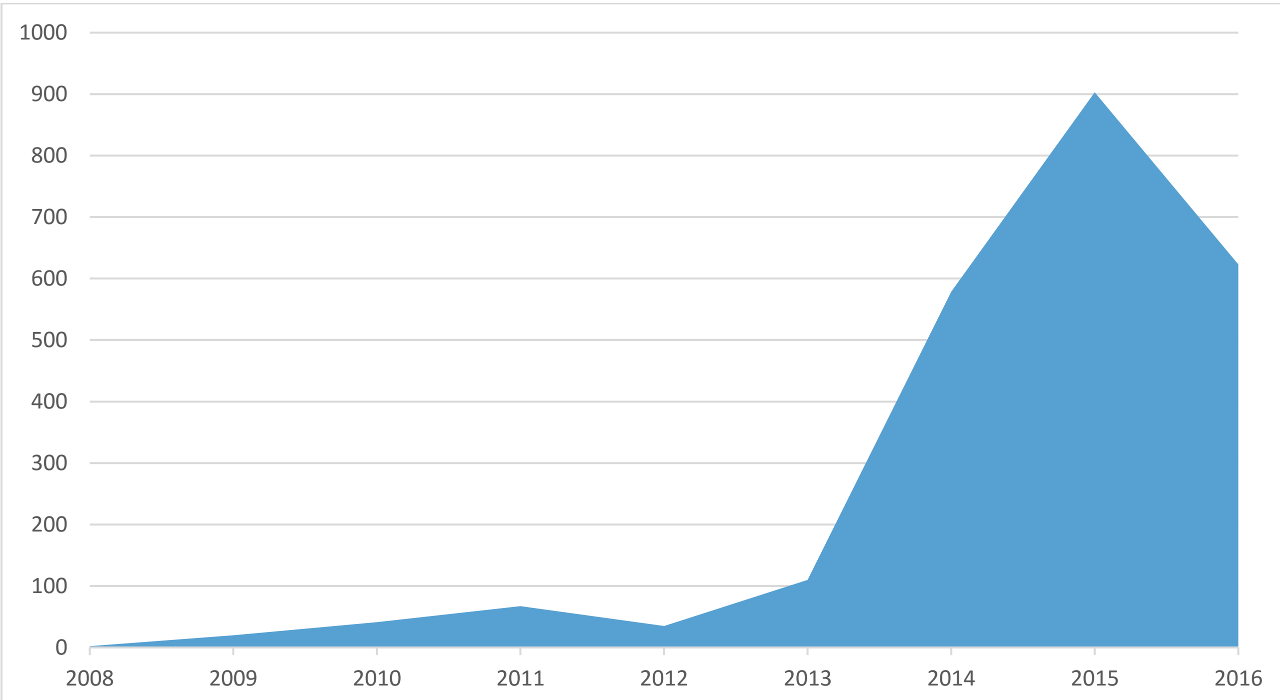
[43] Matt Mandel. “Seismicity in Oklahoma Declines, Thanks to Collaborative Efforts between Producers and Regulators.” *Energy InDepth*. August 24, 2016. Available at https://www.energyindepth.org/national/seismicity-in-oklahoma-declines-thanks-to-collaborative-efforts-between-producers-and-regulators/.

[44] Cornelius Langenbruch and Mark D. Zoback, “How will induced seismicity in Oklahoma respond to decreased saltwater injection rates?” *Science Advances*. November 30, 2016. Available at http://advances.sciencemag.org/content/2/11/e1601542.

Figure 6: Earthquakes in Oklahoma Over Magnitude 3.0



Source: United States Geological Survey and Oklahoma Geological Survey. Available at http://earthquakes.ok.gov/what-we-know/.

Of course, the number of earthquakes should not be the sole metric of focus – increases in the magnitude of the earthquakes matter, too. For example, on November 22, 2016, the U.S. EPA wrote to the Oklahoma Corporation Commission raising concern about the 5.0 magnitude earthquake in Cushing, because of its potential impact on the significant oil storage facilities there.[45] Magnitude and locations matter, too.

Still, to get close to the facts about the problem as well as close to the solution, collaboration and cooperation should be a preferred approach. Commissioner Murphy was quoted in the Energy In Depth article saying "[t]he amount of collaboration and cooperation we have had around this issue has been tremendous, like nothing I've ever seen."[46] Dr. Austin Holland from the U.S. Geological Survey ("USGS") expressed the same when he said "[w]e have a lot of incredible technical people between the oil and gas industry, between regulators, and between researchers. Bring everybody to the table and work on this together, and I'm confident that we'll find the answers we need."[47] The central point of the article is that progress

[45] Associated Press. "EPA: Oklahoma Regulators Should do More to Curb Earthquakes." February 3, 2017. Available at http://staging.hosted.ap.org/dynamic/stories/U/US_OKLAHOMA_EARTHQUAKES_EPA?SITE=AP&SECTION=HOME&TEMPLATE=DEFAULT&CTIME=2017-02-03-19-00-16.

[46] Mandel. "Seismicity in Oklahoma Declines, Thanks to Collaborative Efforts between Producers and Regulators."

[47] Mandel. "Seismicity in Oklahoma Declines, Thanks to Collaborative Efforts between Producers and Regulators."

is being made "without a ban or moratorium on wastewater disposal in the state – something many activists have argued would be the only solution."[48]

E. Conclusions

Low prices for natural gas and oil are a good thing, but there is a limit to how low they can go with consumers still being assured of abundant supply. Recent data on proved reserves indicate a floor of sorts of roughly $3 per MMBtu for gas and roughly $50 per barrel for oil. Prices lower than that would likely mean a decrease in proved reserves.

If low price and abundance are to continue well into the future, the industry must continue to improve the technology as the United States turns to more challenging geographical areas for production. To improve technology, businesses are placing a big bet on big data to address what we have termed under-ground risks. This seems to have a common-sense appeal since the data is there and apparently has yet to be fully applied to decision-making. However, this is not to say that other avenues, including basic research and development, should not be pursued independently.

As to above-ground risks – those affecting regulation for and cost of production – the EPA Final Report on shale gas production's impact on drinking water seems to have restored the uncertainty that had been largely removed by the EPA's previously-issued Draft Report. The ultimate impact of this step backward in the Final Report must be weighed with the impact on regulation from the new administration – something we turn to in the next chapter. On a brighter note, it seems that Oklahoma's approach to addressing the acknowledged concern with earthquakes has gotten well-deserved attention for the collaboration and cooperation it brought forth and, more importantly, for the results it has achieved.

[48] Mandel. "Seismicity in Oklahoma Declines, Thanks to Collaborative Efforts between Producers and Regulators."

II. EPA's Environmental Campaign (An Update)

Historically, the Looking Forward Report has chronicled in detail what we have termed EPA's environmental campaign. Last year we explained the legal justification for and the detailed mechanics of the ultimate action in the environmental campaign for the electricity business – President Obama's Clean Power Plan. Now, however, because of the significant changes that could be brought on by President Trump's election, there is substantial evidence suggesting a potential rollback, or repeal, of the Clean Power Plan, as well as other environmental regulations.

Repeal may not be easy, especially since the Supreme Court has ruled (in a 5-4 vote) that the EPA has the authority to regulate carbon emissions under the existing Clean Air Act.[49] Arguments about what it takes to repeal the Clean Power Plan are discussed in the first section below. The bottom line is that, given the advanced state of the litigation and rulemaking for the Clean Power Plan, the issue becomes less about repeal and more about action to repeal *and replace*.

In the context of repeal and replace, we then turn to the renewed talk of a carbon tax as the primary tool to address concerns about global climate change. The appeal of a carbon tax in today's circumstances lies in a broad policy context rather than in the details of any specific approach. A carbon tax could bring on fundamental change in three ways. First, instead of promoting selected zero-emission technologies like wind and solar, a carbon tax would create an incentive to cut carbon emissions with any type of technology or operational change. In this way, the central appeal of a carbon tax is that it would enlist all Americans in the effort to find a cost-effective way to address global climate change concerns.

Second, a carbon tax may help address a fundamental and growing potential issue for electricity markets, including markets in SPP. That issue is that low offer prices by renewable generation in wholesale markets, assisted by tax incentives, have contributed to lower market prices so much that out-of-market payments to conventional technologies may be needed to assure reliability. (Shale gas' impact on natural gas prices is, of course, the primary driver of lower prices). Third, and even more broadly, a carbon tax could become a core element of comprehensive tax reform in America.

In the second section below, we focus on a high-profile carbon tax proposal from two respected leaders of the Republican Party: Secretaries Shultz and Baker.

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[49] 2016 Looking Forward Report, section III.

A. Repeal and Replace?

The attitude towards President Trump's nominee to lead the Environmental Protection Agency has evolved in the headlines. When the President first nominated Oklahoma Attorney General Scott Pruitt, the Washington Post characterized it as "a move signaling an assault on President Obama's climate change and environmental legacy."[50] Much was made of the fact that Mr. Pruitt had joined with other states to oppose President Obama's Clean Power Plan.[51] The Wall Street Journal, for example, noted that "attorney general Pruitt had sued the EPA at least 14 times."[52]

In sharp contrast to what was said in the headlines, when announcing the nomination President Trump said that his administration "strongly believes in environmental protection, and Scott Pruitt will be a powerful advocate for that mission while promoting jobs, safety and opportunity."[53] The view that we can protect the environment and still create jobs was a central point from the start by the President and Mr. Pruitt. Other central views included Mr. Pruitt's concern that EPA has gone further than Congressional legislation authorized. Some industry representatives also argued that the EPA did not consistently respect states' rights through cooperative federalism.[54]

Mr. Pruitt highlighted these views in his Opening Statement for his Senate Confirmation Hearing.[55] He started with a respectful mention of the "thousands of dedicated public servants at EPA."[56] He called for cooperation between the Congress and EPA, among the states, between the states and the EPA, and between the EPA and the public.[57] He warned that the EPA must use its expertise to fulfill Congressional intent, and never to "end run Congress."[58] He spoke strongly of states' rights saying that federal statues make the states "our nation's frontline environmental implementers and enforcers."[59] And he made clear, once again, his view that

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[50] Chris Mooney, Brady Dennis, and Steve Munson. "Trump names Scott Pruitt, Oklahoma attorney general suing EPA on climate change, to head the EPA." *Washington Post*. December 8, 2016. Available at https://www.washingtonpost.com/news/energy-environment/wp/2016/12/07/trump-names-scott-pruitt-oklahoma-attorney-general-suing-epa-on-climate-change-to-head-the-epa/?utm_term=.0c1f3d7a9a85

[51] Mooney et al. "Trump names Scott Pruitt, Oklahoma attorney general suing EPA on climate change, to head the EPA."

[52] Kimberley A. Strassel. "Scott Pruitt's Back-to-Basics Agenda for the EPA." *Wall Street Journal*. February 17, 2017, Available at https://www.wsj.com/articles/scott-pruitts-back-to-basics-agenda-for-the-epa-1487375872.

[53] Mooney et al. "Trump names Scott Pruitt, Oklahoma attorney general suing EPA on climate change, to head the EPA."

[54] Mooney et al. "Trump names Scott Pruitt, Oklahoma attorney general suing EPA on climate change, to head the EPA."

[55] "Hearing on Nomination of Attorney General Scott Pruitt to be Administrator of the U.S. Environmental Protection Agency." *U.S. Senate Committee on Environment & Public Works*. January 18, 2017. Available at https://www.epw.senate.gov/public/index.cfm/hearings?Id=1FC50BFE-C59F-4815-86F8-E463582935A6&Statement_id=1FC9AA57-3768-4ABE-B33A-F5AEC0988DBF

[56] "Hearing on Nomination of Attorney General Scott Pruitt," 1.

[57] "Hearing on Nomination of Attorney General Scott Pruitt," 2-3.

[58] "Hearing on Nomination of Attorney General Scott Pruitt," 2-3.

[59] "Hearing on Nomination of Attorney General Scott Pruitt," 3.

"[w]e can simultaneously pursue the mutual goals of environmental protection and economic growth."[60]

As the process moved forward, the headlines showed less worry about what Mr. Pruitt might do. The New York Times suggested that Mr. Pruitt would use "a Scalpel, Not a Cleaver" to cut back EPA programs, and that there would be no "shock and awe" to "disorient Washington."[61] Pointing especially to the Clean Power Plan, the New York Times said that "[e]ven if he could kill the Obama-era Clean Power Plan outright, he would not eliminate a legal requirement for the E.P.A. to continue regulating greenhouse gas emissions. A repeal would simply force the Trump administration to write its own climate rule."[62] As we have noted in previous Looking Forward Reports, the U.S. Supreme Court ruled that the EPA has the authority to regulate greenhouse gases the existing Clean Air Act.[63] With its Court-affirmed authority established, it is a reasonable expectation that EPA will exercise that authority to regulate greenhouse gases.

Given this, there is good reason to believe that the Clean Power Plan may become another circumstance calling for a policy of repeal *and replace*. That is the view in the New York Times article above. Keith Goldberg put a fine point on the legal barriers to simple repeal when he wrote that Mr. Pruitt would have to withdraw the Clean Power Plan

> [w]ithout running headlong into the U.S. Supreme Court's rulings in Massachusetts v. EPA and American Electric Power Co. Inc. v. Connecticut, which cemented the agency's Clean Air Act authority to regulate greenhouse gas emissions, as well as the D.C. Circuit's ruling in Coalition for Responsible Regulation et al v. EPA et al., in which it upheld the agency's finding that greenhouse gas emissions endanger human health and welfare.[64]

B. A Carbon Tax as the Replacement

If replacement is required, what would that replacement be? Somewhat surprisingly, two eminent republicans, George P. Shultz and James A. Baker III, implicitly gave an answer in their Op-Ed in the Wall Street Journal on February 7, 2017 titled "A Conservative Answer to Climate Change."[65] The "answer" they proposed was a carbon tax. The authors wrote in terms of a solution that "rests on four pillars":

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[60] "Hearing on Nomination of Attorney General Scott Pruitt," 4.

[61] Coral Davenport. "Scott Pruitt Is Seen Cutting the E.P.A. with a Scalpel, not a Cleaver." *The New York Times*. February 5, 2017. Available at https://www.nytimes.com/2017/02/05/us/politics/scott-pruitt-is-seen-cutting-the-epa-with-a-scalpel-not-a-cleaver.html?_r=0.

[62] Davenport, "Scott Pruitt Is Seen Cutting the E.P.A. with a Scalpel, not a Cleaver."

[63] 2016 Looking Forward Report, section III.

[64] Keith Goldberg. "Scalpel, Not Sledgehammer, Seen as Pruitt's Best Bet." *Law360*. February 24, 2017. Available at https://www.law360.com/articles/895006/scalpel-not-sledgehammer-seen-as-pruitt-s-best-bet

[65] George P. Shultz and James A. Baker III. "A Conservative Answer to Climate Change." *The Wall Street Journal*. February 7, 2017. Available at https://www.wsj.com/articles/a-conservative-answer-to-climate-change-1486512334.

> First, creating a gradually increasing carbon tax. Second, returning the tax proceeds to the American people in the form of dividends. Third, establishing border carbon adjustments that protect American competitiveness and encourage other countries to follow suit. And fourth, rolling back government regulations once such a system is in place.[66]

Multiple publications have described the rationale for the proposal and given some of the mechanics at the *Climate Leadership Council*.[67] However, the best analysis to reveal what such a proposal entails is an independent report from the Department of Treasury's Office of Tax Analysis in January 2017 titled "Methodology for Analyzing a Carbon Tax."[68] Treasury noted from the start that a unique aspect of a carbon tax that distinguishes it from other dedicated excise taxes is that the revenue can be used to reduce other taxes through a so-called "tax swap."[69]

To make the tax proposal tangible, Treasury assumes "a carbon tax that started at $49 per metric ton of carbon dioxide equivalent (mt CO_2-e) in 2019 and increased to $70 in 2028."[70] As an initial estimate, Treasury reports that this tax "would generate net revenues of $194 billion in the first year of the tax and $2.221 trillion over the 10-year window from 2019 through 2028."[71] In the context of a tax swap, Treasury made it clear that the carbon tax would raise a substantial amount of money: "In 2019, this carbon tax revenue would represent approximately 50 percent of projected corporate income tax payments or 20 percent of the OASDI [Old Age, Survivors and Disability Insurance Program] portion of the payroll tax."[72] Alternatively, if the proceeds of the carbon tax were redistributed to individuals – as is called for under the Shultz and Baker dividend plan – "it would amount to $583 per person in the U.S." in the first year.[73]

As to coverage, Treasury notes that "[f]ossil fuel combustion represents roughly 76 percent of U.S. greenhouse gas emissions" and "essentially all of these could be covered by an excise tax levied on coal, natural gas, and petroleum."[74] Treasury reports the possible methods for and complexities of administering a carbon tax. They distinguish, for example, between placement of the tax collection "upstream" or "midstream."[75] An upstream tax "would be levied

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[66] Shultz and Baker, "A Conservative Answer to Climate Change."

[67] See James A. Baker III, et al. "The Conservative Case for Carbon Dividends." *Climate Leadership Council*. February 2017 and David Bailey and David Bookbinder. "A Winning Trade." *Climate Leadership Council*. February 2017. Available at https://www.clcouncil.org/.

[68] John Horowitz, et al. "Methodology for Analyzing a Carbon Tax." *The Department of the Treasury, Office of Tax Analysis*. Working Paper 115, January 2017. Available at https://www.treasury.gov/resource-center/tax-policy/tax-analysis/Documents/WP-115.pdf

[69] Horowitz, et al. "Methodology for Analyzing a Carbon Tax," 3.

[70] Horowitz, et al. "Methodology for Analyzing a Carbon Tax," 3.

[71] Horowitz, et al. "Methodology for Analyzing a Carbon Tax," 3.

[72] Horowitz, et al. "Methodology for Analyzing a Carbon Tax," 3.

[73] Horowitz, et al. "Methodology for Analyzing a Carbon Tax," 3.

[74] Horowitz, et al. "Methodology for Analyzing a Carbon Tax," 4.

[75] Horowitz, et al. "Methodology for Analyzing a Carbon Tax," 4.

on (i) crude oil as it reaches the refinery, (ii) natural gas as it leaves the processor to enter a pipeline system . . . and (iii) coal as it leaves the mine."[76] As implied by the "border carbon adjustment" cited in the Shultz/Baker proposal, Treasury states that to assure a "carbon tax focused solely on domestic use, fuel imports would be taxed and exports would be eligible for a refundable tax credit."[77] As to other details Treasury notes that carbon captured and stored also would be "eligible for a refundable tax credit."[78] So, too, fuels used in a way that does not cause emissions – chemical feedstock for example – "would be exempted from the tax or could claim a credit.[79]

Figure 7: CO_2 Content and Tax Rates for Fossil Fuels at $49/metric ton of Carbon Dioxide Equivalent

Fuel	CO_2 content[1]	Tax @ $49/mt CO_2-e
Natural gas and coal *(Upstream or midstream approach)*[2]		
Natural gas	53.12 kg/mcf	$2.60/mcf
Anthracite	2,578.68 kg/short ton	$126.36/short ton
Bituminous	2,236.80 kg/short ton	$109.60/short ton
Sub-bituminous	1,685.51 kg/short ton	$82.59/short ton
Lignite	1,266.25 kg/short ton	$62.05/short ton
Petroleum		
Midstream approach (representative fuels):		
Gasoline	8.89 kg/gallon	$0.44/gallon
Diesel, home heating oil	10.16 kg/gallon	$0.50/gallon
Jet fuel	9.57 kg/gallon	$0.47/gallon
Upstream approach:		
Crude oil	432 kg/bbl[3]	$21.17/barrel

[1] Source: http://www.eia.gov/environment/emissions/co2_vol_mass.cfm. CO_2 content parameters represent OTA's assessment of tax-relevant emissions and should not be considered definitive for any carbon tax that may be enacted.
[2] For natural gas and coal, upstream and midstream approaches differ in the point in the supply chain at which the fuel is taxed but not the form of the fuel or the per-unit fuel tax at the point of taxation.
[3] Source: https://www.epa.gov/energy/ghg-equivalencies-calculator-calculations-and-references

Figure 7, excerpted from the Treasury report, purports to estimate the effect of the first-year $49 carbon tax on the cost of a variety of fuels. The tax per mt CO_2 equivalent would be

[76] Horowitz, et al. "Methodology for Analyzing a Carbon Tax," 4.
[77] Horowitz, et al. "Methodology for Analyzing a Carbon Tax," 4.
[78] Horowitz, et al. "Methodology for Analyzing a Carbon Tax," 4.
[79] Horowitz, et al. "Methodology for Analyzing a Carbon Tax," 4.

$2.60 per MCF of natural gas, $109.60 per short ton of bituminous coal, and 44 cents per gallon of gasoline.[80]

Figure 8: Tax, Net Revenue, and Emissions under a Carbon Tax (main scenario)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Tax[a] ($/mt CO2-e, nominal)	$49	$52	$54	$56	$58	$60	$62	$65	$67	$70
Revenue and Emissions										
Net revenue[b,c] ($bn, nominal)	$194	$210	$218	$214	$214	$219	$225	$235	$240	$250
Net revenue as pct. of GDP [b,c]	0.90	0.93	0.92	0.87	0.83	0.82	0.80	0.80	0.79	0.79
Emissions (covered sources,[c] mmt CO_2-e)	6,261	5,951	5,551	5,271	5,091	5,032	5,005	4,970	4,941	4,930
Emissions (covered sources) as pct. of baseline[c]	0.95	0.91	0.86	0.82	0.79	0.79	0.79	0.79	0.79	0.79

Source: Methodology for Analyzing a Carbon Tax, *Treasury Department*, Table 2.

Treasury then estimates revenue from the carbon tax, which has its complexities. Figure 8 is excerpted from the Treasury Report. Consistent with the Shultz/Baker estimate, Figure 8 shows that *net* revenue in nominal dollars would be $2.221 trillion over ten years.[81] *Gross* revenue from the carbon tax would be $2.962 trillion.[82] This is one of several complexities in tax revenue estimation and Treasury explained the important difference between *net* and *gross* revenue:

> The difference between gross revenue raised by the tax and the net revenue available for spending or reductions in other taxes (shown in Table 2) arises because the imposition of the carbon tax reduces taxpayer income subject to other Federal taxes and thus reduces income tax revenues at least to some extent. The wedge between gross and net tax revenue due to this effect is referred to as the offset.[83]

As a general matter, Treasury says that “long standing practice” has been to estimate a 25 percent offset for excise taxes, but the carbon tax is so large that it might be best to dig in deeper on the scale of the offset.[84]

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[80] Horowitz, et al. “Methodology for Analyzing a Carbon Tax,” 7.

[81] Horowitz, et al. “Methodology for Analyzing a Carbon Tax,” 10.

[82] Horowitz, et al. “Methodology for Analyzing a Carbon Tax,” 11.

[83] Horowitz, et al. “Methodology for Analyzing a Carbon Tax,” 11.

[84] Horowitz, et al. “Methodology for Analyzing a Carbon Tax,” 11, footnote 17.

Another complexity in estimating revenue is to predict the pace of decline in carbon emissions due to response to the tax and advances in technology. Figure 8 also shows the estimated 21 percent decline in emissions over the years; note that emissions decline even though covered sources are presumed by Treasury to be expanded over time. Still, by year 10, emissions are only 79 percent of the baseline. Treasury did a sensitivity analysis in which it assumed "more rapid technological progress [advances in energy efficiency or renewable energy generation] in which covered emissions fell" to 53 percent of their baseline level by 2028.[85] In this accelerated technology scenario, the cumulative net revenue over the first 10 years was $1.636 trillion, about 26 percent lower than in Treasury's base case estimate.[86]

Several other elements of the tax design are discussed by Treasury including the border carbon tax adjustment.[87] Treasury then turns to the distributional analysis of four ways to make it revenue-neutral.[88] Excerpted Figure 9 shows who pays the carbon tax prior to making it revenue neutral. Families are divided into ten deciles from lowest to highest family income. The tenth column from the left shows which deciles pay the proposed carbon tax. For example, the highest decile pays 36.4 percent of the tax while the lowest decile pays 0.6 percent. The top three deciles together pay about 66.7 percent of the carbon tax.[89]

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[85] Horowitz, et al. "Methodology for Analyzing a Carbon Tax," Table 3.

[86] Horowitz, et al. "Methodology for Analyzing a Carbon Tax," 13. Table 3.

[87] Horowitz, et al. "Methodology for Analyzing a Carbon Tax," 15-16.

[88] Horowitz, et al. "Methodology for Analyzing a Carbon Tax," 16, 23.

[89] Horowitz, et al. "Methodology for Analyzing a Carbon Tax," 24, Table 5.

Figure 9: Carbon Tax of $49 per Metric Ton without Revenue Recycling

Adjusted Family Cash Income Decile	Number of Families (millions)	Distribution of Cash Income (%)	Distribution of Total Federal Taxes		Average Federal Tax Rate		Tax Change				Change in After-Tax Income (%)
			Current Law (%)	Proposal (%)	Current Law (%)	Proposal (%)	Amount ($B)	Average ($)	Percent Distribution (%)	As a % of Current Law (%)	
0 to 10	16.4	1.0	-0.5	-0.4	-10.3	-9.4	1.2	72	0.6	-8.1	-0.8
10 to 20	17.2	2.1	-0.4	-0.3	-4.4	-3.2	3.9	229	2.0	-28.8	-1.2
20 to 30	17.2	2.8	0.2	0.3	1.4	2.7	5.7	332	2.9	98.1	-1.4
30 to 40	17.2	3.7	1.0	1.2	5.6	7.0	7.9	460	4.1	25.5	-1.5
40 to 50	17.2	5.0	2.2	2.4	9.2	10.7	10.8	630	5.6	15.7	-1.6
50 to 60	17.2	6.6	3.9	4.1	12.3	13.8	14.8	861	7.6	12.2	-1.7
60 to 70	17.2	8.5	6.1	6.3	15.0	16.5	19.3	1,120	9.9	10.1	-1.8
70 to 80	17.2	11.2	9.4	9.6	17.6	19.1	25.1	1,461	12.9	8.6	-1.8
80 to 90	17.2	15.5	15.5	15.6	20.9	22.4	33.8	1,964	17.4	7.0	-1.8
90 to 100	17.2	45.1	62.5	61.0	29.0	30.0	70.7	4,111	36.4	3.6	-1.5
Total	172.1	100.0	100.0	100.0	21.0	22.3	194.3	1,129	100.0	6.2	-1.6
90 to 95	8.6	11.2	12.4	12.4	23.3	24.7	23.4	2,718	12.0	6.0	-1.8
95 to 99	6.9	15.2	18.5	18.3	25.5	26.7	27.9	4,052	14.4	4.8	-1.6
99 to 99.9	1.5	9.4	14.6	14.1	32.7	33.6	13.3	8,611	6.9	2.9	-1.4
Top .1	0.2	9.4	17.0	16.2	37.7	38.2	6.1	35,640	3.2	1.2	-0.7

Source: Methodology for Analyzing a Carbon Tax, *Treasury Department*, Table 5.

In terms of change in after-tax income due to the carbon tax, the twelfth column shows that on average families suffer a 1.6 percent decline in after-tax income. The decline for the highest decile is 1.8 percent while decline for the lowest decile is 0.8 percent.[90] Note, importantly, that this is the gross impact of the carbon tax; it does not capture the effect of redistribution or offsetting tax cuts that would make the carbon tax revenue neutral.

Treasury closes its analysis of the impact of the tax on after-tax income by assessing four different tax swaps. The Shultz/Baker proposal would redistribute the tax revenue per capita – that would be $583 per person in year one – and the result of this redistribution on after-tax income is shown in excerpted Figure 10 the sixth column from the left.

[90] Horowitz, et al. "Methodology for Analyzing a Carbon Tax," 24, Table 5.

Figure 10: The Distribution of $49/mt Carbon Tax and Revenue Recycling Options

Adjusted Family Cash Income Decile	Number of Families (millions)	Distribution of Cash Income (%)	Current Law Federal Tax Burden as a % of Cash Income (%)	Change in After-Tax Income				
				No Revenue Recycling (%)	$583 Per Person Rebate (%)	Reduce OASDI Payroll Tax Rate (%)	Reduce Corporate Tax Rate (%)	1/3 Rebate, 1/3 Payroll 1/3, Corp Tax Cut (%)
0 to 10	16.4	1.0	-10.3	-0.8	8.9	0.0	-0.5	2.8
10 to 20	17.2	2.1	-4.4	-1.2	4.7	0.0	-1.0	1.3
20 to 30	17.2	2.8	1.4	-1.4	3.1	0.1	-1.1	0.7
30 to 40	17.2	3.7	5.6	-1.5	2.0	0.0	-1.1	0.3
40 to 50	17.2	5.0	9.2	-1.6	1.2	0.1	-1.1	0.1
50 to 60	17.2	6.6	12.3	-1.7	0.6	0.1	-1.1	-0.1
60 to 70	17.2	8.5	15.0	-1.8	0.1	0.2	-1.0	-0.3
70 to 80	17.2	11.2	17.6	-1.8	-0.3	0.3	-1.0	-0.3
80 to 90	17.2	15.5	20.9	-1.8	-0.7	0.4	-0.8	-0.4
90 to 100	17.2	45.1	29.0	-1.5	-1.0	-0.3	1.5	0.0
Total	172.1	100.0	21.0	-1.6	0.0	0.0	0.0	0.0
90 to 95	8.6	11.2	23.3	-1.8	-1.0	0.3	-0.6	-0.4
95 to 99	6.9	15.2	25.5	-1.6	-1.1	-0.2	0.1	-0.4
99 to 99.9	1.5	9.4	32.7	-1.4	-1.2	-0.9	2.1	0.0
Top .1	0.2	9.4	37.7	-0.7	-0.7	-0.6	6.3	1.7

Source: Methodology for Analyzing a Carbon Tax, *Treasury Department,* Table 6.

The highest decile families would see their after-tax income *fall* by 1.0 percent.[91] The lowest decile would see an *increase* in after-tax income of 8.9 percent.[92] With the per capita payment, families in seven of the ten deciles would enjoy an *increase* in after-tax income per this Treasury analysis. This reflects the fact that these families – 70 percent of all families – would receive a tax rebate worth more than what they would pay in taxes under the Shultz/Baker proposal. The top three deciles would suffer a decrease in after-tax income ranging from 0.3 percent to 1.0 percent.[93]

In sharp contrast, if the carbon tax revenue was used to reduce the "corporate tax rate," only the highest decile would enjoy an *increase* in after tax income – families in all the other nine deciles would suffer a decline in after-tax income, ranging from 0.5 percent to 1.1 percent.[94] Because of these different impacts on after-tax income, how the proposals achieve revenue neutrality may become a pivotal issue. The Shultz/Baker proposal sided with the per capita distribution, which uses the carbon tax to redistribute income from the higher deciles to the

91 Horowitz, et al. "Methodology for Analyzing a Carbon Tax," 26, Table 6.

92 Horowitz, et al. "Methodology for Analyzing a Carbon Tax," 26, Table 6.

93 Horowitz, et al. "Methodology for Analyzing a Carbon Tax," 26, Table 6.

94 Horowitz, et al. "Methodology for Analyzing a Carbon Tax," 26, Table 6.

lower. Those proposing the cut in corporate tax rates would suggest their approach leads to new investment and related productivity gains brought forth with the lower marginal tax rate.

Despite the pedigree of its authors, Republicans have not rallied around the Shultz/Baker proposal. Even the Wall Street Journal, on whose Op-Ed page the proposal first appeared, rejected it, concluding that "[a]ll of this would be a political disaster for President Trump and Republicans, and with minimal impact on global temperatures."[95] Still, the Wall Street Journal acknowledged that "[a] carbon tax would be better than bankrupting industries by regulation and more efficient than a 'cap-and-trade' emissions credit scheme."[96] And the Journal opened the door a bit to a different proposal by writing that "[s]uch a tax might be worth considering if traded for radially lower taxes on capital or income."[97] However, the Journal found additional concerns including the view that the dividend plan would be "a new de facto entitlement with an uncertain funding future," even as carbon emissions decline.[98] And further, the import fee would be another concern for the Journal because it "looks like an appeal to Mr. Trump's protectionist impulses."[99]

C. Conclusions

There would nothing easy about winning Congressional approval for, designing and implementing a carbon tax. Still, taking a broad view, a carbon tax may be a tax whose time will come in the heat of Congressional debates for three interconnected reasons. First, a carbon tax may be needed to replace President Obama's Clean Power Plan. Because the Supreme Court has affirmed the EPA's authority under the Clean Air Act to regulate greenhouse gases, it seems clear that if the Clean Power Plan is repealed, it must then be replaced. A carbon tax may be the market-based approach that is best to enlist all segments of America in the effort to cut carbon emissions.

Second, a carbon tax may be needed to finance comprehensive tax reform. With one to two trillion dollars in revenue over its first ten years, a carbon tax could finance substantial tax reform. More broadly, it may have appeal to those who believe that, if we must tax something, it would be better to tax something we might not want – carbon emissions – instead of taxing something we do want – smart investment and hard work.

Third, a carbon tax could help address an issue (particularly important to SPP) caused by current federal tax subsidies and state mandates for renewables. While the surge in renewable generation has conferred benefits in the U.S., it has led to an abundance of renewable power resources with zero marginal costs. That, in turn, means electricity prices are lower than they

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[95] "The Carbon Tax Chimera: The Shultz-Baker proposal sounds better than it would work." *The Wall Street Journal*. February 25, 2017. Available at https://www.wsj.com/articles/the-carbon-tax-chimera-1487979109.

[96] "The Carbon Tax Chimera: The Shultz-Baker proposal sounds better than it would work."

[97] "The Carbon Tax Chimera: The Shultz-Baker proposal sounds better than it would work."

[98] "The Carbon Tax Chimera: The Shultz-Baker proposal sounds better than it would work."

[99] "The Carbon Tax Chimera: The Shultz-Baker proposal sounds better than it would work."

otherwise would have been; of course, abundant shale gas' downward pressure on market prices has been the primary driver. Low market prices, in turn, may mean that conventional resources – especially those needed to assure reliability – may not be profitable enough in the SPP energy market to stay on-line at times. A carbon tax changes all that by serving as an incentive for any technology with zero or low carbon emissions – including but not limited to renewables – by raising prices for power from technologies that have higher emissions. Ideally, the carbon tax sets a full price for power including power's impact on global climate change.

III. Distributed Energy Resources, Decentralization, and the Changing Utility Model (An Update)

A. Introduction

Since we first introduced the topic in 2013, we have been seeking to answer what is becoming one of the most important questions for grid planners, regulators, market participants, and ratepayers: are distributed energy resources[100] (a) an existential competitive threat to the grid, or (b) a potential complement that may require efforts to plan and integrate, or (c) both above? In 2014, for example, we found that "there is no definitive answer to whether and to what extent distributed technologies will represent a head-on competitive threat to the existing utility network model" and that some studies suggest that distributed resources and the grid may be "complements, not competitors."[101] In 2015, we explained that "there is no conclusive evidence suggesting that widespread decentralization is imminent," but that there was "constructive activity" in private innovation and public policy that "may suggest an emerging challenge to the traditional utility model."[102] And last year, we noted that economies of scale make utility-scale renewables cheaper than distributed versions and, that in most cases, distributed energy resources – particularly solar PV and energy storage – are "new competition…for the production of electricity," but such resources rely on the grid to deliver that electricity.[103]

This year, we revisit the fundamental question and, once again, find no easy answers; we find that distributed energy resources are not yet an existential threat to the transmission grid, but that they are likely to challenge generation-owning utilities in the production of electricity and could also emerge as alternatives to traditional grid investments. More specifically, we find some emerging themes in the analysis of and commentary on distributed energy resources.

First, this topic is timely. Cheryl LaFleur, Acting Chairman of FERC, recently stated that one of the four "biggest challenges" facing grid operators today is managing "an increasingly decentralized electric power system;" she stated that "[w]e have really crossed a tipping point" and noted that "[w]hat people have been writing about for decades is actually happening."[104] Moreover, as we explain herein, distributed energy resources are already integrated and operating in regional power grids across the U.S.

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[100] For the purposes of this Report, we define distributed energy resources to include resources that are behind the meter and/or connected to the distribution grid. These can include distributed generation of all technologies, energy storage, and microgrids, among others.

[101] 2014 Looking Forward Report, 5.

[102] 2015 Looking Forward Report, 9.

[103] 2016 Looking Forward Report, 7 to 8.

[104] Molly Christian. "FERC's LaFleur lays out top 4 challenges to power grid." *S&P Global Market Intelligence.* March 21, 2017.

Second, the evidence continues to suggest that the transmission grid remains essential and is often relied upon by distributed energy resources in their value proposition or for reliability. Net metering customers, microgrids, and others all tend to use grid power when it is economic to do so, and most such installations are not intended to take customers completely off-grid.

Third, while the grid remains essential, one impact of distributed energy resources is that fewer kilowatt-hours will be delivered on the transmission grid. This means that grid planners, like SPP, may see reduced needs for new transmission investment, while generation-owning utilities face new competition for the supply of kilowatt-hours and must adapt their planning and forecasting accordingly. New energy efficiency efforts further reduce demand for kilowatt-hours from the grid and exacerbate "load migration" away from utility-scale, grid-delivered power. This means that the Board should consider all forces that are reducing the kilowatt-hours on the grid and flattening demand growth, not just distributed energy resources (like rooftop solar installations). The California ISO is already dealing with these impacts: in its 2016-2017 Transmission Plan, it cancelled 13 previously-approved transmission projects and put five others on hold, citing both lower demand growth and increased penetration of distributed energy resources.[105]

Fourth, the evolving U.S. generation resource mix – major new investment in natural gas-fired and renewable generation, shutdown of aging baseload coal, gas, and nuclear generation – could create new opportunities for distributed energy resources. Recent studies by MIT and ICF recommend the consideration of distributed energy resources as alternatives to traditional grid investments – like generation and transmission – and suggests regulatory overhauls to allow such competition to occur. Moreover, in places like New York and California, investments in such distributed alternatives have already begun; we provide some examples below.

Fifth, and finally, the Board should be aware that there is a torrent of activity related to distributed energy resources ongoing in almost every state in the U.S., and new ventures start every day. To best serve the Board, we highlight a few of the most compelling case studies that demonstrate the diversity of this activity, the breakneck pace of innovation, and the caliber of human talent and resources that are at work in this area. These case studies include, among others, (a) California ISO's efforts to allow distributed energy resource aggregators into their markets, and the four aggregator entities already applying to do so, (b) an example of an "empowered" end-user – a small town in Ohio – successfully investing in the solar-plus-storage model, and (c) the introduction of "blockchain" technology to the electricity industry.

The takeaway for the Board is that new case studies like these appear regularly and could merit Board attention throughout the year. What follows here is an admittedly lengthy discussion that documents for the Board the full depth and breadth of the discussion of and

[105] "2016-2017 Transmission Plan." *California ISO*. March 17, 2017, 3. Available at http://www.caiso.com/Documents/Board-Approved_2016-2017TransmissionPlan.pdf. ("CAISO Transmission Plan")

investment in this increasingly active area of distributed energy resources.

B. Decentralization's "Tipping Point?"

The first theme we draw out for the Board is the timeliness of this topic and the emergence of distributed energy resources. Acting FERC Chairman Cheryl LaFleur is not alone in her assessment that decentralization is "really happening" and may have already passed a "tipping point."[106] At a March 15, 2017 conference hosted by the Edison Foundation's Institute for Electric Innovation, utility executives and state commissioners from across the U.S. discussed the issue of distributed energy resources and their impact on the U.S. electricity industry. Alan Oshima, the president and CEO of Hawaiian Electric Company, which perhaps more than any other utility, has seen the most rapid increase in distributed energy resources, claimed that "[w]hat's happening to us will happen to everyone."[107] He believes distributed energy resources are "going to transform the power system faster than cell phones remade the communications sector" because "[c]ustomers are going to demand it."[108]

While it is not clear if distributed energy resources have reached such a tipping point, or what such a tipping point implies, some in the utility business seem to agree that distributed energy resources' growth outlook is strong. In its 2017 "State of the Electric Utility Survey," Utility Dive (in association with PA Consulting) found that of the 600 electric utility employees that responded, a majority of respondents indicated that they expect "moderate-to-significant growth" in nearly every distributed energy resource listed, including distributed solar, behind-the-meter storage, demand response, and smart inverters and other grid communication technologies.[109] In addition, according to the MIT Energy Initiative:

> "[a] 2015 survey of global electric power sector executives found that 97 percent expect medium or high levels of disruption in their market segments by 2020, with 86 percent of executives in North America and 91 percent in Europe projecting major changes to the market model in which they operate by 2030."[110]

What was once conceptual is becoming a reality: for example, in a recent MIT Energy Initiative Working Paper, the authors identify 144 "distributed energy business models" currently operating today, providing services such as demand response and energy management, electrical and thermal storage, and solar PV.[111] In terms of specific amount of distributed *generation*,

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[106] Christian, "FERC's LaFleur lays out top 4 challenges to power grid."

[107] Michael Copley. "Hawaii's energy upheaval 'will happen to everyone.'" *S&P Global Market Intelligence*. March 16, 2017. ("Copley Article")

[108] Copley Article.

[109] Utility Dive in association with PA Consulting, "2017 State of the Electric Utility Survey." Slides 45-46.

[110] "Utility of the Future." *MIT Energy Initiative*. December 2016, 9. Available at http://energy.mit.edu/wp-content/uploads/2016/12/Utility-of-the-Future-Full-Report.pdf. ("MIT Utility of the Future Report")

[111] Scott P. Burger and Max Luke. "Business Models for Distributed Energy Resources: A Review and Empirical Analysis," *MIT Energy Initiative Working Paper*. April 2016, 3. ("MIT Business Models Paper").

which is one subset of distributed energy resources, EIA indicates that 3.4 GW of new distributed solar PV capacity came online in 2016,[112] which brought total distributed solar PV installations to over 13 GW in the U.S by early 2017.[113] In total, at the end of 2016, 1.3 million households have solar PV installations.[114]

Beyond distributed solar, other distributed energy resources – such as non-solar distributed generation and energy storage technologies – are and will continue to be "of interest," according to MIT.[115] For example, according to MIT Energy Initiative, "combined heat and power (CHP) units and fuel cells accounted for 8 percent of all U.S. generation capacity in 2015, and this capacity is expected to grow."[116] MIT also notes that "75 percent of backup generation capacity in the United States is fueled by diesel or natural gas."[117] Finally, MIT states that "thermal energy storage, lithium-ion batteries, and other energy storage resources (such as flow batteries) are becoming more competitive," "are increasingly being deployed in a distributed fashion," and "while the total market size for energy storage resources remains small and localized, the US market for non-pumped hydro energy storage grew by more than 240 percent in 2015."[118]

While it is true that the falling cost of distributed energy resources and subsidies like net metering and tax credits help make the economic case for investment, other factors are at play. Those factors include (a) environmental performance (e.g., the potential for 100 percent renewable energy), (b) "doorstep" reliability even when the grid is experiencing outages, (c) greater personal choice by informed consumers, and (d) the avoidance of grid costs, each of which we have noted in the past.[119] Now, utilities are recognizing that their customers – especially the next generation of ratepayers – may introduce new scrutiny of their costs and demand their electricity services differently than past generations. Asim Haque, Chairman of the Public Utilities Commission of Ohio, recently made this point when he stated:

> Part of what you're going to have to do in this space, I think, is conceptually say not necessarily what is cost-effective, but what is cost-worthy based upon what your customer base wants…There are generations of customers that are coming up right now who can't fathom that this is how power is delivered, and they are effectively, without much input and without much control, forced to pay a bill that is totally an enigma when

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[112] "U.S. electric generating capacity increase in 2016 was largest net change since 2011." *U.S. Energy Information Administration*. February 27, 2017. Available at http://www.eia.gov/todayinenergy/detail.php?id=30112.

[113] "Electric Power Monthly with Data for December 2016." *U.S. Energy Information Administration,* February 2017, Table 6.1.B. Available at http://www.eia.gov/electricity/monthly/pdf/epm.pdf.

[114] "Solar Industry Data." *Solar Energy Industries Association*. Available at http://www.seia.org/research-resources/solar-industry-data.

[115] MIT Utility of the Future Report, 3.

[116] MIT Utility of the Future Report, 3.

[117] MIT Utility of the Future Report, 3 (footnote omitted).

[118] MIT Utility of the Future Report, 3.

[119] See, for example, 2016 Looking Forward Report, 58 to 59.

> they open it up every single month.[120]

Chairman Haque's statement suggests that the prospects for success of distributed energy resources and increased penetration will increase with time as the next generation of ratepayers' preferences shape the services offered by participants in the electricity industry.

C. The Transmission Grid Remains Essential

A second theme we are highlighting for the Board is that the grid remains essential. While distributed energy resources are already having an impact on the existing utility model and the electricity industry in general, they are not yet pushing consumers to go "off-grid." This is because, as we have noted before, "cost-effective, decentralized solar technology is not yet available to allow customers to truly disconnect from the grid."[121] Moreover, we have noted that "owners of distributed resources today are particularly reliant on the grid for backup power and/or access to markets to sell their excess power."[122]

In its landmark "Utility of the Future Report,"[123] MIT comes to a similar conclusion, noting the grid's economies of scale and high reliability. MIT states:

> With current technologies, system-wide, efficient, and grid-isolated solutions rarely happen in developed countries as a well-developed, interconnected electricity system takes advantage of economies of scale (of electricity generation resources and networks, risk and system management, and the complementarity of energy resources throughout a large territory) to provide a highly reliable electricity supply at a cost that is difficult to improve upon off-grid.[124]

MIT further claims that "[m]ost of the published studies on grid defection…usually underestimate the costs of the typical, low-reliability, off-grid system."[125] MIT highlights the results of one study – from EPRI, in 2016 – that "estimates the net present costs of off-grid supply for a US single-family household…for different estimated levels of reliability."[126] MIT states that, according to EPRI's study, an off-grid system using rooftop solar PV and storage "is more than 10 times more expensive than the grid-connected one for the same reliability level, and still about five times more expensive if a very low reliability level (80 percent) is considered

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[120] Copley Article.

[121] 2016 Looking Forward Report, 65.

[122] 2016 Looking Forward Report, 65.

[123] The 368-page report had a contributing staff of 37 professionals and an advisory committee of 27 others from academia, regulatory, regional transmission organizations, consulting, utilities, industry market participants and project developers, and leading thinkers in the electricity business.

[124] MIT Utility of the Future Report, 120.

[125] MIT Utility of the Future Report, 120.

[126] MIT Utility of the Future Report, 120.

acceptable for the off-grid system."[127] MIT claims that if a diesel generator is added to the solar-plus-storage off-grid system, reliability improves, but "the cost is still several times more expensive than purchasing the power from the grid, and, moreover, the amount of carbon and other pollutant emissions dramatically increases, offsetting the benefits of installing renewables."[128]

D. Nevertheless, Grid-Delivered Kilowatt-Hours may be Decreasing, Leading to "Flattening Demand" – Which Introduces Risks to RTOs/ISOs and Utilities

Our third theme is that "flattening demand" – sometimes attributable in part to penetration of distributed energy resources – is occurring, and will likely have impacts on grid planners and utilities. Despite the lack of true grid defection, distributed energy resources are increasing competition for the production of kilowatt-hours, and as a result, are decreasing the need for electricity delivered over the transmission grid. That is, for every electron produced at the distributed level, or provided through demand response, that is one less electron needed from the grid. Thus, as penetration of distributed energy resources increases, fewer kilowatt hours may be demanded from the grid,[129] even if the owners of those distributed energy resources remain reliant on the grid for reliability and the economic viability of their distributed investments (via net metering, for example).

Exacerbating this phenomenon is an old concept: energy efficiency and conservation, which has helped flatten demand for utility-scale power to a greater extent. Some have argued that "the U.S. would require about 50% more energy to deliver our current GDP" but for "the numerous energy efficiency improvements made since 1973."[130] Figure 11 shows the annual growth in U.S. electricity sales from 1950 to 2015, including averages by decade (the red line).

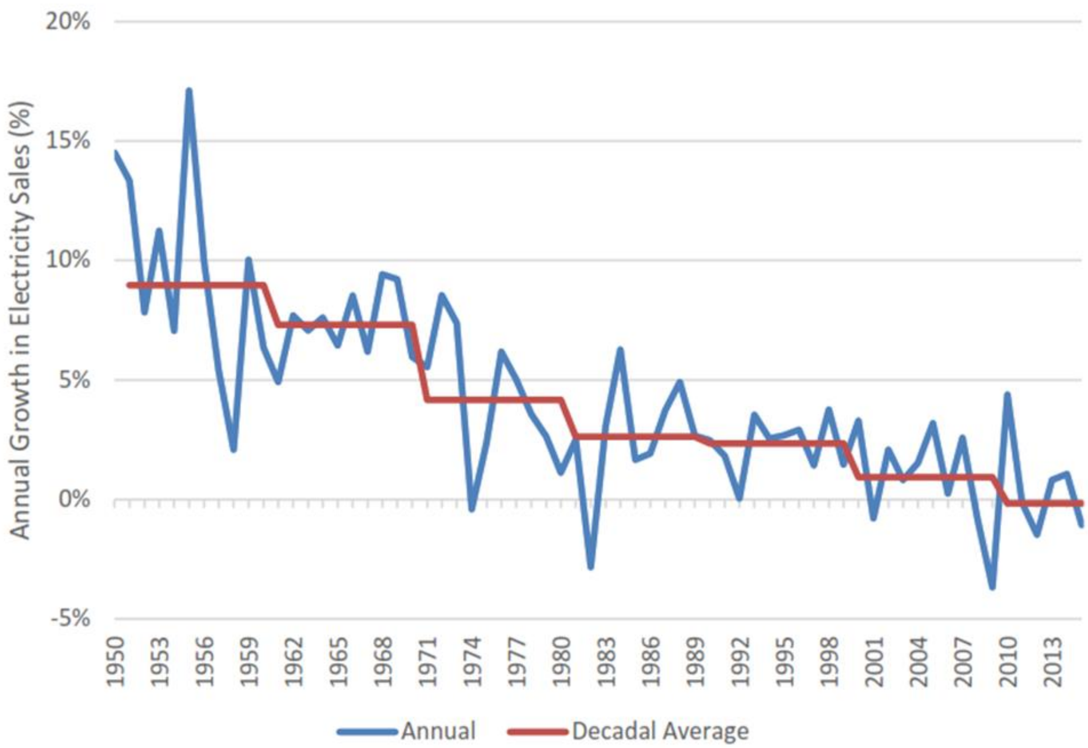
[127] MIT Utility of the Future Report, 120.

[128] MIT Utility of the Future Report, 121.

[129] Fredrich Karl, et al. "The Future of Electricity Resource Planning." *Berkeley National Laboratory*. September 2016, 18. Available at https://emp.lbl.gov/sites/all/files/lbnl-1006269.pdf. ("Berkeley Report")

[130] Susan F. Tierney. "The Value of 'DER' to 'D': The Role of Distributed Energy Resources in Supporting Local Electric Distribution System Reliability." *Analysis Group.* March 31, 2016, 8. Available at http://www.analysisgroup.com/uploadedfiles/content/news_and_events/news/value_of_der_to%20_d.pdf. ("Analysis Group Report")

Figure 11: Annual Growth in Electricity Sales, 1950 to 2015 and Averages by Decade



Source: Berkeley Report, Figure 7.

For the Board, the metric that matters most is decreasing demand of electricity from the grid, no matter the cause. It should not make much difference whether demand for electricity from the grid is decreasing because of production by and competition from distributed energy resources, or because energy efficiency is eroding the overall demand for electricity. In both cases, the power delivered on the grid is lower.

There are a few important implications of this "flattening demand." First, investment in flattening demand is coming in many forms and from increasingly complex and innovative sources. In a case study below involving Google's use of artificial intelligence to reduce electricity consumption at its facilities, we show that the caliber of resources, thinking, and investment into energy efficiency has increased considerably. Second, flattening demand can increase the risk of overbuilding the transmission system. Third, flattening demand will impact utility planning efforts, making it increasingly important for utilities to include distributed energy resources and demand-side resources in their planning and forecasting activities. We address each of these three points in the subsequent subsections.

1. Flattening Demand Investment and Innovation: A Modern Energy Efficiency Case Study

While most energy efficiency investments involve human design and human decisions, DeepMind, a leader in artificial intelligence research that is owned by Google's parent company, Alphabet, Inc., recently applied machine learning—that is, artificial intelligence—to the task of managing the energy consumption at its data centers.[131] DeepMind explains that, for ten years, it has focused on reducing energy usage by building "super-efficient servers at Google" and inventing "more efficient ways to cool [Google's] data centers."[132] DeepMind claims that it gets "3.5 times the computing power out of the same amount of energy" as five years ago.[133]

Nevertheless, according to DeepMind, "[o]ne of the primary sources of energy use in the data centre environment is cooling" which "is typically accomplished via large industrial equipment such as pumps, chillers and cooling towers."[134] DeepMind explains that data centers are "dynamic environments" that are "difficult to operate optimally" for several reasons, including:

> The equipment, how we operate that equipment, and the environment interact with each other in complex, nonlinear ways. Traditional formula-based engineering and human intuition often do not capture these interactions. The system cannot adapt quickly to internal or external changes (like the weather). This is because we cannot come up with rules and heuristics for every operating scenario.
>
> Each data centre has a unique architecture and environment. A custom-tuned model for one system may not be applicable to another. Therefore, a general intelligence framework is needed to understand the data centre's interactions.[135]

So, in 2014, DeepMind began applying machine learning to operate the data centers more efficiently. DeepMind claims that they "reduce[d] the amount of energy…for cooling by up to 40 percent."[136] DeepMind explains how they did it:

> Using a system of neural networks trained on different operating scenarios and parameters within our data centres, we created a more efficient and adaptive framework to understand data centre dynamics and optimize efficiency.
> We accomplished this by taking the historical data that had already been collected by thousands of sensors within the data centre -- data such as temperatures, power, pump speeds, setpoints, etc. -- and using it to train an ensemble of deep neural networks. Since

[131] Richard Evans and Jim Gao. "DeepMind AI Reduces Google Data Centre Cooling Bill by 40%." *DeepMind*. July 20, 2016. Available at https://deepmind.com/blog/deepmind-ai-reduces-google-data-centre-cooling-bill-40/. ("DeepMind")

[132] DeepMind.

[133] DeepMind.

[134] DeepMind.

[135] DeepMind.

[136] DeepMind.

our objective was to improve data centre energy efficiency, we trained the neural networks on the average future PUE (Power Usage Effectiveness), which is defined as the ratio of the total building energy usage to the IT energy usage. We then trained two additional ensembles of deep neural networks to predict the future temperature and pressure of the data centre over the next hour. The purpose of these predictions is to simulate the recommended actions from the PUE model, to ensure that we do not go beyond any operating constraints.

…Our machine learning system was able to consistently achieve a 40 percent reduction in the amount of energy used for cooling, which equates to a 15 percent reduction in overall PUE overhead after accounting for electrical losses and other non-cooling inefficiencies. It also produced the lowest PUE the site had ever seen.[137]

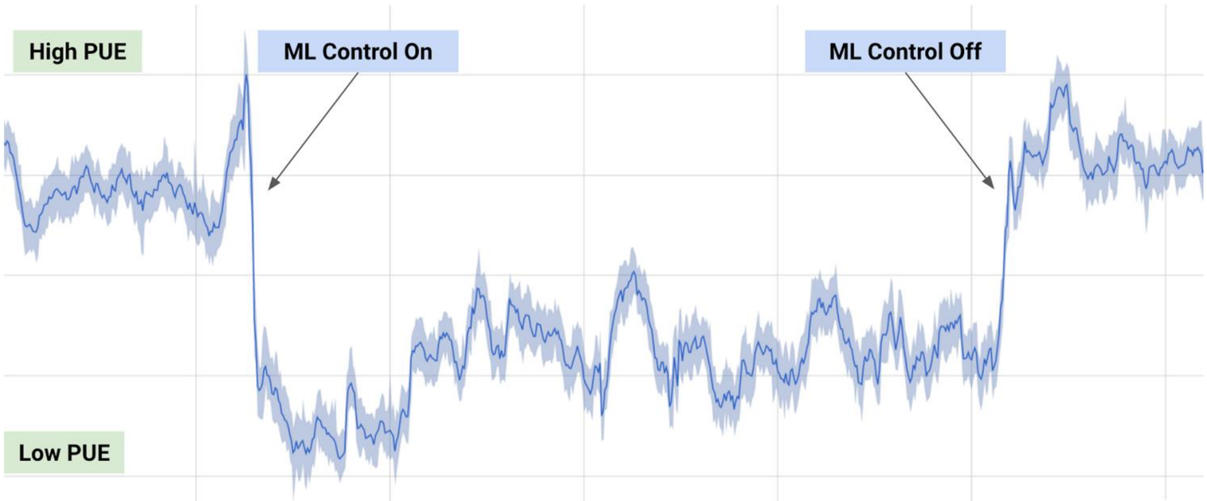
Below, Figure 12 shows the impact of turning over control of the Google data center to DeepMind's artificial intelligence—this is shown as "ML Control" in the Figure, which means "machine learning control." Figure 12 shows that while under ML Control, the "PUE," which is a measure of data center efficiency and "is determined by dividing the amount of power entering a data center by the power used to run the computer infrastructure within it,"[138] was much lower. The lower the PUE, the more efficient the data center.[139]

[137] DeepMind.

[138] Marget Rouse. "Power Usage Effectiveness (PUE)." *SearchDataCenter*. Available at http://searchdatacenter.techtarget.com/definition/power-usage-effectiveness-PUE.

[139] Ibid.

Figure 12: Comparison of Google Data Center's Efficiency under and not under DeepMind's Machine Learning Control



Source: DeepMind.

In 2014, data centers consumed about 70 billion kilowatt-hours per year, representing about 2 percent of total U.S. electricity consumption; consumption by data centers is expected to grow by 4 percent between 2016 and 2020.[140] That means that there may be considerable demand for applications like DeepMind's machine learning to help manage increasing electricity needs of data centers. Moreover, the application of artificial intelligence to distributed controls in buildings is a burgeoning field with other competitors, such as IBM.[141]

2. Flattening Demand's Impact on RTOs/ISOs: A Brief Case Study from California Highlighting the Potential Risk of Over-Investing in Transmission

To the extent that distributed energy resources and energy efficiency drive lower load growth going forward, RTOs and ISOs may find that new transmission investment may not be warranted in some cases. An example demonstrating the impact of flatter demand – driven in part by distributed energy resources – comes from California where more than two dozen previously-approved transmission projects were either cancelled or put on hold due, in large part, to lower-than-expected load forecasts and increased penetration of distributed energy resources.

On March 17, 2017, the California ISO published its most recent transmission plan. In it, the California ISO approved a total of just two new transmission projects, both for reliability

[140] Yevgeniy Sverdlik. "Here's How Much Energy All US Data Centers Consume." *Data Center Knowledge*. June 27, 2016. Available at http://www.datacenterknowledge.com/archives/2016/06/27/heres-how-much-energy-all-us-data-centers-consume/.

[141] Alper Uzmezler. "When Will Machine Learning Reach Smart Buildings?" *HPAC Engineering*. September 14, 2016. Available at http://hpac.com/building-controls/when-will-machine-learning-reach-smart-buildings.

purposes, costing a total of $24 million.[142] The plan included no new economic projects, nor any public policy projects, which typically accommodate new renewable resources.[143] Moreover, 13 projects that were previously approved in past plans were cancelled because they were no longer needed;[144] the ISO's plan also halted development of 15 other projects until the ISO can "further evaluate the uncertainties in variations in load forecast and other parameters."[145] According to Keith Casey, CAISO's vice president of market and infrastructure development, "[t]he cancellation and hold of dozens of transmission projects is due to changing circumstances, *particularly declining load forecasts and increased penetration of distributed renewable energy resources* and their associated production profiles."[146]

3. Flattening Demand's Impact on Utilities' Planning and Forecasting: Case Studies from Berkeley Labs

Flattening demand also challenges utilities' planning and forecasting efforts. In a recent report, Berkeley National Laboratories looked at how some utilities address distributed energy resources and demand-side resources (including energy efficiency) in their forecasts and planning. According to the Berkeley Report, in most cases utilities, "[treat] the quantity of distributed generation in future years to be exogenous to the planning process."[147] This means, according to the Berkeley Report, that "instead of using the planning process to determine how much distributed generation to anticipate or procure, the utilities instead used separate forecasts of distributed generation to adjust their residual resource needs."[148]

For example, PECO, a utility in PJM, "[does] not create an explicit forecast for customer adoption of distributed generation."[149] Florida Power & Light uses a "single forecast of distributed PV adoption" that includes "a pilot program for voluntary, community-based solar."[150] Other utilities, including Hawaiian Electric, PacifiCorp, SoCal Edison, and the Tennessee Valley Authority, among others, "all created multiple forecasts of distributed generation adoption…that represent 'what-if' scenarios where distributed generation adoption is consistent with other factors in the scenario."[151] For example, Hawaiian Electric created four scenarios with "oil prices and public support for renewables two of the biggest sources of uncertainty facing the utility… For each scenario, it created a distributed PV forecast that was consistent with the scenario."[152]

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[142] CAISO Transmission Plan, 2.

[143] Kelly Andrejasich. "CAISO transmission plan includes $24M in reliability projects." *S&P Global Market Intelligence*. March 16, 2017. ("CAISO Transmission Article")

[144] CAISO Transmission Plan, 102.

[145] CAISO Transmission Plan, 103.

[146] CAISO Transmission Article (emphasis added).

[147] Berkeley Report, 35.

[148] Berkeley Report, 35-36.

[149] Berkeley Report, 37.

[150] Berkeley Report, 38.

[151] Berkeley Report, 38.

[152] Berkeley Report, 38.

According to the Berkeley Report, utilities "[to] some degree…used the resource planning process to ensure that the bulk power system will be able to integrate expected levels of generation."[153] Distributed generation was represented in the process "as a change to the annual energy or the peak demand" or through the adjustment of hourly load profiles "by hourly profiles of distributed generation to develop an hourly net load."[154]

Again, however, because "most utilities treated distributed generation as exogenous to the planning process, few identified ways to target distributed generation deployment such that it maximizes system benefits."[155] One of the few exceptions to this in the Berkeley Report comes from TVA:

> TVA is working with the Electric Power Research Institute to model locational-specific impacts of distributed PV on the distribution grid. TVA will use that analysis to identify preferential sites for deployment of solar at the levels recommended in its IRP.[156]

The Berkeley Report also addresses utility planning efforts for demand response and energy efficiency resources. The Berkeley Report finds that "[t]here has been a significant degree of convergence in processes and methods for evaluating energy efficiency and demand response resources across the United States."[157] Notably, regarding utilities' evaluation of "demand-side resources as an alternative to transmission and distribution investments," the Berkeley Report notes:

> The lack of integration among planning processes for generation, demand-side resources, transmission, and distribution has led to more discrete approaches to assessing demand-side alternatives to transmission and distribution investments ('non-wires alternatives'). These assessments often take place outside the formal resource planning process, but influence planning decisions. Investments in resources to defer distribution investments, for instance, will have implications for bulk system resource needs.[158]

However, only two of the utilities included in the Berkeley Report had formalized processes to evaluate the potential for deferring distribution investments.[159] Several leading reports have suggested that utilities can and should be more proactive in planning for and soliciting new distributed energy resources, which can have the positive effect of allowing the utility to identify where resources may be most helpful.[160] In the next section, we discuss how distributed energy resources may have a unique role in the changing U.S. supply mix, and in

[153] Berkeley Report, 39.
[154] Berkeley Report, 39.
[155] Berkeley Report, 40.
[156] Berkeley Report, 40.
[157] Berkeley Report, 42.
[158] Berkeley Report, 45.
[159] Berkeley Report, 45.
[160] See, for example: MIT Utility of the Future Report, XI; Analysis Group Report, ES-2, 19-21.

some cases, are already deferring or even potentially alleviating the need for transmission and distribution investments.

E. Distributed Energy Resources May Emerge as a Competitive Force to Traditional Grid Investments

Our fourth theme is that we may be entering a unique moment for distributed energy resources to emerge as potential competitors to traditional utility investments, such as transmission, distribution, and utility-scale generation. Leading thinkers – like those behind the MIT Utility of the Future Report – are making this case and are suggesting regulatory overhauls to allow distributed energy resources to compete on the same level as all other resources. According to the report, this approach could lead to overall improvements in economic efficiency in future grid investments, avoiding the sometimes-unequal outcomes that can be associated with subsidies.

1. MIT, ICF Studies Suggest Targeted Deployment of Distributed Energy Resources is Part of Utility of the Future, but Changes are Needed

In its extensive report issued in December 2016, the MIT Energy Initiative describes its vision for the "utility of the future," which features "[s]marter consumption of electricity and, where cost-effective, the deployment of distributed energy resources, could deliver billions of dollars in savings by improving the utilization of electricity infrastructure."[161] According to the MIT Energy Initiative, distributed energy resources are able to "provide services either more effectively, cheaply, or simply in locations inaccessible to more centralized resources."[162] Thus, according to the MIT Energy Initiative, in order to seek the "optimization of net social welfare,"[163] a framework is needed to "establish a level playing field for the provision and consumption of electricity services, whether via centralized or distributed resources."[164]

The MIT Utility of the Future Report suggests that the current power grid is potentially outdated and inefficient:

> To date, power systems have been designed to meet infrequent peaks in demand and to comply with engineering safety margins established in an era when electricity customers were largely inflexible and blind to the true costs and potential benefits of their electricity consumption or production decisions. In many cases, this has resulted in costly and significantly underutilized infrastructure.[165]

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[161] MIT Utility of the Future Report, ix.

[162] MIT Utility of the Future Report, 29.

[163] MIT Utility of the Future Report, ix.

[164] MIT Utility of the Future Report, ix.

[165] MIT Utility of the Future Report, ix.

According to the MIT Energy Initiative, there are plenty of available, new resources that could lead to more efficient investment, but poor price signals prevent optimal outcomes:

> Customers now face unprecedented choice regarding how they get their power and how they manage electricity consumption…[including] the ability to invest in distributed generation, smart appliances, and energy efficiency improvements. At present, the vast majority of power systems lack a comprehensive system of efficient prices and regulated charges for electricity services. As a result, some customers are making inefficient investments and are overcompensated for the services that they provide to the power system. At the same time, many opportunities that could deliver greater value are being left untapped because of inadequate compensation.[166]

The MIT Energy Initiative provides several recommendations regarding its vision of such a framework, many of which are aimed at introducing a "level playing field" for all resources to "achieve efficient operation and planning in the power system."[167] For example, MIT argues for "dramatically improv[ed] prices and regulated charges (i.e., tariffs or rates)" including more accurate and granular injection and consumption data from all customers, elimination of "flat, volumetric tariffs," and even the potential to collect the costs of efficiency programs, subsidies for renewable energy, and other public policy costs through "broader taxes or other means" instead of through rates in order to avoid "the possibility of societally inefficient grid defection" by some customers."[168]

MIT suggests improvements to "wholesale market design…to better integrate decentralized resources, reward greater flexibility, and create a level playing field for all technologies."[169] These improvements include enabling "transactions to be made closer to real time to reward flexible resources and to enable better forecasting and control of variable renewable resources and electricity demand."[170] MIT also recommends that bidding formats "should be updated to reflect the operational constraints of novel resources such as demand response and energy storage, as well as new patterns of operation of conventional power plants," and "more efficient pricing of reserves."[171]

MIT also suggests smarter deployment of distributed energy resources, such as siting and operating such resources where they provide the most value on the distribution grid. According to MIT, distributed energy resources can provide unique "locational value" that utility-scale investments cannot; thus, "areas that have heavily congested networks or that are experiencing rapid growth in electricity demand" can mean deployment of distributed generation with

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[166] MIT Utility of the Future Report, ix.

[167] MIT Utility of the Future Report, ix.

[168] MIT Utility of the Future Report, ix-x.

[169] MIT Utility of the Future Report, xi.

[170] MIT Utility of the Future Report, xi.

[171] MIT Utility of the Future Report, xi.

"locational value [that] may be significant."[172] MIT also notes that "[u]nlocking the contribution of resources that already exist" such as existing distributed generation, which "can be an efficient alternative to investing in electricity generation and network capacity."[173] Nevertheless, MIT recognizes "economies of scale still matter" for utility-scale renewables, and that the "incremental costs associated with failing to exhaust economies of unit scale can outweigh locational value."[174]

ICF, also in a recent study,[175] appears to be in agreement with some of these conclusions from the MIT Utility of the Future Report. ICF notes that "[s]ystematic planning for accommodating [distributed energy resources] can have far-reaching positive impacts such as capital deferral, increased grid resiliency, peak reduction, and power quality support."[176] ICF also agrees that "programs that are designed for targeted penetration of [distributed energy resources] are essential to leverage the full capability of [distributed energy resources]."[177]

2. Two Case Studies in States Where "Targeted" Deployment of Distributed Energy Resources Has Already Occurred

a. Procurements of "Non-Wire Alternatives" to Defer "Traditional Infrastructure Upgrades" in New York

In 2013, Consolidated Edison's ("ConEd") forecasts demonstrated that "increased customer electric demand growth in Brooklyn and Queens began to overload the capabilities of the sub-transmission feeders serving the Brownsville No. 1 and 2 substations" located in Brooklyn and by 2018 the sub-transmission feeders would be overloaded by 69 MW during peak hours of the summer months.[178] ConEd estimated the cost of the substation upgrade to fix the issue in time to be $1.2 billion.[179] Rather than invest in the traditional upgrade, ConEd sought and was granted permission from the New York Public Service Commission to forgo the traditional upgrade and instead address the reliability issue with distributed energy resources including distributed generation and demand response – totaling the needed 69 MW – for an estimated cost of $200 million.[180]

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[172] MIT Utility of the Future Report, xi.

[173] MIT Utility of the Future Report, xi.

[174] MIT Utility of the Future Report, xi. This is a point we made in our Looking Forward Report (at page 54) last year.

[175] Haider Khan and Hameed Safiullah. "DER Optimization: Cost-effective Utility Solutions with Energy Efficiency, PV, and Storage." *ICF International*. August 18, 2016. Available at https://www.icf.com/perspectives/white-papers/2016/der-optimization-cost-effective-utility-solutions. ("ICF DER Report")

[176] ICF DER Report, 3.

[177] ICF DER Report, 3.

[178] Gregory Elcock. "Brooklyn Queens Demand Management Program Implementation and Outreach Plan." *Consolidated Edison*. January 29, 2016, 3. Available at http://www.documentcloud.org/documents/2782996-BQDM-Update-1-2016.html. ("ConEd BQDM Plan")

[179] Gavin Bade. "ConEd awards 22 MW of demand response contracts in Brooklyn-Queens project." *Utility Dive*. August 8, 2016. Available at http://www.utilitydive.com/news/coned-awards-22-mw-of-demand-response-contracts-in-brooklyn-queens-project/424034/. ("ConEd Utility Dive Article")

[180] Robert Walton. "The non-wire alternative: ConEd's Brooklyn-Queens pilot rejects traditional grid upgrades." *Utility Dive*. August 3, 2016. Available at http://www.utilitydive.com/news/the-non-wire-alternative-coneds-brooklyn-queens-pilot-

ConEd's efforts come in the context of New York's "Renewing the Energy Vision," or "REV" initiative, which we have discussed in past Looking Forward Reports.[181] Other New York utilities have followed suit: in July 2016, Rochester Gas and Electric, a New York utility, issued a request for proposals for "distributed generation, demand response, energy efficiency, energy storage," and any other distributed technology that could meet the identified reliability need in order to defer $11.8 million in substation investment.[182] Another New York utility, New York State Electric & Gas, issued its own request for proposals in February 2016 seeking proposals for "non-wire alternatives" that would "address reliability and power quality issues" at its Java substation.[183]

b. Procurement of Distributed Energy Resources in California to Help Replace Retiring San Onofre Nuclear Generator

California has also been at the forefront of utility procurement of distributed energy resources. For example, in light of the retirement of the 2,200 MW San Onofre nuclear generating station in 2013, Southern California Edison ("SoCal Edison") and San Diego Gas & Electric ("SDG&E") sought to procure up to 1,500 MW of capacity to replace the retiring nuclear facility.[184] Distributed energy resources were allowed to compete alongside utility-scale resources. In the end, the majority of winning projects represented utility-scale generation—a total of 1,698 MW of natural gas-fired generation was selected, along with an additional 100.5 MW of utility-scale storage. In addition, however, distributed energy resources also won a significant portion of the procurement: 50 MW of distributed renewable generation, 160.6 MW of distributed energy storage, and 75 MW of demand response; the remainder (136.2 MW) was energy efficiency. The winning projects are shown below in Figure 13.

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rejects-traditional/423525/.

[181] 2015 Looking Forward Report, 55-56.

[182] "RFP Documents." *Rochester Gas & Electric.* Available at http://www.rge.com/SuppliersAndPartners/RFP.html; Robert Walton. "New York utility turns to DERs to avoid $11.8M substation upgrade." *Utility Dive*. July 14, 2016. Available at http://www.utilitydive.com/news/new-york-utility-turns-to-ders-to-avoid-118m-substation-upgrade/422599/.

[183] "Request for Proposal Java Substation Non Wire Alternative." *NYSEG*. February 8, 2016. Available at http://www.nyseg.com/MediaLibrary/2/5/Content%20Management/NYSEG/SuppliersPartners/PDFs%20and%20Docs/NWA-RFP/Java%20NWA%20RFP.pdf.

[184] Jeff St. John. "California's Plan to Replace San Onofre Nuclear: Green Success or Natural Gas Giveaway?" *GreenTech Media.* March 14, 2014. Available at https://www.greentechmedia.com/articles/read/cpucs-songs-decision-green-breakthrough-or-natural-gas-giveaway. ("GreenTech Media Article")

Figure 13: Winning Projects in California Procurement of San Onofre Replacement Capacity

Seller	Resource Type	MWs	Number of Contracts
NRG	Energy Efficiency	102.5	8
Onsite Energy Corporation	Energy Efficiency	11.0	11
Sterling Analytics LLC	Energy Efficiency	16.7	7
NRG	Demand Response	75.0	7
SunPower Corp.	Behind-the-Meter Renewable	44.0	4
Ice Energy Holdings, Inc.	Behind-the-Meter Thermal Energy Storage	25.6	16
Advanced Microgrid Solutions	Behind-the-Meter Battery Energy Storage	50.0	4
Stem	Behind-the-Meter Battery Energy Storage	85.0	2
AES	In-Front-of-Meter Battery Energy Storage	100.0	1
AES	Combined Cycle Gas Fired Generation	1284.0	2
Stanton Energy Reliability Center	Peaking Gas Fired Generation	98.0	1
	TOTAL:	1891.8	63

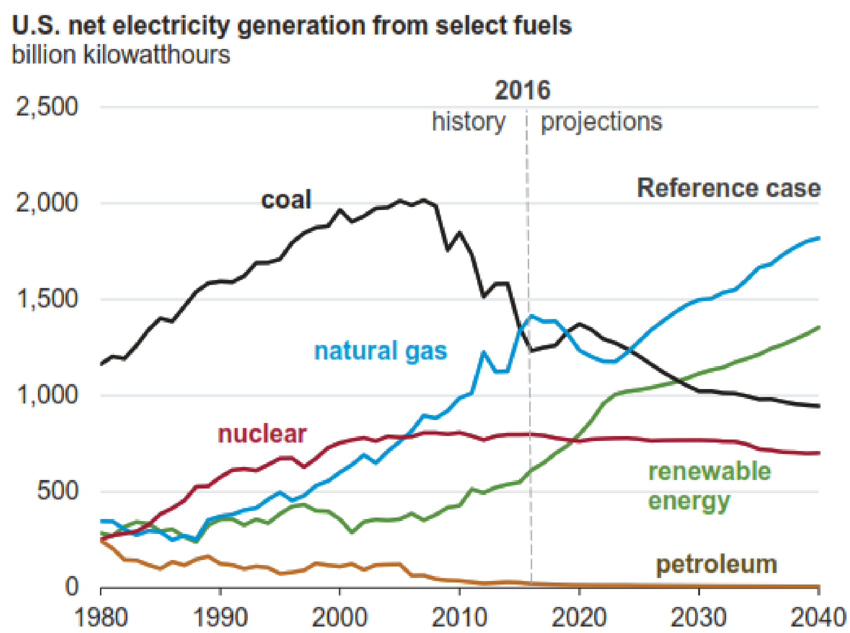
Seller	Resource Type	MWs	Number of Contracts
Onsite Energy Corporation	Energy Efficiency	6.0	6
SunPower Corp.	Behind-the-Meter Renewable	6.0	2
NRG Energy, Inc.	In-Front-of-Meter Battery Energy Storage	0.5	1
NRG Energy, Inc.	Peaking Gas Fired Generation	316.0	2
	TOTAL:	328.5	11

Source: Eric Wesoff, Jeff St. John. "Breaking: SCE Announces Winners of Energy Storage Contracts Worth 250 MW." *GreenTech Media.* November 5, 2014. Available at https://www.greentechmedia.com/articles/read/breaking-sce-announces-winners-of-energy-storage-contracts.

3. Going Forward, How the Changing U.S. Resource Mix May Help Distributed Energy Resources Emerge

There is little doubt that the generating resource mix in the U.S. is changing dramatically, from one dominated almost equally by coal-, nuclear-, and gas-fired generation, to one much more reliant on renewable generation and natural gas-fired resources. In 2016, according to the U.S. EIA, of the 27 GW of new generating capacity that was added to the U.S. power grid, 8.7 GW were wind, 7.7 GW were solar, while 9 GW were natural gas-fired generators.[185] As shown in Figure 14 below, the U.S. EIA expects this trend toward increased gas and renewables to continue. Focusing in particular on solar PV, over the next four years, announced investment in new solar PV generation is expected to reach approximately $35.5 billion; the projects represent about 14 GW of capacity and have expected online dates between 2017 and 2020.[186] (About $362 million of that investment is to be located in SPP.)[187]

Figure 14: U.S. EIA Annual Energy Outlook Reference Case



Source: U.S. EIA Annual Energy Outlook 2017, 70.

The impact of this gas-renewables renaissance is widely felt, but one area where it may have an impact is on the likelihood of "targeted" and increased deployment of distributed energy resources, as we explain below.

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[185] "U.S. electric generating capacity increase in 2016 was largest net change since 2011." *U.S. Energy Information Administration.* February 27, 2017. Available at http://www.eia.gov/todayinenergy/detail.php?id=30112.

[186] Ian Campbell. "$36B in US solar PV investments planned for next 4 years." *S&P Global Market Intelligence.* March 1, 2017.

[187] Ibid.

a. Challenges Caused by the New U.S. Resource Mix

This new supply mix has produced new challenges. One challenge is the "indiscriminate procurement" of new renewable generation without considering when those renewable megawatt hours are being produced.[188] A report by Strategen Consulting states: "For example, in the Southwest, the addition of solar PV resources could have diminishing returns in reducing fuel consumption if a significant portion of PV generation is already being curtailed due to overgeneration."[189] Strategen finds: "Already some states are experiencing challenges as renewable energy production during certain times is beginning to provide diminished value in terms of reduced fuel consumption or capacity contribution."[190] Such challenges include "[s]horter, steeper ramping events that require [the system operator] to quickly bring capacity online or offline," "[o]versupply and curtailment during midday hours of peak renewable generation and decreased load," and "[r]eduction in frequency response due to lack of available flexible resources."[191]

Another challenge is operational, something the SPP Market Monitor has noted that SPP faces in integrating its largest renewable resource, wind:

> Wind integration brings low cost generation to the SPP region but supports very little future capacity needs. There are a number of operational issues in dealing with substantial wind capacity. Wind energy output varies…about three times more than load…[and] is counter-cyclical to load…The increasing magnitude of wind since 2007, along with the concentration, volatility, and timeliness of wind, can create challenges for grid operators with regard to managing transmission congestion and resolution of ramp constraints.[192]

Moreover, as we explain later in chapter 7, another challenge posed by the new U.S. supply mix is low power prices that is making it difficult for existing, baseload generation to compete, potentially leading to – in some cases – premature retirement of fossil fuel-fired and nuclear generation. Indeed, the combination of shale gas and increased penetration of renewables has led to unprecedentedly low power prices; in ERCOT, for example, some renewable energy resources saw negative locational marginal prices in 18 percent of all hours in 2011, while the California ISO had nodes that saw negative LMPs 6 percent of the time that same year.[193] These market conditions in part led the President and CEO of NRG Energy, Inc. to

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[188] "Evolving the RPS: A Clean Peak Standard for a Smarter Renewable Future." *Strategen Consulting.* December 1, 2016, 6-7. ("Strategen Report")

[189] Strategen Report, 6.

[190] Strategen Report, 3.

[191] Stragen Report, 5.

[192] SPP Market Monitoring Unit. "2015 State of the Market." August 15, 2016, 42.

[193] R. Schmalensee. "The Performance of U.S. Wind and Solar Generators." *The Energy Journal*. Volume 37, Number 1(2016): 123-151.

recently state his belief that the independent power producer-model is "now obsolete" and "unable to create value over the long term."[194]

b. Targeted Deployment of Distributed Energy Resources May Help Address Those Challenges

As we noted above, according to the Utility of the Future Report from MIT, distributed energy resources are able to "provide services either more effectively, cheaply, or simply in locations inaccessible to more centralized resources."[195] MIT estimates the full "locational value" of "distributed solar PV" in Long Island, New York to be as high as $84/MWh.[196] MIT estimates this value to be equal to the sum of various quantified benefits of the distributed solar PV investment, including (i) reduced congestion benefits on the wholesale transmission grid, (ii) reduced distribution losses on the network, and (iii) deferred network investment, among others.[197]

As noted above, ICF found that "[s]ystematic planning for accommodating [distributed energy resources] can have far-reaching positive impacts such as capital deferral, increased grid resiliency, peak reduction, and power quality support."[198] Peak reduction, for example, can help address the problem of retiring baseload capacity, since the system is planned based on peak load plus a reserve margin. Moreover, in New York and California, distributed energy resources have already begun successfully competing with and succeeding against traditional grid infrastructure investments.

Caution should accompany any hope regarding distributed energy resources' ability to help solve some of the operational issues identified above. First, a construct is not yet in place to allow distributed energy resources to fully participate and compete with more traditional resources. According to the MIT Energy Initiative, in order to seek the "optimization of net social welfare,"[199] a framework is needed to "establish a level playing field for the provision and consumption of electricity services, whether via centralized or distributed resources."[200]

Second, it is too early to know if distributed energy resources can compete with traditional grid investments on a large scale. As we have noted, economies of scale still matter, and grid-scale generation investments are lower in cost than distributed alternatives. And as we showed above in the California case study involving replacement capacity for San Onofre, the large majority of replacement resources were utility-scale generation and storage.

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[194] Lucas Bifera. "NRG CEO: 'IPP model is now obsolete.'" *S&P Global Market Intelligence.* February 28, 2017.

[195] MIT Utility of the Future Report, 29.

[196] MIT Utility of the Future Report, 285-288.

[197] MIT Utility of the Future Report, 285-288.

[198] ICF DER Report, 3.

[199] MIT Utility of the Future Report, ix.

[200] MIT Utility of the Future Report, ix.

Third, it remains to be seen if the examples of "non-wires" solutions to transmission reliability concerns in New York will prove successful in any long-term way. For example, ConEd's choice of 69 MW of distributed energy resources for $200 million appears, at face value, more economic than the $1.2 billion cost of the traditional transmission upgrade. However, upgrading the transmission system is a known quantity with a long-term useful life and expectations of performance and reliability; the performance of the distributed energy resources – given their shorter track records – may not be as certain and which will make investment in such alternatives to be something of a test case for their effectiveness.

c. Declining Costs and Evolving State Mandates May Further Aid Distributed Energy Resources

Two factors that will help distributed energy resources emerge are declining technology costs and state mandates for renewable and distributed energy resources. Regarding costs, in its December 2016, Lazard provided its annual update[201] to its analysis of the levelized cost of energy across a variety of generating technologies. As shown, in Figure 15, residential rooftop solar PV has a levelized cost of energy of $138/MWh to $222/MWh, without subsidies—that represents a decrease of about 25 percent from Lazard's 2015 estimates. Lazard estimates that rooftop commercial and industrial solar PV, meanwhile, has a levelized cost of energy as low as $88/MWh, which is a decrease of about 19 percent from 2015 estimates.[202]

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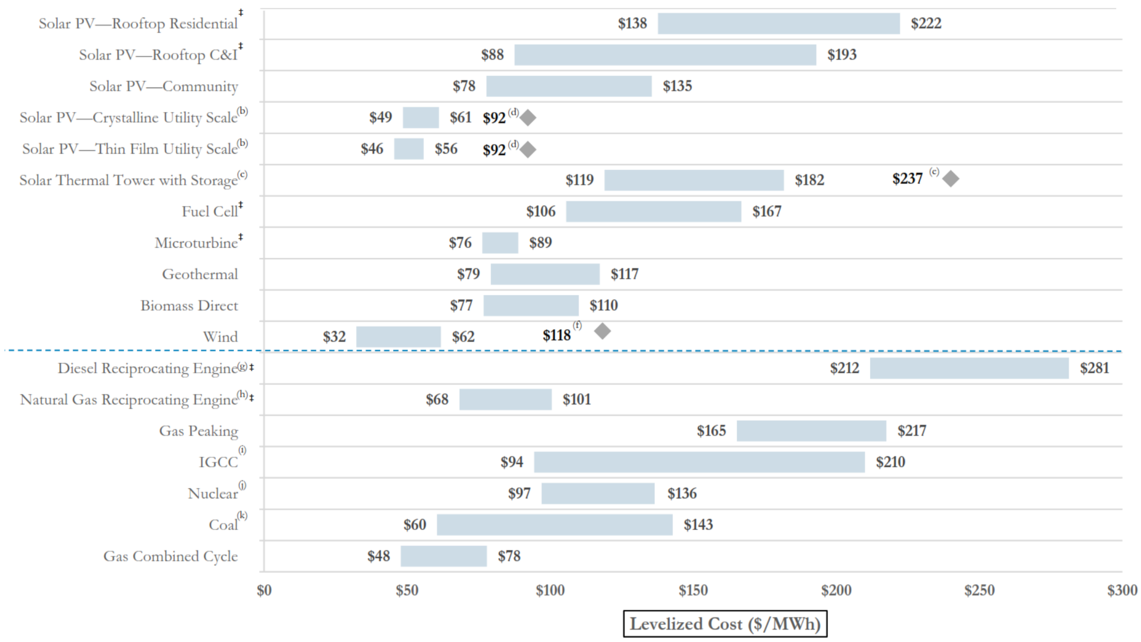
[201] "Lazard's Levelized Cost of Energy Analysis – Version 10.0." *Lazard*. December 15, 2016. Available at https://www.lazard.com/perspective/levelized-cost-of-energy-analysis-100/. ("Lazard") Lazard's data – which shows the levelized cost of energy both with and without subsidies – was developed with the help of "a leading consulting and engineering firm" along with "Lazard's commercial knowledge" and "input from a wide variety of industry participants. Lazard, 21.

[202] 2016 Looking Forward Report, 53.

Figure 15: Lazard's Unsubsidized Levelized Cost of Energy Comparison



Source: Lazard, "Lazard's Levelized Cost of Energy Analysis – Version 10.0," December 2016, 2.

Energy storage, meanwhile, also continues to fall in price, though in many cases remains considerably more expensive than generation alternatives. At the utility-scale, Lazard[203] estimates that the levelized cost of storage without subsidies is as low as $116/MWh using its estimate of the cheapest energy storage technology available, compressed air energy storage.[204] In fact, Lazard considers energy storage to be "economically viable" in two U.S. markets – PJM and the New York ISO – and "potentially viable" in the California ISO markets.[205] Lazard's claim is a function of both declining cost of storage and revenues available to storage resources in those markets.[206] At the distribution level, the economics of energy storage are much less attractive: Lazard estimates that the levelized cost of storage without subsidies at the residential level using the cheapest storage technology available – lithium-ion batteries – is between $890/MWh and $1,476/MWh.[207]

Beyond costs, state-level mandates are in many cases likely to remain in place in the near term and may evolve to include carve-outs for distributed energy resources. One such mandate is the state-level renewable portfolio standard. In all, and as shown in Figure 16 below, nine states have active proposals to increase their current RPS. (One of those states is partially in SPP—New Mexico is considering a bill that would increase the existing RPS from its current

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[203] "Lazard's Levelized Cost of Storage – Version 2.0." *Lazard*. December 15, 2016. Available at https://www.lazard.com/perspective/levelized-cost-of-storage-analysis-20/. ("Lazard LCOS")

[204] Lazard LCOS, 11.

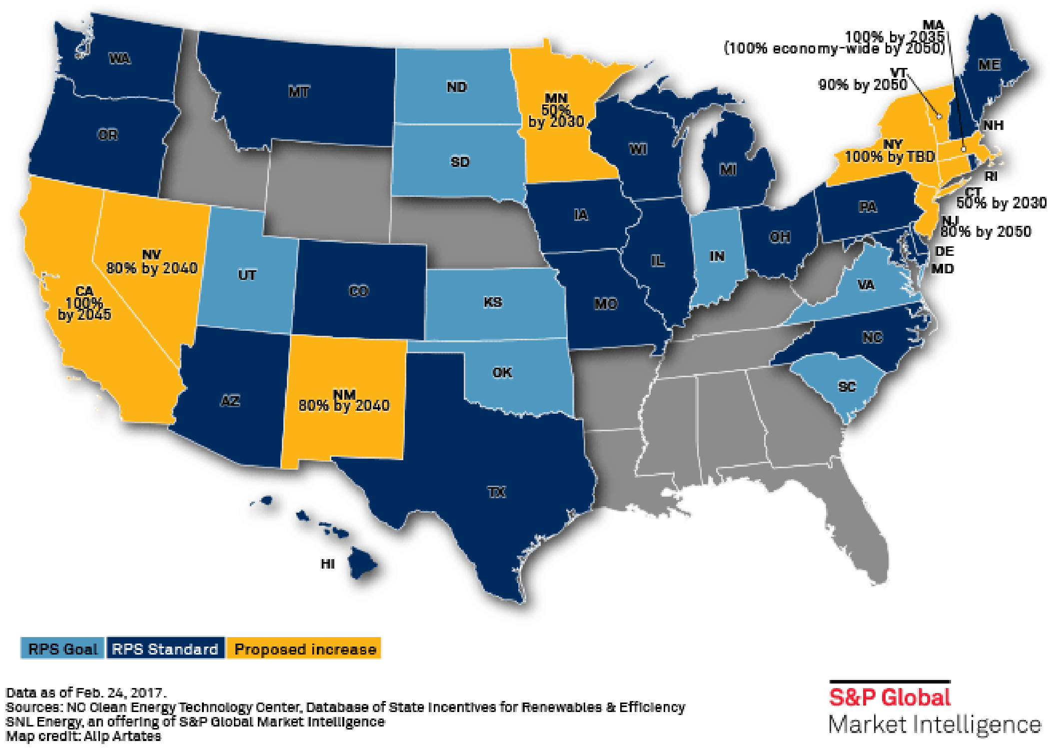
[205] Lazard LCOS, 23.

[206] Lazard LCOS, 22.

[207] Lazard LCOS, 12.

goal of 20 percent by 2020 to 80 percent by 2040.[208])

Figure 16: Proposed Renewable Portfolio Standard Increases



Source: S&P Global Market Intelligence, "Bold bets: States go all-in on renewable energy," February 28, 2017.

Beyond simply retaining or increasing their existing state RPS, some states may also go further to consider more "targeted" RPS standards, which could include specific procurement of distributed energy resources. This would address what Strategen Consulting called the problem of the "indiscriminate procurement" of renewable resources that has been blamed for a variety of grid challenges.[209] RPS standards can become more targeted if (a) they included a temporal component – which would seek renewable energy production at peak periods, or (b) if they included a locational component, which gave qualifying resources full credit for their location on the transmission – or distribution – grid. That could also mean participation by distributed energy resources, which, according to Strategen Consulting, are "more valuable due to [their] proximity to load, particularly in transmission-constrained areas."[210] States could also include a direct carve-out for distributed energy resources in their RPS; for example, Illinois has already conducted several state-level procurements for distributed generation resources of all

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[208] Robert Walton. "New Mexico lawmakers propose expanding RPS to 80% by 2040." *Utility Dive*. February 3, 2017. Available at http://www.utilitydive.com/news/new-mexico-lawmakers-propose-expanding-rps-to-80-by-2040/435425/.

[209] Strategen Report, 6.

[210] Strategen Report, 12.

technologies pursuant to Illinois' RPS law, which dictates that at least one percent of Illinois' utilities' renewable energy credits be generated by distributed generation.[211]

Independent of RPS standards, other state policies can help drive further penetration by distributed energy resources. Net metering is the most prevalent example of this type of policy; 41 states and the District of Columbia have some form of net metering policy.[212] However, some states are at work on new compensation mechanisms for distributed energy resources to help address some of the negative consequences of unchecked net metering policies. New York, for example, is developing a replacement for its net metering construct called the "Value Stack," which is a pricing mechanism aimed at compensating distributed energy resources in a way that considers their full "locational, environmental, and temporal values" of the projects.[213]

It should be noted that other states, such as North Dakota, Oklahoma, Ohio, Wyoming, and Utah, have active proposals to *limit* renewable energy generation growth, which, in turn, could limit growth of distributed energy resources. For example, in Wyoming, Senate File 71 would introduce an "eligible generating resource standard" that would require jurisdictional electric utilities to procure a minimum of 95 percent of its electricity in 2018 and 100 percent of its electricity in 2019 (and beyond) from coal, hydroelectric, natural gas, nuclear, oil, or distributed generation—but not from utility-scale wind and solar.[214] In Oklahoma, Governor Mary Fallin recommended in the state's Executive Budget for 2018 a "Wind Production Tax" of $0.005 per kWh produced, and an acceleration of the sunset of the state's tax credit for wind.[215]

F. Three Selected Distributed Energy Resource Case Studies

Early in the third chapter of the MIT Utility of the Future Report, the authors state:

> The significant presence of [distributed energy resources] – either actual or anticipated – necessitates a reconsideration of how [distributed energy resources] can most effectively provide electricity services. It implies that the electric power sector's customary 'top-down' paradigm must be abandoned, and that a fresh look at the design, operation, and regulation of distribution and transmission networks is required.[216]

Many are already at work on the "fresh look" of the existing paradigm, and there is indeed a torrent of information and activity in the reshaping of the electric utility industry. The following case studies provide some highlights of some parties at the forefront. They include (a)

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[211] Illinois Public Utilities Act. Available at http://www.ilga.gov/legislation/ilcs/ilcs5.asp?ActID=1277&ChapterID=23.

[212] MIT Utility of the Future Report, 84.

[213] Robert Walton. "New York issues DER valuation order under REV docket to transition from net metering." *Utility Dive*. March 9, 2017. Available at http://www.utilitydive.com/news/new-york-issues-der-valuation-order-under-rev-docket-to-transition-from-net/437775/.

[214] "Senate File No. SF0071, Electricity production standard." *State of Wyoming.* 2017.

[215] "Executive Budget Fiscal Year 2018." *State of Oklahoma.* Executive Summary.

[216] MIT Utility of the Future Report, 37.

California ISO's new tariff for distributed energy resources, (b) an example of a small town in Ohio building its own mini-grid in Midcontinent ISO's footprint, and (c) the introduction of "blockchain" technology to the electricity industry.

1. California ISO's Tariff for Distributed Energy Resources

With almost 600,000 residential solar PV installations and a host of state initiatives seeking to increase in-state distributed energy resources penetration, California is considered to have "some of the most ambitious legislation and standards to spur [distributed energy resource] growth, and it requires utilities, electric service providers, and community choice aggregators to increase the procurement and integration of renewable energy resources and [distributed energy resources]."[217]

California ISO, for its part, revised its open access transmission tariff to "facilitate participation of aggregations of distribution connected or 'distributed' energy resources in its wholesale markets."[218] According to CAISO, the purpose of the tariff revisions was to establish "an initial framework to enable aggregations of energy resources connected to distribution systems within the CAISO's balancing authority area to participate in the CAISO's energy and ancillary services markets."[219] CAISO explains that such distributed energy resources will be recognized as "a new type of market resource similar to a generating facility."[220] The aggregator of the distributed energy resources can then either become, or contract with, a scheduling coordinator in order to participate in CAISO's markets.[221] When CAISO sends dispatch instructions, the scheduling coordinator will "disaggregate" those instructions to the individual distributed energy resources.[222] CAISO further explains:

> The distributed energy resource provider will also submit settlement quality meter data for its aggregation to the CAISO through its scheduling coordinator. The distributed energy resource provider will also need to interface with the utility distribution company or metered subsystem that operates the distribution system in the CAISO balancing authority area where resources in its aggregation are connected. The CAISO's tariff revisions recognize the need for coordination between the CAISO and distribution system operators.[223]

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[217] ScottMadden. "51st State Perspectives: Distributed Energy Resources Integration." *Smart Electric Power Alliance.* December 2016, 8. Available at http://www.scottmadden.com/wp-content/uploads/2016/12/SEPA-ScottMadden-51st-State-Report_DER-Integration-CA-NY.pdf.

[218] California Independent System Operator. "Informational Report of the California Independent System Operator Corporation." FERC Docket No. ER16-1085. November 30, 2016, 1. Available at http://www.caiso.com/Documents/Nov30_2016_InformationalReport_DistributedEnergyResourceProvider_ER16-1085.pdf. ("CAISO Informational Report")

[219] CAISO Informational Report, 1.

[220] CAISO Informational Report, 1.

[221] CAISO Informational Report, 1-2.

[222] CAISO Informational Report, 2.

[223] CAISO Informational Report, 2.

While CAISO's efforts to implement its distributed energy resources aggregation faces "key challenges," such as getting "'concurrence'…from the utilities that run the distribution grids,"[224] CAISO recently reported that it has received applications from four entities seeking to become aggregators of distributed energy resources in CAISO's markets.[225] One of those entities is an investor-owned utility – San Diego Gas & Electric – which plans on "establishing an aggregation" that would include "energy storage systems" worth "3-4 MW of capacity" that would participate in CAISO markets by 2018.[226] The other three entities are non-utility developers; for example, one developer – Apparent Energy – plans two aggregations of 1 to 1.5 MW each in Pacific Gas & Electric's distribution territory and near Santa Clara that would use "Apparent Energy's intelligent grid operating system to coordinate operations."[227]

2. Minster, Ohio: An "Empowered" End-User

In a section of the MIT Utility of the Future Report titled "The rise of empowered consumers," the Report notes:

> [Distributed energy resources] may give rise to a potentially revolutionary change in the relationship of network agents to energy users…Formerly passive 'consumers' will be able to match their utilization of energy with their diverse individual preferences and values because they will have a meaningful level of choice.[228]

Moreover, in discussing end-users' potential defection from the grid, the MIT Utility of the Future Report notes also that "[f]or individual customers, the economic case for defecting from the grid is enhanced by the potential to avoid network charges and the costs of various electricity policies."[229]

While MIT goes on to use this evidence to recommend a "redesign of the current system" and "what should and should not be included in regulated electricity tariffs,"[230] we seek to highlight MIT's point to tee up the potential for a more dynamic, active end user. That active approach could manifest itself in multiple ways, including grid defection, particularly if transmission rates rise. (And we note that, according to the Edison Electric Institute, investor-owned utilities are projected to invest approximately $61 billion in new transmission over the next three years.)[231]

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[224] Jeff St. John. "As California Prepares for Wholesale Distributed Energy Aggregation, New Players Seek Approval." *GTM*. March 14, 2017. Available at https://www.greentechmedia.com/articles/read/California-companies-are-vying-for-aggregated-distributed-energy.

[225] CAISO Informational Report, 4.

[226] CAISO Informational Report, 6.

[227] CAISO Informational Report, 4-5.

[228] MIT Utility of the Future Report, 38.

[229] MIT Utility of the Future Report, 39.

[230] MIT Utility of the Future Report, 39.

[231] Richard Martin. "EEI sees coming peak in transmission investment." *S&P Global Market Intelligence*. December 22, 2016.

One example of such an active end user is the Village of Minster, Ohio, a town of 2,850 residents located about 90 miles northwest of Columbus which because the first municipality to invest in a solar-plus-storage model. In 2014, Minster signed a power purchase agreement for a 4.2 MW solar PV project with Half Moon Ventures, a private developer.[232] However, when the Ohio state legislature "froze" the renewable portfolio standard, the RECs needed to finance the project – representing about $2.5 million – disappeared.[233] Instead of abandoning the project, Minster "researched other options, both technical and financial," and decided to incorporate a 7 MW lithium ion battery storage unit into the PPA.[234]

The benefits of Minster's PPA include a 7 cents/kWh cost that is less than the average price it pays for wholesale power.[235] The economics behind this compelling price include revenue streams, like capacity credits and frequency regulation payments from PJM and the 30 percent production tax credit, and cost savings offered by peak shaving – the PPA reduced Minster's summer peak demand by almost one third – and the deferral of distribution grid investments.[236]

Going forward, Half Moon "has six similar deals in advanced discussions" in the PJM footprint, while Minster is "planning its own microgrid" to protect against the costs of outages to local industries.[237]

Another example of an empowered end-user is Google, which, like Apple, Facebook, and others, are seeking to power their operations from 100 percent renewable energy resources.[238] Google stands out because it seeks to purchase output from renewable generation through power purchase agreements (rather than simply buying offsets or renewable energy credits alone).[239] For example, Google's Pryor, Oklahoma data center – one of thirteen Google data centers in the world – have led Google to sign power purchase agreements for 572 MW of wind from Oklahoma-generated wind facilities—more than 10 percent of the state's total wind capacity.[240] In all, Google has signed 20 power purchase agreements for approximately 2.6 GW of renewable energy.[241] Such scale has made corporations like Google influential in state energy policies,[242]

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[232] K Kaufman. "Energy Future in Ohio Cornfields." *Public Utilities Fortnightly*. December 2016, 31. ("Minster PUF Article")

[233] Minster PUF Article, 32.

[234] Minster PUF Article, 32.

[235] Minster PUF Article, 32.

[236] Minster PUF Article, 32; Herman K. Trabish. "Inside the first municipal solar-plus-storage project in the US." *Utility Dive.* July 5, 2016. Available at http://www.utilitydive.com/news/inside-the-first-municipal-solar-plus-storage-project-in-the-us/421470/.

[237] Trabish. "Inside the first municipal solar-plus-storage project in the US."

[238] Richard Martin. "Big tech companies close in on 100% renewable goals." *S&P Global Market Intelligence*. January 12, 2017. ("Martin Article")

[239] Ibid.

[240] Adam Wilmoth. "Google builds on renewable energy." *NewsOK*. December 6, 2016. Available at http://newsok.com/article/5529732.

[241] Ibid.

[242] Michael Copley. "States urged to accommodate corporate appetite for renewables." *S&P Global Market Intelligence.*

and in some cases, corporations are pushing for – and receiving – regulatory changes at the state level to allow them to pursue their renewable energy goals. For example, in North Carolina, corporations are not allowed to directly contract for the type of power they want;[243] so, when Google built a data center in Lenoir, a town in Duke Energy's footprint, Google negotiated a "Green Source Rider" to allow it to purchase renewable energy from third-party renewable projects through the utility.[244]

3. Introduction of Blockchain Technology

In a May 15, 2016 article in *Fortune* titled "How Blockchain Technology Can Reinvent The Power Grid," the authors state:

> 'Instead of the command-and-control system the utilities have now where a handful of people are actually running a utility grid, you can design the grid so that it runs itself,' said Lawrence Orsini, cofounder and principal of LO3 Energy. 'The network becomes far more resilient because all of the assets in the grid are helping to maintain and run the utility grid.' It's a distributed peer-to-peer Internet of Things network model with smart contracts and other controls designed into the assets themselves (i.e., the blockchain model)…
>
> With increasing generation of renewable power at the local level, the Internet of Things is challenging the regulated utility model. *While the utilities are looking at benefits to their existing infrastructure ('smart grid'), connecting microgrids could lead to entirely new energy models.*[245]

Blockchain technology has received a lot of attention since it was created in 2008 – and a lot of investment. As of the first quarter of 2016, total venture capital investment in blockchain startups exceeded $1.1 billion.[246] And now, large companies such as Siemens are seeking ways to use blockchain technology to change the way electricity is transacted.

Blockchain technology is a "distributed database" that serves as a digital ledger of economic transactions—not just for financial transactions but for "virtually everything of value."[247] (That could include electricity products.) The blockchain "exists as a shared – and continually reconciled – database" that "isn't stored in any single location, meaning the records it

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December 6, 2016.

[243] Martin Article.

[244] Ibid.

[245] Alex Tapscott and Don Tapscott. "How Blockchain Technology Can Reinvent The Power Grid." *Fortune*. May 15, 2016. Available at http://fortune.com/2016/05/15/blockchain-reinvents-power-grid/ (emphasis added).

[246] Garrick Hileman. "State of Blockchain Q1 2016: Blockchain Funding Overtakes Bitcoin." *CoinDesk*. May 11, 2016. Available at http://www.coindesk.com/state-of-blockchain-q1-2016/.

[247] "What is Blockchain Technology? A Step-by-Step Guide for Beginners." *Blockgeeks*. 2016. Available at http://blockgeeks.com/guides/what-is-blockchain-technology/. ("Blockchain Article")

keeps are truly public and easily verifiable;" moreover, "no centralized version of [the blockchain's information] exists for a hacker to corrupt."[248]

Blockchain technology could achieve widespread application at some point, particularly because it offers transparency and "incorruptibility," as its approach of storing data across a network "eliminates the risks that come with data being held centrally."[249] It also is completely decentralized, in that it cannot be controlled by one single entity.[250] Currently, "finance offers the strongest use cases for the technology" and "the World Bank estimates that over $430 billion U.S. in money transfers were sent in 2015 [relying upon it."[251]

In the electricity industry, as hinted at by the *Fortune* article quoted above, blockchain technology could be used for peer-to-peer, decentralized trading of electricity products. According to one author on the subject:

> Millions of homes could become autonomous agents, contracting power automatically with the highest bidder. With potentially millions of distributed power sources, the system needs to continuously track everything, including the ability to authenticate each node in the network — to ensure its reliability, which is why blockchian is critical to all of this.[252]

Currently, there are at least two examples of blockchain technology being deployed. One is in the European Union, where there is a proliferation of "prosumers" – or, consumers who put energy back into the network. Recent studies suggest that if 50 percent of households were to become prosumers, "the European energy distribution networks would become inefficient and waste significant amounts of…energy."[253] To address these potential issues, the European Union funded a project called "Scanergy," which uses blockchain technology to allow "prosumers" to trade renewable energy in real-time.[254] The Scanergy project included "a real-time automated market trading system called NRG-X-Change," which "checks the supply of renewables and the overall demand for electricity in a given neighborhood via its smart meters every 15 minutes, then automatically brokers trades with other neighborhoods for any excess or shortfall."[255]

A second example comes from Brooklyn, where LO3 Energy and Siemens are "developing a solution for a blockchain-based microgrid" which would be "the first of its kind in the world."[256] According to the Siemens Press Release:

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[248] Blockchain Article.

[249] Blockchain Article.

[250] Blockchain Article.

[251] Blockchain Article.

[252] Don Tapscott. "Blockchain Holds key to reinventing energy grid." *Huffington Post*. July 29, 2016. Available at http://www.huffingtonpost.com/don-tapscott/blockchain-holds-key-to-r_b_11258136.html. ("Tapscott Article")

[253] Giulio Prisco. "An Energy Blockchain for European Prosumers." *BitCoin Magazine*. May 2, 2016. Available at https://bitcoinmagazine.com/articles/an-energy-blockchain-for-european-prosumers-1462218142/. ("Scanergy Article")

[254] Scanergy Article.

[255] Scanergy Article.

[256] Joint Press Release by Siemens and LO3 Energy. "Siemens and U.S. startup LO3 Energy collaborate on blockchain

> For the first time, a microgrid control solution from Siemens is being combined with the peer-to-peer trading platform from LO3 Energy known as TransActive Grid. This solution will enable blockchain-based local energy trading between producers and consumers in Brooklyn's Boerum Hill, Park Slope, and Gowanus neighborhoods as well as balance out local production and consumption.[257]

The Siemens Press Release continues:

> The combination of a microgrid control solution and blockchain technology will make it possible for a provider of photovoltaic systems on the roofs of buildings in Brooklyn to feed its excess electricity back into the existing local grid and receive payments from the purchasers.[258]

In fact, according to the Siemens Press Release, "[p]reliminary tests of peer-to-peer transactions between neighbors were successfully completed in April 2016."[259] Since then, "LO3 has had more than 130 buildings sign up for participation."[260] Meanwhile, Siemens and LO3 see the Brooklyn project as "a starting point for developing other joint microgrid projects in US and other countries."[261]

G. Conclusion

The major takeaway for the Board is that distributed energy resources do not yet represent an existential threat to the grid, which remains essential for electricity users. Rather, distributed energy resources are likely to have their greatest impact in two areas: distributed energy resources are likely to challenge generation-owning utilities in the production of electricity and could also emerge as alternatives to traditional grid investments. Moreover, the Board should realize that the topic of distributed energy resources and a less centralized electricity system is not going away and both discussion and investments are likely to accelerate in coming years. The lengthy presentation of case studies in this chapter is meant to document the depth, breadth, and high caliber of both the discussion and investment. For example, the rise of the empowered consumer – such as Minster, Ohio's burgeoning resources or Google's push for 100 percent renewables at its data centers, including the one in Pryor, Oklahoma, which has already led to regulatory changes in states in which Google operates – means that end users could begin having an impact on regulatory policy. Given this, it may be advisable that the

microgrids." November 21, 2016, 1. Available at http://www.siemens.com/press/pool/de/pressemitteilungen/2016/energymanagement/PR2016110080EMEN.pdf. ("Siemens Press Release")

[257] Siemens Press Release, 2.

[258] Siemens Press Release, 2.

[259] Siemens Press Release, 2.

[260] Tapscott Article.

[261] Siemens Press Release, 1.

Board stay informed on developments related to distributed energy resources throughout the year, and generally intensified its interest in how such resources could be integrated in the SPP footprint to save money and improve reliability.

IV. An Update on Jurisdictional Issues in the Electricity Industry

A. Refresher on Jurisdictional Issues Covered Since 2012

In past *Looking Forward Reports*, we have brought to the Board information about significant and impactful litigation concerning the jurisdictional split between federal and state regulators in the electricity business. The primary jurisdictional issue was states' rights in assuring resource adequacy, particularly in states participating in wholesale markets. In 2012, we stated:

> "All 50 states have authority over decisions related to resource adequacy and generation within their borders. However, the extent of that authority becomes less clear when a utility joins an RTO that has a multi-State capacity market under Federal jurisdiction."[262]

That fact was highlighted by two cases – one in New Jersey, the other in Maryland – that went all the way to the U.S. Supreme Court and were decided last spring. We introduced these cases in 2012 when a group of generator owners in PJM challenged both the states of New Jersey and Maryland for their separate efforts to build new capacity in response to in-state reliability threats.[263] In 2015, we updated the story, noting that, on appeal, both cases had been separately decided in U.S. District Courts *which* ruled that, by effectively setting a wholesale price for capacity and energy – which is federal domain under the Federal Power Act – the state actions violated the Supremacy Clause of the U.S. Constitution;[264] and in 2016, we noted that the cases were appealed, with the *Maryland* case subsequently heard at the U.S. Supreme Court.[265]

We noted that the *Maryland* case was related to another electricity case involving state and federal jurisdiction – the so-called *EPSA* case[266] – which had been decided by the Supreme Court in January 2016. We explained that in a 6-2 decision, "the Supreme Court held that the Federal Power Act 'provides FERC with the authority to regulate wholesale market operators' compensation of demand response bids.'"[267] We provided an extensive discussion of the *EPSA* Decision, noting, for example, that the Supreme Court was clear that when FERC sets a wholesale rate, "it has some effect" on retail rates, but that fact "is of no legal consequence."[268] We explained that this finding by the Supreme Court, in part, could be the basis for reversing the

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[262] 2012 Looking Forward Report, 48.

[263] 2012 Looking Forward Report, 48 to 50.

[264] 2015 Looking Forward Report, 64 to 66.

[265] 2016 Looking Forward Report, 42 to 43.

[266] *FERC v. Electric Power Supply Association et al.,* 14-840, Argued October 14, 2015, Decided January 25, 2016; *EnerNOC Inc. et al. v. Electric Power Supply Association et al.,* 14-841, January 2015. Available at http://www.supremecourt.gov/opinions/15pdf/14-840_k537.pdf. ("*EPSA* Decision")

[267] 2016 Looking Forward Report, 45, citing *EPSA* Decision, Syllabus, 2.

[268] 2016 Looking Forward Report, 45, citing *EPSA* Decision, 19.

lower courts' decisions in the *Maryland* case;[269] regardless, we explained that if the Supreme Court ruled in favor of federal preemption of state authority over resource adequacy in the *Maryland* case, the cases could impact all states, not just those in organized capacity markets.[270] We noted:

> If the Supreme Court…does not reverse the lower courts, the decision in the *Maryland* case could create a slippery slope; *other state programs in all states – not just states participating in wholesale capacity markets – could be preempted under similar reasoning*. As we have pointed out in the past, states' efforts to procure (a) full requirements electricity service for its default customers, (b) renewable resources pursuant to Renewable Portfolio Standards, (c) demand-side products, (d) peaking capacity, and (e) utility rate-base generation could all be in danger if the New Jersey and Maryland cases are not overturned.[271]

B. The *Maryland* Decision, Including Legal Experts' Analysis

The U.S. Supreme Court has now ruled on the *Maryland* case,[272] finding that the state of Maryland "invade[d] FERC's regulatory turf,"[273] and thus, its actions were preempted under the Supremacy Clause and the contracts were invalidated. Specifically, a group of legal experts writing in a paper published by the Lawrence Berkeley National Laboratory state:[274]

> [T]he Court unanimously affirmed the rulings of lower courts holding that Maryland's program impermissibly conflicted with and was preempted by federal law. Relying on the Supremacy Clause and pre-emption doctrine, the Court agreed with their conclusion that the program 'sets an interstate wholesale rate, contravening the FPA's division of authority between state and federal regulators.'[275]

The authors of the Berkeley Jurisdictional paper further explain that the Supreme Court attempted to "limit" their decision and to explain what states can and cannot do:

> The Court emphasized that its holding was limited. Similar to its conclusion in *EPSA* that the fact that a FERC action setting a wholesale rate or changing wholesale markets may incidentally affect retail rates is 'of no legal consequence,' the Court in *Hughes* explained that states 'may regulate within the domain Congress assigned to them [under

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[269] 2016 Looking Forward Report, 47 to 48.

[270] 2016 Looking Forward Report, 48 to 49.

[271] 2016 Looking Forward Report, 48 to 49 (emphasis added).

[272] Supreme Court of the United States, Nos. 14-614 and 14-623, *Hughes, Chairman, Maryland Public Service Commission v. Talen Energy Marketing, LLC, fka PPL EnergyPlus, LLC, et al.*, and *CPV Maryland, LLC, v. PPL EnergyPlus, LLC, et al.* April 19, 2016. ("*Maryland* Decision"). Available at https://www.supremecourt.gov/opinions/15pdf/14-614_k5fm.pdf.

[273] *Maryland* Decision, 12.

[274] Jeffery S. Dennis, Suedeen G. Kelly, Robert R. Nordhaus, and Douglas W. Smith. "Federal/State Jurisdictional Split: Implications for Emerging Electricity Technologies." *Lawrence Berkeley National Laboratory.* December 2016. Available at https://emp.lbl.gov/sites/all/files/lbnl-1006675.pdf. ("Berkeley Jurisdictional Paper")

[275] Berkeley Jurisdictional Paper, 18 (footnotes omitted).

> the FPA] even when their laws incidentally affect areas within FERC's domain.' But states 'may not seek to achieve ends, however legitimate, through regulatory means that intrude on FERC's authority over interstate wholesale rates.' In this regard, the 'fatal defect that renders Maryland's program unacceptable,' the Court explained, was the fact that it 'condition[ed] payment of funds on capacity clearing the auction.' Nothing in the opinion, the Court emphasized, 'should be read to foreclose' states from 'encouraging production of new or clean generation through measures 'untethered to a generator's wholesale market participation.'' Thus, the Court noted that it was not addressing 'the permissibility of various other measures States may employ to encourage development of new or clean generation, including tax incentives, land grants, direct subsidies, construction of state-owned generation facilities, or re-regulation of the energy sector.'[276]

Since the *Maryland* Decision, legal experts have weighed in on their expectations for the decision's implications. For example, at the 2016 Energy Bar Association meeting in Washington, which was transcribed in Volume 37 of the *Energy Law Journal*, four legal experts offered their thoughts on the *Maryland* case and two other cases addressing state-federal jurisdictional issues.

Max Minzer, General Counsel of FERC, echoed the authors of the Berkeley Jurisdictional paper regarding the "focused" nature of the *Maryland* Decision. Mr. Minzer stated that the *Maryland* Decision "was very focused on the idea of preserving a wide range of tools for states to incentivize or affect generation, while being *very focused* on the specific attributes of those contracts for differences, including the bidding and clearing requirement, as well as the make-whole construction of those contracts that led to a *very narrow decision* about preemption."[277]

Mr. Minzer also made it clear that he believed that the *Maryland* Decision still leaves states with options to exercise their jurisdiction over resource adequacy. He noted:

> Well, the Court I think was clear that a significant number of traditional state activities that could in theory have an impact on the wholesale rate are likely to be preserved after [the *Maryland* Decision]. There's a long discussion at the end about the range of things that states can do without running afoul of the specific problem with constructs at issue in that case.[278]

Stuart Caplan, a partner and co-chair of Dentons' U.S. energy practice, argued that the *Maryland* Decision – in conjunction with the *EPSA* Decision before it – fails to provide a clear, bright line between federal and state jurisdiction, noting: "I find that there's an unsatisfying lack

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[276] Berkeley Jurisdictional Paper, 18 to 19, quoting *Maryland* Decision (footnotes omitted).

[277] "The Court Has Spoken: What Does It All Mean?" *Energy Law Journal*. Volume 37. November 11, 2016. Available at http://eba-net.org/sites/default/files/20-307-329-Transcript%20-%20FINAL_0.pdf. ("ELJ Article"), 311 (emphasis added).

[278] ELJ Article, 311.

of clarity in the decisions as to the basis of jurisdiction in some cases, and as to the basis of preemption."[279] Mr. Caplan continued:

> So is it okay for a state to establish REC prices? Or to administer a market for REC prices? That's setting a price for wholesale sales. Is it okay for a state to adopt a program to supplement the revenue that a nuclear power plant receives because it would be very hard to satisfy the carbon reduction targets of the EPA rule without the nukes?[280]

Ultimately, Mr. Caplan found:

> It's amazing that we can read so many decisions and so many briefs and not be able to draw a nexus between the basis of jurisdiction and the form of preemption…But to me that's what was wanting in those decisions, clarity squandered…[281]

Clare Kindall, Head of the Energy Department for the Connecticut Attorney General's Office, agreed that the split between federal and state jurisdiction was not clear, noting her opinion that "there will be a lot of litigation over what exactly a state can and cannot do."[282] Ms. Kindall explained why she expects such litigation to continue:

> [T]he states will need significant tools in order to encourage reliable and clean energy in specific local areas. And the question will become: Where can the state do that? And I think that litigation—in fact, Connecticut currently is in the middle of litigation on this exact issue. And so I think there will be a large number of cases that will emerge about where are those lines going to be drawn. And I believe the Federal Power Act is really designed for cooperative federalism. You know, there is a role for FERC and there is a role for the states. And this room will spend most of the next ten years drawing those lines.[283]

Ms. Kindall also provided specifics regarding actions to which states retained their rights, even after the *Maryland* and *EPSA* Decisions:

> [The states] can do subsidies. They can do all kinds of other supports and subsidies. And the Court was pretty clear on that. And bilateral contracting is long established as being separate from the markets.[284]

Neverthess, Ms. Kindall noted the *Maryland* Decision:

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[279] ELJ Article, 312.

[280] ELJ Article, 314.

[281] ELJ Article, 324.

[282] ELJ Article, 312.

[283] ELJ Article, 312.

[284] ELJ Article, 314.

> pegged to the market is going to raise some flags. However, then the question becomes do the ratepayers pay twice? And how do you avoid ratepayers paying twice for the energy they need, and then paying again…to meet the various goals in the market…if you're paying for energy that doesn't clear the market, and you still need to make a certain amount in the market, then the ratepayer pays both for the market—for the subsidy, or for the energy they have supported to have reliable or clean energy, and then but they also need to pay for energy to be in the market up to a certain level. So the ratepayer pays twice. And that really was the whole purpose behind the contract-for-differences mechanisms, which I think are pretty well shot at this point.[285]

Finally, Erin Murphy, now a partner at Kirkland & Ellis LLP, noted that the *Maryland* and *EPSA* Decisions tee up the possibility of case-by-case approaches to jurisdictional matters:

> …I think it's probably quite frustrating for people who practice in this area because I'm not sure, you know, the opinions are sort of designed to say we are going to look at each of these a little bit on a case-by-case basis, and look at these factors, and it's going to depend on a particular program.[286]

Such cases could include two recently adopted state "programs" – one in New York, the other in Illinois – which provide new revenue streams to existing nuclear generation in those states.[287] In New York, the New York Public Service Commission adopted a "Clean Energy Standard" that "provides for a per megawatt hour payment for zero emissions credits to nuclear power generators," while in Illinois, the legislature passed and the governor signed a law that requires the procurement of "zero emissions credits…for each megawatt hour of retail electricity that is delivered by each electric utility in Illinois to their customers over a period of ten years."[288] Notably, both cases involve states that are participants in wholesale capacity markets, and both cases are the subject of active litigation.[289] Ms. Murphy, addressing such subsidies, stated:

> …if what you're doing effectively amounts to looking at what the market as established by FERC is going to give you, and having the state decide you should get something different, I mean I think that was kind of the core of what the Court seemed to think was problematic…So I think anything that kind of pegs itself directly to that rate in the auction has the potential to raise the concern that was animating the Court in [the

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[285] ELJ Article, 316.

[286] ELJ Article, 313.

[287] Chapman and Cutler LLP. "Two Lawsuits Challenge Constitutionality of the Zero Emissions Credits Program of Illinois' Future Energy Jobs Act." *Chapman and Cutler LLP*. February 21 2017, 1. Available at http://www.chapman.com/media/publication/738_Chapman_Lawsuits_Zero_Emissions_Future_Energy_Jobs_Illinois_022117.pdf. ("ZEC Paper")

[288] ZEC Paper, 1.

[289] ZEC Paper, 1.

Maryland Decision].[290]

Concluding, Ms. Murphy suggested that the dynamics of the U.S. electricity industry has led to these jurisdictional conflicts, and that these cases will be helpful to determine the jurisdictional split in this new era. She stated:

> [B]y the way courts think about things…it takes a decade of a market changing to really tee up a lot of these legal challenges. And I think that's why you are seeing these things kind of reaching the Supreme Court now. It's in a sense a product of changes that have been going on in a marketplace…and there's more room for tension I think than there's ever been in the way the markets work right now. And when you've got that kind of practical dynamic going on…maybe it's not the worst thing in the world for courts to kind of think about it as, well, we'd like to have bright-line rules but we need to make sure we understand what their consequences are now that we have a market that looks a little bit different from what Congress was thinking about when it passed the Federal Power Act almost a century ago.[291]

C. The Litigation Begins? A Case Study in Connecticut

However, in addition to legal opinions, parties are challenging state actions based on, among other things, the Supreme Court's reasoning in the *Maryland* Decision. This may be one of the so-called "consequences" to which Ms. Murphy refers. That consequence involves a challenge by a renewable generation-owning entity of a state procurement for renewable resources. The history is lengthy and complicated, but it may foreshadow the type of litigation that the EBA panel members hinted at.

The issue in Connecticut actually began in 2013, when Connecticut lawmakers passed a state law that allowed Connecticut state agencies to issue RFPs for renewable generation and require the state's electric distribution utilities to enter into long-term contracts for up to 4 percent of their total energy requirements.[292] Later that year (2013), Connecticut issued just such an RFP; at the conclusion of the RFP, one losing bidder – Allco Finance Group Ltd., a renewable generator based in New York – challenged the results of the RFP in district court, arguing, among other things, that the RFP "invades FERC's exclusive jurisdiction to set wholesale rates and therefore is pre-empted and void" and this is in violation of "the Federal Power Act and the Supremacy Clause of the United States Constitution…"[293]

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[290] ELJ Article, 315.

[291] ELJ Article, 329.

[292] Glen Boshart. "In another fight over state subsidies, court halts Connecticut renewables RFP." *S&P Global Market Intelligence*, November 7, 2016. ("Boshart Article").

[293] "Complaint for Declaratory and Injunctive Relief for Violations of the Supremacy Clause of the United States Constitution, the Federal Power Act and the Public Utility Regulatory Policies Act of 1978." Allco Finance Limited v. Daniel C. Esty, United States District Court, District of Connecticut. Case 3:13-cv-01874-JBA. December 18, 2013, page 11 and paragraph 55, page 13.

A year later, in December 2014, the U.S. District Court, District of Connecticut ruled on Allco's complaint, dismissing it for lack of standing, but also on substantive jurisdictional grounds. The Court stated that Allco's claim failed on the merits, because the 2013 Connecticut RFP "does not seek to regulate wholesale energy sales but rather is a permissible regulation of utilities under the State's jurisdiction."[294] Subsequent to the District Court's decision in December 2014, Allco filed an appeal of the decision to the U.S. Court of Appeals for the 2nd Circuit, which was denied.[295]

The Tri-State RFP

Connecticut, meanwhile, sought additional renewable energy through a three-state RFP. Specifically, on November 12, 2015, "specified state agencies and electric distribution companies in Connecticut, Massachusetts, and Rhode Island" announced the issuance of the "Tri-State RFP," which sought "offers for clean energy and for transmission to allow for the delivery of clean energy" to the three procuring states in order to help meet those states' "clean energy goals."[296] Winning bidders would be awarded power purchase agreements with contract terms up to twenty years in length.[297]

A total of twenty-four bids were submitted in response to the RFP;[298] in October 2016, the evaluation team completed its work and selected for contract negotiation a total of seven bids representing 460 megawatts of energy.[299]

Allco renewed its efforts against Connecticut's actions and filed two additional complaints against Connecticut—one in April 2015 for the state's role in the Tri-State RFP, and another in March 2016, attacking both the Tri-State RFP and the 2013 Connecticut RFP. In August 2016, the U.S. District Court for the District of Connecticut issued its omnibus ruling on both pending Allco complaints, dismissing them both.[300]

On September 28, 2016, Allco appealed both District Court rulings to the U.S. Court of Appeals for the 2nd Circuit.[301] In its appeal, Allco repeated its allegations that Connecticut had

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[294] Decision. United States District Court, District of Connecticut. Case 3:13-cv-01874-JBA. December 10, 2014, page 21.

[295] Boshart Article.

[296] "Specified State Agencies and Electric Distribution Companies in Connecticut, Massachusetts and Rhode Island." *New England Clean Energy RFP*. November 12, 2015, 2. Available at https://cleanenergyrfpdotcom.files.wordpress.com/2015/11/clean-energy-rfp-final-111215.pdf. ("Tri-State RFP")

[297] Tri-State RFP, 11.

[298] All twenty-four bids can be viewed at the Tri-State RFP website, available at https://cleanenergyrfp.com/bids/.

[299] "Bidders Selected for Contract Negotiation." *New England Clean Energy RFP*. October 25, 2016. Available at https://cleanenergyrfp.com/2016/10/25/bidders-selected-for-contract-negotiation/.

[300] Omnibus Ruling in Related Cases on Motions to Dismiss Complaints and for Preliminary Injunctive Relief. United States District Court for the District of Connecticut. Case 3:15-cv-00608-CSH, August 18, 2016, pages 42-42. ("2016 Connecticut Ruling").

[301] The United States Court of Appeals for the Second Circuit. *Allco Finance Limited v. Robert Klee, et al*., Case Nos. 16-2946 and 16-2949. September 28, 2016. Available at https://statepowerproject.files.wordpress.com/2014/03/ct-2nd-allco-initial-

violated the Supremacy Clause of the U.S. Constitution.[302] Allco cited the *Maryland* Decision in making its argument, stating:

> Just last term, a unanimous United States Supreme Court invalidated the State of Maryland's attempts to compel wholesale sales with State-selected generators, just like what Connecticut has done, and plans to do, here.[303]

Allco also alleged that Connecticut had violated the Dormant Commerce Clause of the U.S. Constitution because the state "facially discriminates against out-of-region renewable energy generators by excluding their renewable energy attributes from qualifying" for the RFP.[304] It should be noted that this aspect of the Allco-Connecticut case is novel, since, in the *Maryland* Decision, the U.S. Supreme Court did not address whether the state had violated the Commerce Clause, only the Supremacy Clause, in making its ruling.[305]

In its September 2016 appeal, Allco also asked for a preliminary injunction against Connecticut, which would prevent Connecticut from participation in the Tri-State RFP, or any similar RFPs, going forward.[306] On October 25, 2016, the three states announced the selection of a short-list of bids in the Tri-State RFP; sponsors of those bids, which total 460 MW of wind and solar resources, would move to contract negotiation phase, with all other bids being rejected and no longer considered.

One week later, on November 2, 2016, the Second Circuit granted Allco's request for an emergency injunction, stating:

> [Connecticut is] enjoined from awarding, entering into, executing, or approving any wholesale electricity contracts in connection with the current energy solicitation [the Tri-State RFP] during the pendency of this appeal[.][307]

However, in December, the Second Circuit vacated the emergency injunction, allowing Connecticut to resume its participation in the Tri-State RFP.[308] The case remains open, and oral

brief-092816.pdf ("Allco Appeal").

[302] Allco Appeal, 3.

[303] Allco Appeal, 6.

[304] Allco Appeal, 27.

[305] *Maryland* Decision, 7.

[306] Allco Appeal, 73-74.

[307] The United States Court of Appeals for the Second Circuit. *Allco Finance Limited v. Robert Klee, et al.* Case Nos. 16-2946 and 16-2949. November 2, 2016, 1. Available at https://statepowerproject.files.wordpress.com/2014/03/ct-2nd-cir-injunction-order.pdf.

[308] The United States Court of Appeals for the Second Circuit. *Allco Finance Limited v. Robert Klee, et al.*, Case Nos. 16-2946 and 16-2949. December 12, 2016, 1. Available at https://statepowerproject.files.wordpress.com/2014/03/ct-2nd-order-vacating-injunction.pdf. ("Second Circuit Vacating Order")

arguments were heard in December. In its short order vacating the injunction, the Court stated: "An opinion will follow in due course."[309]

D. Why This Matters to SPP

The takeaway of this chapter for the Board should be that while the Supreme Court has, through its *Maryland* and *EPSA* Decisions, provided some guidance on the jurisdictional split between the states and the federal government, there is not yet in place a definitive "bright line" that will prevent future jurisdictional friction. Instead, as suggested by Erin Murphy, the Supreme Court avoided drawing a "bright line" between state and federal jurisdiction. As a result, Clare Kindall's assertion appears likely in that litigants "will spend most of the next ten years drawing those lines" between federal and state jurisdiction.[310]

Such cases can involve state action to solicit new generation resources or keep existing generation online through payments that occur outside the FERC-jurisdictional wholesale market; in fact, the Connecticut case, as well as the out-of-market nuclear cases in New York and Illinois, all demonstrate this type of case.

Moreover, the continuing increase in penetration by distributed energy resources will introduce new jurisdictional challenges for regulators, market participants, and courts to address. This was a point we raised to the Board last year and which was addressed at length in the Berkeley Jurisdictional Paper,[311] whose authors note that in the U.S. DOE's most recent Quadrennial Energy Review, the DOE foresees both the potential for, and danger of, jurisdictional conflict regarding emerging distributed energy technologies:

> The QER finds…that the 'interacting and overlapping' division of authority between 'federal, regional and state institutions and regulatory structures' – introduced when the Federal Power Act of 1935 extended federal oversight to elements of the electricity sector – could 'impede development of the grid of the future [and] . . . the development of markets that efficiently integrate' new and emerging technologies. While 'technology is indifferent to state-Federal boundaries and jurisdictions,' the QER explains, 'technology users cannot be.'[312]

For SPP and its member states, these cases matter, even though SPP does not operate a capacity market. SPP states still risk running afoul of the *Maryland* Case precedent with routine state actions, such as competitive solicitations for supply resources and renewable portfolio

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[309] Second Circuit Vacating Order, 1.

[310] ELJ Article, 312.

[311] Berkeley Jurisdictional Paper, 23.

[312] Berkeley Jurisdictional Paper, 1. Citing Quadrennial Energy Review: Energy Transmission, Storage, and Distribution Infrastructure. April 2015, 3-22, 3-27. Available at http://energy.gov/sites/prod/files/2015/07/f24/QER%20Full%20Report_TS%26D%20April%202015_0.pdf.

standard legislation. SPP's fourteen member states all do some form of bilateral contracting, and most (ten) have renewable portfolio standards or voluntary targets. SPP and its member states will want to stay up to speed on the implications of future cases further defining the federal-state jurisdictional split.

V. Electric Vehicles (An Update)

A. Introduction and Background

Electric vehicles represent new sources of potential demand and supply to the grid, a point we have made in past Looking Forward Reports. In writing about EVs in 2011, we explained that any fear of a "demand shock" caused by EV penetration was limited.[313] We demonstrated, for example, that even if President Obama's goal of 1 million EVs by 2015 was met, and SPP was to see the penetration of 30,000 EVs in its territory, the additional load in SPP would be 38 MW on-peak and 25 MW off-peak.[314] (The U.S. failed to reach market penetration of 1 million EVs by 2015. Indeed, we pointed out that the EIA's own forecasts showed that the U.S. would not see 1 million EVs until 2021 or 2022.[315])

Nevertheless, we have remained on the lookout for evidence of increased – or pending – penetration by EVs. Last year, we introduced the concept of the "SHEAM" model – shared, electric, automated vehicles – that some analysts believe will revolutionize how automobiles are purchased, owned, and operated in the U.S. and elsewhere. Specifically, we cited a Morgan Stanley research note in which they claim that EVs have not seen higher penetration rates because they are a poor investment with a 28-year payback period, assuming $3/gallon gas and 10,000 miles/year driven.[316] We noted that Morgan Stanley argued that if automobiles "utilization rates" were increased from their current levels of 3.5% of the time to 24% of the time (about 60,000 miles/year driven), the payback period for an EV would fall to 4.6 years.[317] And we noted that one way to increase vehicle miles per year is to share them – like taxicabs. If the cars are made driverless, they can be on the road that much more, since computers do not need breaks; hence, Morgan Stanley's "SHEAM" moniker: shared, electric, autonomous vehicles.[318]

This year, we begin by looking at the current state of EV penetration and some of its traditional forces, such as cost reductions and federal mandates on fuel mileage emissions. We then renew our focus on autonomous vehicles ("AVs") and the SHEAM model, which has more analysts suggesting that, if EVs are to gain significant penetration in the U.S. market for automobiles, the SHEAM model will likely play an essential role. That means that to anticipate the future of EVs, it is necessary to consider the future of AVs or, more broadly, the SHEAM business model. We include a new report by McKinsey that speaks to this point, and we note that because the SHEAM model is so important to EV penetration, the Board should recognize that anything that advances autonomous vehicles and shared vehicles can also advance electric vehicles. We note several examples of new investment in shared, electric, and autonomous

[313] 2011 Looking Forward Report, 32 to 35.

[314] 2011 Looking Forward Report, 33 to 34.

[315] 2014 Looking Forward Report, 72.

[316] 2016 Looking Forward Report, 74 to 75.

[317] 2016 Looking Forward Report, 75.

[318] 2016 Looking Forward Report, 74 to 78.

vehicles, including a $15 billion acquisition of a microchip maker for autonomous vehicle technology.

We then provide cautions about the prospects for significant increases in EV penetration. Notably, we explain that, just as the factors that propel autonomous and shared vehicles can also propel electric vehicles, the challenges that face autonomous and shared vehicles can also slow electric vehicle penetration and progress. We conclude with some implications for SPP, providing suggestions for how best to consider new developments in the electric vehicle industry.

B. An Update on EV Penetration and Reasons for its Increase

Before we address the SHEAM model for EVs, which continues to get more attention and investment, but remains years in the future, we begin by updating the Board on current EV penetration. According to McKinsey, global EV sales "rose 60 percent in 2015 alone to nearly 450,000, up from 50,000 in 2011."[319] McKinsey attributes this increase to several factors, many of which are more "traditional" factors, such as reductions in battery costs and legislative mandates, such as U.S. federal vehicle emissions standards requirements for carmakers of approximately 42 mpg by 2020 and 54.5 mpg by 2025.[320] McKinsey states: "[g]lobal electric vehicle (EV) sales have risen quickly over the past five years, fueled by generous purchase subsidies, falling battery costs, fuel economy regulations, growing commitments from car companies, and rising interest from consumers."[321]

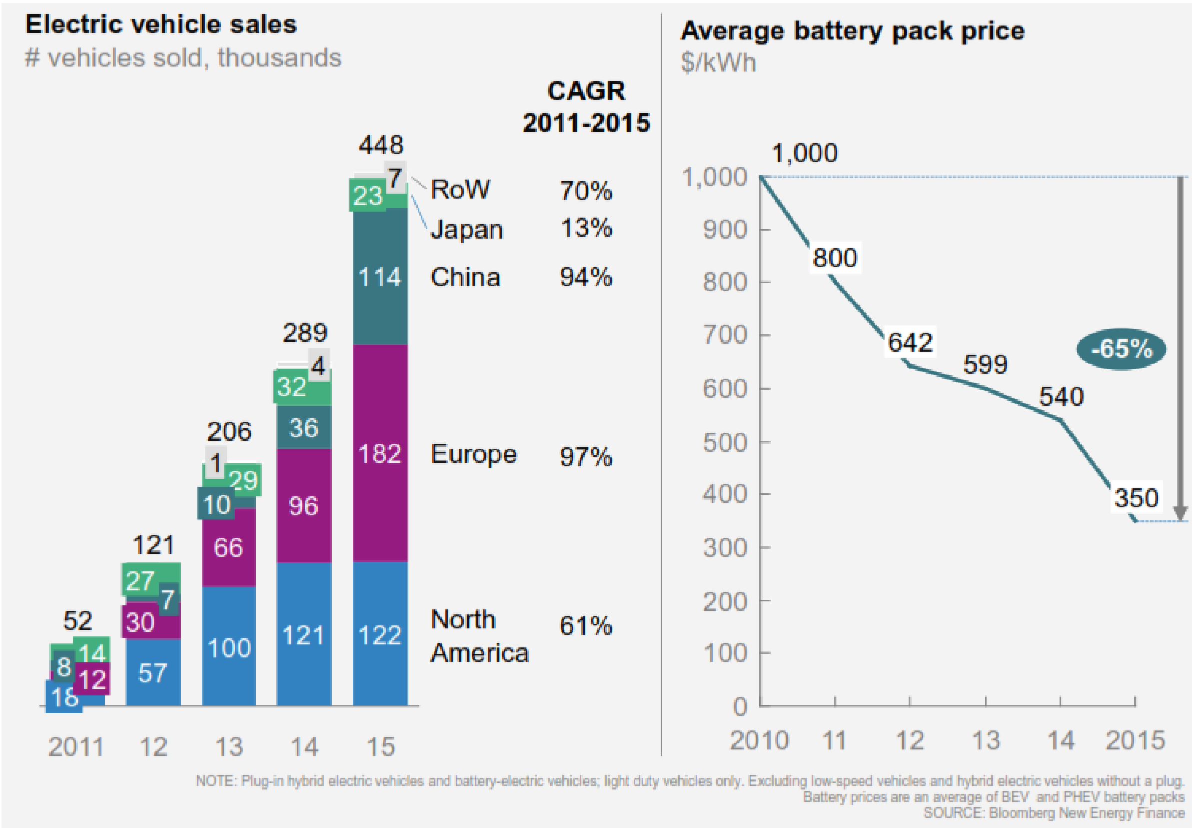
Figure 17 below illustrates McKinsey's point, which notes that the average battery costs for electric vehicles have come down 65 percent from 2011 to 2015, and penetration by EVs worldwide has increased substantially.

[319] McKinsey & Co. and Bloomberg New Energy Finance. "An Integrated Perspective on the Future of Mobility." October 2016, 15. ("McKinsey EV Report")

[320] McKinsey EV Report, 16; Jerry Hirsch. "Automakers ahead of schedule for 2020 fuel economy targets." *Los Angeles Times*. May 27, 2015. Available at http://www.latimes.com/business/autos/la-fi-hy-ucs-autos-fuel-economy-20150526-story.html.

[321] McKinsey EV Report, 15.

Figure 17: Worldwide Vehicle Sales (thousands) and Average Battery Pack Costs ($/kWh)



Source: McKinsey EV Report, Exhibit 1.

Nevertheless, this increase in EV penetration is not substantial enough to increase EV penetration beyond a small fraction of the overall market for vehicles. Only seven countries – Norway, the Netherlands, Sweden, Denmark, France, China, and the United Kingdom – have seen the market share of electric vehicles (including hybrids) exceed one percent.[322] And in the U.S., despite being a record year in terms of EV sales, just 0.82 percent of the cars purchased in 2016 were electric, including plug-in hybrids.[323]

All this suggests that for EVs to achieve significant penetration in the U.S. and worldwide, the traditional factors may not be enough. To truly become a major part of the overall market, EVs may need to become shared and autonomous.

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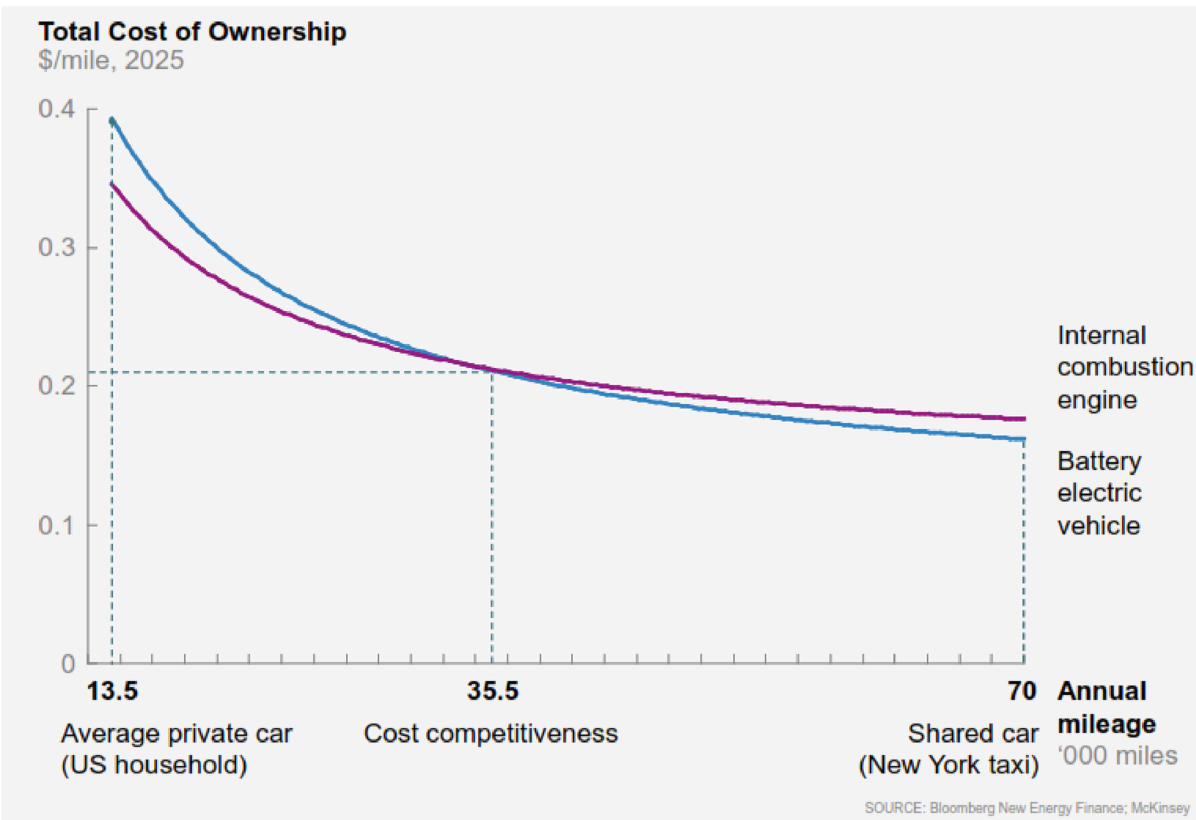
322 "Global EV Outlook 2016: Beyond one million electric cars." *International Energy Agency*. 2016, 4. Available at https://www.iea.org/publications/freepublications/publication/Global_EV_Outlook_2016.pdf.

323 Zachary Shahan. "7 Models = 81% Of Electric Car Sales In US (2016 US Electric Car Sales Report)." *Clean Technica*. January 6, 2017. Available at https://cleantechnica.com/2017/01/06/7-models-81-electric-car-sales-us-us-electric-car-sales-report/.

C. A Renewed Call for the Importance of the Shared, Electric, Autonomous Vehicle Model

In 2016, another major report echoed the importance of the SHEAM model for electric vehicle investment and penetration. McKinsey & Company and Bloomberg New Energy Finance published a report addressing the future of mobility that echoed the relevance of the SHEAM model: "more shared mobility could boost electric-vehicle (EV) sales because shared vehicles are used more intensely, improving the economics of ownership."[324] McKinsey illustrates this point by demonstrating how, with higher mileage, EVs can be more economical than internal combustion vehicles. This is shown in Figure 18.

Figure 18: Total Cost of Ownership ($/mile, 2025) for EVs vs. Conventional Vehicles



Source: McKinsey EV Report, Exhibit 9

McKinsey further notes that, by 2025, "cost difference between a privately owned [EV] and a hailed ride would shrink dramatically,"[325] so much so that if "a private consumer were open to share a ride with another traveler, the economics become even more attractive: on average, using a self-driving, electric, pooled taxi could be 30-60 percent cheaper per mile than a

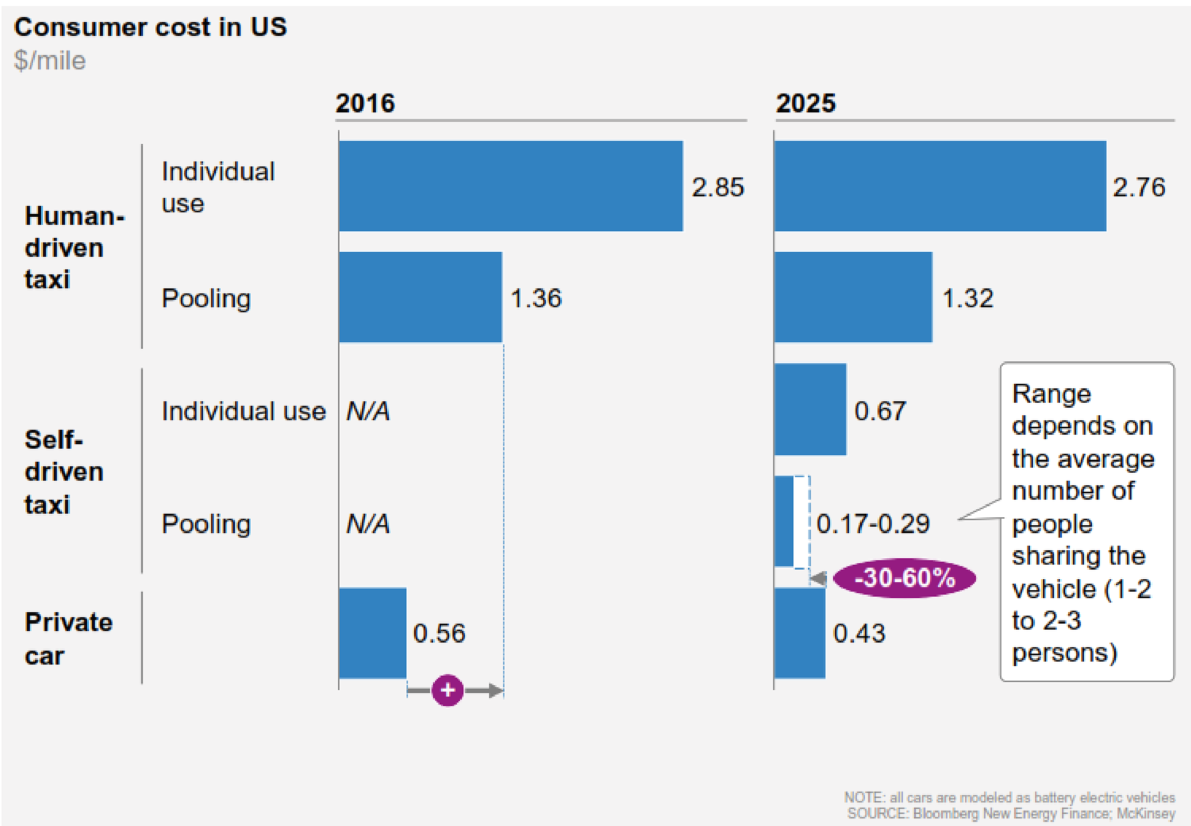
[324] McKinsey EV Report, 6.

[325] McKinsey EV Report, 23.

private vehicle."[326] McKinsey concludes that by 2025, "a private [EV] would cost $0.43/mile, whereas a consumer could use a self-driving, pooled taxi for as little as $0.17/mile-$0.29/mile."[327]

McKinsey's point is illustrated in Figure 19, which shows that by 2025, the cost of a SHEAM electric vehicle could be substantially cheaper than owning a private EV, on a dollars per mile basis.

Figure 19: Consumer Cost, in Dollars per Mile, of Human-Driven Taxis, Self-Driven Taxis, and Private Ownership of EVs



Source: McKinsey EV Report, Exhibit 10

The key takeaway from the SHEAM model for EVs is that it represents a sea change in thinking regarding the potential penetration of EVs. Instead of simply looking at the reduction in battery costs as the way EVs would compete with conventional vehicles, the SHEAM model

[326] McKinsey EV Report, 25.

[327] McKinsey EV Report, 25. McKinsey further notes: "Costs are estimated based on the total cost of ownership, assuming 70,000 miles driven annually, average driver salaries, 10 percent overhead costs and a 10 percent required rate of return on invested capital for the fleet operator. We assume a utilization factor of 50 percent for taxis and 70 percent for pooled cars. This does not take into account a price premium for any additional journey time required to pick up multiple passengers." McKinsey EV Report, note 17.

offers a fast-track method for new EV penetration. To wit, we noted last year that the impact of increasing a vehicle's utilization rate from the national average of 3.5% to 24% (like a taxicab) had the same impact on the economics of EV ownership as a 90 percent reduction in battery costs from current levels.[328]

D. Will Autonomous Vehicles be Electric?

One presumption of the SHEAM model is that all (or most) autonomous vehicles will be electric. If true, the implication is that anything that drives demand for autonomous vehicles will increase demand for electric vehicles. For example, the RAND Corporation, in a recent report on automated vehicles, identified several factors driving the push for autonomous vehicles, including safety: 30,000 people die and 2.5 million more are injured in car accidents in the U.S., the "vast majority" of which are caused by human driver error.[329] These real potential benefits of the introduction of autonomous vehicles can help drive EV penetration if a significant portion of those autonomous vehicles are electric. But the question should be asked: must autonomous vehicles be electric?

In its 2016 report, the RAND Corporation discusses all types of autonomous vehicles, from internal combustion engine versions, to hybrids, to fully electric vehicles.[330] The RAND Report finds, for example, that "AV technology can play a substantial role in improving fuel economy"[331] through (a) more efficient driving of a vehicle – "smooth and gradual acceleration and deceleration, and other optimum driving habits that would be enabled by greater automation," (b) "optimize[d] traffic throughput [which would] reduce the distance needed for safety between vehicles," and (c) lighter vehicle designs from fewer safety features built into cars, enabled by the reduction in risk of accidents brought on by greater automation.[332] None of these factors identified by RAND are exclusive to electric vehicles.

Moreover, automation will likely happen in stages and not necessarily in coordination with the development of EVs. In fact, semi-autonomous cars are already on the market and not all are electric or plug-in hybrids; for example, in 2016, Mercedes introduced its E300 internal combustion vehicle that has certain autonomous-driving capabilities.[333] To aid in this expected transition to autonomous vehicles, the National Highway Traffic Safety Administration created a five-level "hierarchy" to describe the level of a vehicle's autonomy. At Level 0, there is no automation and the driver is in complete control; Level 1 features "function-specific automation"

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[328] 2016 Looking Forward Report, 75.

[329] James M. Anderson, et al. "Autonomous Vehicle Technology: A Guide for Policymakers." *The RAND Corporation*, 2016, 4. Available at www.rand.org/t/rr443-2. ("RAND Report")

[330] RAND Report.

[331] RAND Report, 28.

[332] RAND Report, 28-30.

[333] Bill Howard. "2017 Mercedes-Benz E-Class extends the boundaries of self-driving at Detroit auto show." *Extreme Tech*. January 12, 2016. Available at https://www.extremetech.com/extreme/220928-2017-mercedes-benz-e-class-extends-the-boundaries-of-self-driving-at-detroit-auto-show.

where one or more functions of a vehicle are automated, but those functions operate independently, and the human driver retains overall control of the vehicle; Level 2 automation features at least two primary functions that are automated and work in concert with each other; Level 3 allows for "limited self-driving automation," in which a driver can cede all functions of the vehicle under certain traffic conditions (e.g., on a highway) to the autonomous driving system; and Level 4 is fully autonomous.[334]

Car manufacturers are now using this hierarchy to describe their AV efforts. Ford has announced that it will produce a fleet of Level 4 autonomous vehicles by 2021;[335] Mobileye and Delphi claim that they will produce autonomous driving systems for Level 4 cars by 2019.[336]

Nevertheless, some believe that it is "inevitable" that AV and EV technology will merge. According to Lux Research, there are a number of reasons why this is likely to be true, notably that: (a) "early adopters" of these technological advances "want both innovations in the same car;" (b) it is "easier to implement autonomous features on EVs" because "higher voltages and energy stored in an EV battery pack" allow "much more design freedom when it comes to self-driving hardware and software implementations," and, also, that controlling an electric motor and battery pack is "simpler" than controlling an internal combustion engine, which has "thousands of moving parts and complex cabling;" (c) refueling is more conducive for EVs a "self-driving car will have a hard time filling itself with gasoline" but a self-driving EV can "drive to an open parking spot, align itself properly, and self-charge using wireless charging; (d) automation will help make EVs more energy efficient through more optimal driving (e.g., smoother acceleration and deceleration), which will reduce range anxiety for EVs;[337] (e) both AV and EV technologies are expected to mature at approximately the same time—in the 2030 timeframe; and (f) both technologies will become either directly "mandated by governments" or indirectly mandated via new taxes or cost-components added to internal combustion engine vehicles.[338]

And, indeed, GM, Nissan, and Google have all used EVs as their "starting platform" for their AV prototypes.[339] Uber's test-fleet of driverless vehicles in Pittsburgh – which we explain in the next subsection – uses a hybrid model, while the GM-Lyft partnership will begin testing self-driving, *electric* taxis in the next few months according to *The Wall Street Journal*.[340]

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[334] RAND Report, 2 to 3.

[335] Alex Davies. "Ford Says It'll Have a Fleet of Fully Autonomous Cars in Just 5 Years." *Wired*. August 16, 2016. Available at https://www.wired.com/2016/08/ford-autonomous-vehicles-2021/.

[336] Mike Colias. "Delphi, Mobileye Join Forces to Develop Self-Drive System." *Wall Street Journal*. August 23, 2016. Available at https://www.wsj.com/articles/delphi-mobileye-join-forces-to-develop-self-drive-system-1471924804.

[337] The RAND Corporation also makes this point; see RAND Report, 29-34.

[338] Cosmin Laslau. "Six Reasons Why Electric Vehicles and Autonomous Vehicles Will Inevitably Merge." *Lux Research*. September 9. 2016. Available at: http://blog.luxresearchinc.com/blog/2016/09/six-reasons-why-electric-vehicles-and-autonomous-vehicles-will-inevitably-merge/.

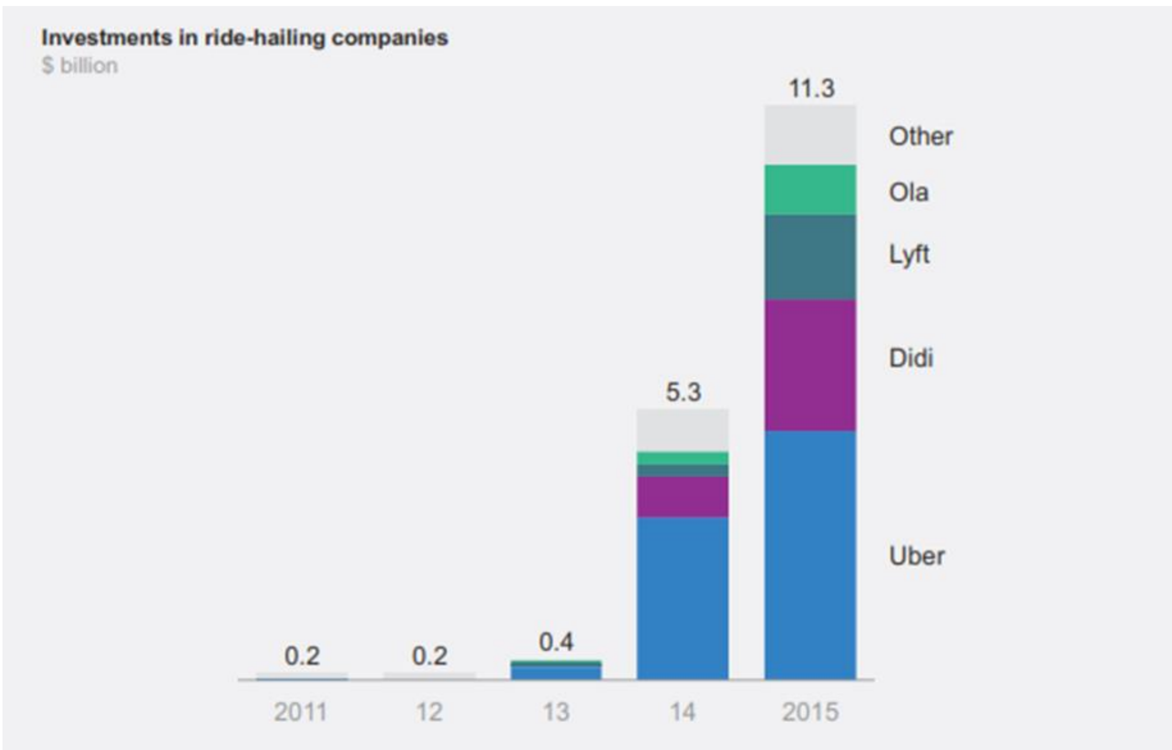
[339] Ibid.

[340] Mike Ramsay and Gautham Nagesh. "GM, Lyft to Test Self-Driving Electric Taxis." *Wall Street Journal*. May 5, 2016. Available at https://www.wsj.com/articles/gm-lyft-to-test-self-driving-electric-taxis-1462460094.

E. More Evidence of Investments in Shared, Electric, Autonomous Vehicles

Over the past year, we have continued to see significant new investments that may push the SHEAM model for electric vehicles closer to reality. In general, as McKinsey points out, investment in ride-sharing services – Lyft, Uber, etc. – and investment in autonomous vehicles – Daimler, BMW, Intel, Verizon-backed investments – has also dramatically increased in recent years.[341] Figure 20 below, from McKinsey, shows the extent of growth in investments in shared vehicle companies—in total, investment reached $11.3 billion in 2015.

Figure 20: Investments in Ride-Hailing Companies ($billion)

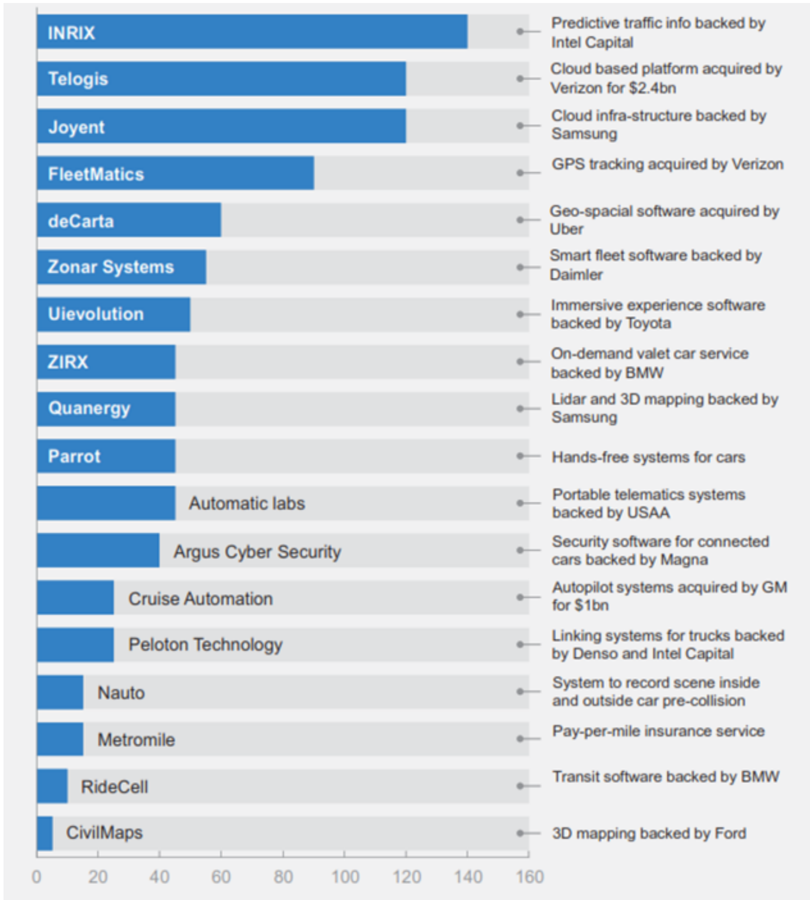


Source: McKinsey EV Report, Exhibit 3

Figure 21 below shows that autonomous vehicle ventures have also seen significant increases in new investments, ranging from the tens of millions of dollars to approximately $140 million.

[341] McKinsey EV Report, 17, 19.

Figure 21: Acquisitions of and Investments in Autonomous Driving Initiatives ($million)



Source: McKinsey EV Report, 6

Notably absent from Figure 21 is Intel Corporation's $15 *billion* acquisition of Mobileye, a maker of microchips for autonomous vehicle technology, in March 2017.[342] According to Bloomberg, Mobileye makes "systems that alert drivers to pedestrians, unintended lane departures and speed limit violations" and "which can also trigger braking to prevent an accident."[343] Moreover, according to Bloomberg, "Mobileye has been pushing to sign up more carmakers for its advanced products, such as technology that collects data from vehicle fleets to build a real-time, crowd-sourced mapping service."[344] This made Mobileye of interest to Intel; according to Bloomberg:

> Intel is trying to accelerate a push into what many chip companies view as the next big opportunity: self-driving cars and the data they generate. With Mobileye, Intel gains the

[342] Ian King and Gabriella Coppola. "Intel to Buy Mobileye for About $15 Billion in Car Tech Push." *Bloomberg Technology*. March 13, 2017. Available at https://www.bloomberg.com/news/articles/2017-03-13/intel-to-buy-mobileye-for-about-15-billion-themarker-says. ("Intel Article")

[343] Intel Article.

[344] Intel Article.

> ability to offer automakers a larger package of components they will need as vehicles become more autonomous. The Santa Clara, California-based company estimates the market for vehicle systems, data and services will be worth as much as $70 billion by 2030.[345]

Looking more closely at other individual investments – and planned investments – by leading companies, there are several examples to highlight.

As we noted in last year's Looking Forward Report, GM invested $500 million into ride-sharing service provider Lyft.[346] GM's CEO, Mary Barra, recently stated that the "emerging practice of sharing rides and cars" is the biggest shift in the way GM thinks; she noted that while GM has experience in EVs, "connected" vehicles, and autonomous driving, they needed "a different mindset" for ride-sharing, which unlike the other forces changing the automobile industry, it is not a "technology-driven" change.[347] GM plans to have its own self-driving cars within Lyft's ride-sharing service,[348] and Barra believes ride sharing with autonomous vehicles is the only way to make it "scale" and be "cost effective."[349]

Elon Musk, CEO of Tesla, has laid out "Part Deux" of his "Master Plan," which is meant to "get off fossil fuels," and "achieve sustainability."[350] A crucial part of Musk's so-called Master Plan is to integrate energy generation, energy storage, and EVs—this latter category includes Tesla's existing two models of EVs, plus coming models of "a future compact SUV," a "new kind of pickup truck," "heavy-duty trucks," and "high passenger-density urban transport."[351] Musk also notes that "[a]s the technology matures, all Tesla vehicles will have the hardware necessary to be fully self-driving with fail-operational capability, meaning that any given system in the car could break and your car will still drive itself safely."[352] Musk also claims that once "true self-driving is approved by regulators," Tesla owners:

> …will be able to sleep, read or do anything else enroute to your destination. You will also be able to add your car to the Tesla shared fleet just by tapping a button on the Tesla phone app and have it generate income for you while you're at work or on vacation, significantly offsetting and at times potentially exceeding the monthly loan or lease cost. This dramatically lowers the true cost of ownership to the point where almost anyone could own a Tesla. Since most cars are only in use by their owner for 5% to 10% of the day, the fundamental economic utility of a true self-driving car is likely to be several

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[345] Intel Article.

[346] 2016 Looking Forward Report, 79.

[347] Katie Fehrenbacher. "GM's CEO: The Sharing Economy Is a Bigger Shift Than Electric, Autonomous." *Fortune*. October 6, 2016. Available at http://fortune.com/2016/10/06/gm-ceo-ride-sharing/.

[348] Ibid.

[349] Ibid.

[350] Elon Musk. "Master Plan, Part Deux." *Tesla*. July 20, 2016. ("Musk Master Plan"). Available at: https://www.tesla.com/blog/master-plan-part-deux.

[351] Musk Master Plan.

[352] Musk Master Plan.

> times that of a car which is not. In cities where demand exceeds the supply of customer-owned cars, Tesla will operate its own fleet, ensuring you can always hail a ride from [Tesla] no matter where you are.[353]

In Pittsburgh, Uber has been testing a "small" fleet of autonomous vehicles since September 2016. They are not EVs, *per se*, but Ford Fusion hybrids, and are equipped with "a special roof-mounted array of cameras, GPS receivers, and a LIDAR (laser radar) system that collectively generate over a million data points every second."[354] Moreover, the "autonomous system is designed to handle acceleration, braking, steering, and point-to-point navigation."[355]

And on November 22, 2016, Apple filed a letter with the National Highway Traffic Safety Administration in which it revealed that it is "investing heavily in the study of machine learning and automation…in many areas, including transportation."[356] Apple noted that "automated vehicles have the potential to greatly enhance the human experience—to prevent millions of car crashes and thousands of fatalities each year and to give mobility to those without."[357] While the Apple Letter does not specifically mention EVs, specifically, the Financial Times claims that "[h]undreds of Apple staff have been working on an electric car for more than two years."[358]

F. Two Cautions for the Development of the Electric Vehicle Industry

Despite the foregoing optimism, there are reasons for caution before we assume that the EV revolution is inevitable; or that it will be done quickly. We provide two cautions below.

1. Lack of Legal Infrastructure to Support Autonomous Vehicles

If the SHEAM model is to be the primary driver of widespread EV adoption, governments will have to adapt their laws to allow autonomous vehicles on the road, with clearly-defined rules regarding liability. That is yet to be done. In Pennsylvania, for example, the law requires a human being to be able to take control of a vehicle; thus, Uber's fleet of self-driving taxis are not fully autonomous, and instead have a human behind the wheel to comply with the law.[359]

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[353] Musk Master Plan.

[354] Jeff Zurschmeide. "Uber's Pittsburgh robotaxis amuse riders, still struggle with double parked cars." Digital Trends, October 18, 2016. ("Digital Trends Article"). Available at http://www.digitaltrends.com/cars/uber-pittsburgh-robo-taxi-experiment/.

[355] Ibid.

[356] Apple's Comments on the Federal Automated Vehicles Policy, National Highway Traffic Safety Administration. Docket No. NHTSA-2016-0090. November 22, 2016, 1. ("Apple Letter")

[357] Apple Letter, 1.

[358] Tim Bradshaw. "Apple reveals plans for self-driving car." Financial Times. December 3, 2016. Available at https://www.ft.com/content/5c643f94-b983-11e6-8b45-b8b81dd5d080.

[359] Digital Trends Article.

Elon Musk's expectations on the significant amount of time it will take for regulators to approve autonomous vehicles is in his "Master Plan":

> Even once the software is highly refined and far better than the average human driver, there will still be a significant time gap, varying widely by jurisdiction, before true self-driving is approved by regulators. We expect that worldwide regulatory approval will require something on the order of 6 billion miles (10 billion km). Current fleet learning is happening at just over 3 million miles (5 million km) per day.[360]

Since 2012, at least 34 states, plus D.C., have considered AV legislation;[361] eleven of those states have enacted legislation, while two others have Executive Orders in place related to AVs.[362] Figure 22 shows the states that have done either.

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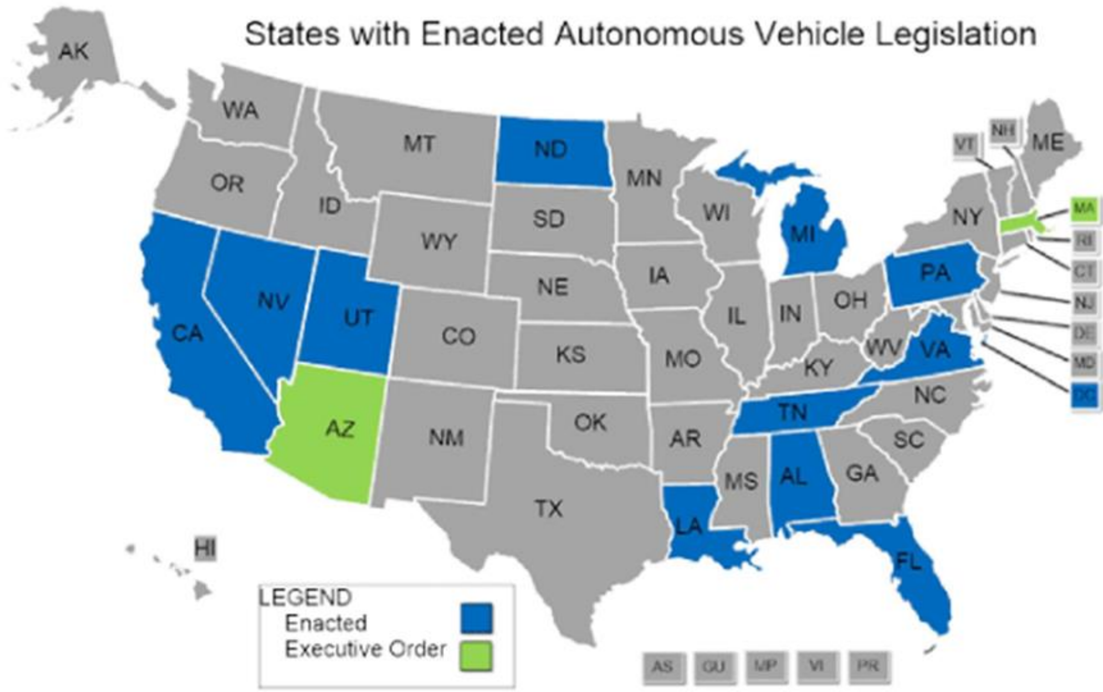
[360] Musk Master Plan.

[361] "Autonomous Vehicles: Self-Driving Vehicles Enacted Legislation." *National Conference of State Legislatures*. Updated February 21, 2017. Available at http://www.ncsl.org/research/transportation/autonomous-vehicles-legislation.aspx. ("NCSL Summary Page")

[362] Ibid.

Figure 22: States with Enacted Autonomous Vehicle Legislation or Executive Orders



Source: NCSL Summary Page.

Beyond just allowing AVs on the road, states must also define liability for manufacturers, drivers, insurers, and car-sharing providers. RAND Corporation explains that the "existing liability regime does not seem to present unusual liability concerns for owners or drivers of vehicles equipped with AV technologies. In fact, the decrease in the number of crashes and the associated lower insurance costs that these technologies are expected to bring about will generally encourage the adoption of this technology by drivers and automobile insurance companies."[363]

For manufacturers, however, "liability is expected to increase" which "may lead to inefficient delays in the adoption of these technologies."[364] RAND Corporation claims that such delays "may be perfectly appropriate for technologies that are extremely complex, such as vehicles that are fully autonomous, where there would be enormous difficulties proving complete reliability, given the range of conditions in which the vehicle will need to operate."[365]

[363] RAND Report, 132.

[364] RAND Report, 132.

[365] RAND Report, 133.

Moreover, according to RAND Corporation, there are many options available to help define liability, including federal preemption of the states whereby the federal government sets national standards but also exempts manufacturers from state court liability,[366] or creating a new model whereby manufacturers (or car-sharing providers) offer driving as a "service" rather than a "product," requiring customers to sign service contracts which limit the manufacturers' liability.[367] RAND Corporation concludes:

> Uncertainty itself over the magnitude of the liability risks may also deter and delay introduction of these technologies. This can create a catch-22 because the court system can resolve this uncertainty only when claims are actually brought and litigated, which, of course, requires that the technology be introduced. Nonetheless, we anticipate that as this technology is gradually introduced into the marketplace, the legal standards will be clarified.[368]

2. Lack of Existing Physical Infrastructure for EV Charging

A second caution related to EV adoption relates to the lack of existing physical infrastructure for EV charging, which is needed to reduce range anxiety. That may be changing, however.

The Obama White House announced two initiatives in 2016 to increase EV charging infrastructure. First, in July 2016, the White House set aside up to $4.5 billion in loan guarantees for the deployment of electric vehicle charging facilities,[369] while in November 2016, the White House announced the designation of 48 "National Electric Vehicle Charging Corridors" across the U.S., which set aside funds for states in these corridors – 35 states in all – to identify EV charging stations near upcoming exits; according to the White House, drivers can expect "existing or planned" charging stations within every 50 miles on these corridors.[370]

Utilities, meanwhile, are putting forth proposals to build out the EV charging infrastructure in some states. For example, in Oregon, both Portland General Electric Co. and PacifiCorp have filed regulatory applications to install EV charging stations and "launch programs to accelerate the adoption of electric vehicles."[371] PacifiCorp, for example, would "install, own and operate up to seven charging stations…in 2018 and 2019," which would

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[366] RAND Report, 133.

[367] RAND Report, 133-134.

[368] RAND Report, 134.

[369] The White House. "FACT SHEET: Obama Administration Announces Federal and Private Sector Actions to Accelerate Electric Vehicle Adoption in the United States." July 21, 2016. Available at https://obamawhitehouse.archives.gov/the-press-office/2016/07/21/fact-sheet-obama-administration-announces-federal-and-private-sector.

[370] The White House. "Obama Administration Announces New Actions To Accelerate The Deployment of Electrical Vehicles and Charging Infrastructure." November 3, 2016. Available at https://obamawhitehouse.archives.gov/the-press-office/2016/11/03/obama-administration-announces-new-actions-accelerate-deployment.

[371] Jeff Stanfield. "Oregon utilities launch programs to expand electric vehicle use." *S&P Global Market Intelligence*. January 4, 2017.

"include multiple dual-standard DC fast chargers."[372] In California, the California Public Utilities Commission recently approved Pacific Gas & Electric's ("PG&E") application to spend up to $130 million and deploy infrastructure to support up to 7,500 electric vehicle charging ports.[373] And in Massachusetts, National Grid has sought approval from the Massachusetts Department of Public Utilities for its proposed $23.8 million "Electric Vehicle Market Development Program,"[374] which seeks to install 1,280 electric vehicle charging ports in National Grid's Massachusetts footprint.[375]

Additional uncertainty is also introduced by the administration change in the U.S. It is unclear what President Trump will do regarding EVs, including former President Obama's efforts on EVs (highlighted above). Some, however, have suggested that the "future of U.S. coast to coast zero emission mobility on our nation's highways is in serious jeopardy with President Trump in the White House."[376]

G. Implications for SPP

The bottom line here is that to accurately anticipate the future of EVs, it is necessary to consider the future of AVs or, more broadly, the SHEAM business model. And for the moment, the evidence in not in the form of booming EV sales, but, rather, in significant investments being made in AV/SHEAM ventures by large, savvy investors including Apple, Google, Ford, GM and others. Whether there will ever be a significant adoption of EVs in SPP's footprint – and if so, how fast – is uncertain. In fact, recent forecasts of electric vehicle penetration have varied widely. The U.S. Energy Information Administration forecasts 7.5 million EVs on the road in the U.S. in 2025; GreenTech Media expects that number to be 11.4 million.[377]

Whatever its likelihood, a greater adoption of EVs in SPP's footprint would mean both a new source of demand and a new source of supply of electricity, something that could provide SPP and utilities with additional areas for innovation. According to a recent article in GreenTech Media, "[s]ince each car has an electrical load that can be nearly as great as that of a house, utilities are interested in manipulating charging so that EVs can draw power when it's best for the grid while also ensuring the customer has a full battery when needed."[378] In California, for

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[372] Ibid.

[373] Jeff Stanfield. "PG&E gets approval for utility-owned electric vehicle charging stations." *S&P Global Market Intelligence*. December 15, 2016.

[374] National Grid. "D.P.U. 17-13 – Petition of Massachusetts Electric Company and Nantucket Electric Company, each d/b/a National Grid for Pre-Approval of Electric Vehicle Market Development Program, and of Electric Vehicle Program Provision." Massachusetts Department of Public Utilities Docket No. D.P.U. 17-13. January 20, 2017.

[375] Karsten A. Barde and Brian J. Cronin, on behalf of National Grid. "Pre-Filed Direct Testimony." D.P.U. 17-13. January 20, 2017. Page 29, lines 7-16.

[376] Carolyn Fortuna. "What will happen to Obama's National EV Charging Corridor initiative?" *Teslarati*. November 14, 2016. Available at http://www.teslarati.com/fate-of-national-ev-charging-corridor-trump-ebell/.

[377] Dan Cohan. "Electric car sales predictions are all over the map." *The Hill*. January 24, 2017. Available at http://thehill.com/blogs/pundits-blog/transportation/315958-forecasts-for-electric-car-sales-are-all-over-map.

[378] Katherine Tweed. "SCE Tests Electric Vehicles for Demand Response." *GreenTech Media*. February 17, 2015. Available at

example, Southern California Edison launched a pilot program that sought to allow EVs as suppliers of electricity and grid services. Specifically, customers can "opt in to demand response" when they plug in and have options available, including to get a full charge, no matter the price, or to allow curtailment if there is a demand response event.[379]

Another implication of EV penetration for SPP is cybersecurity, particularly for EVs that are autonomous and shared or otherwise electronically connected. According to the RAND Corporation Report, "as AVs become more computerized and more connected, they provide another aspect of critical infrastructure and a potential target for a cyberattack."[380]

Increases in EV could also have impacts elsewhere in the increasingly-integrated electricity sector; for example, McKinsey states that a "virtuous cycle" could arise if the SHEAM model led to significant EV adoption. McKinsey explains:

> In turn, higher EV production could accelerate innovation and reduce the cost of batteries. That opens up applications in adjacent systems, such as distributed storage. And the plummeting cost of distributed power generation could improve the greenhouse-gas abatement potential of EVs because they would get more of their juice from low-carbon sources. In these and other cases, there is a powerful dynamic of mutual reinforcement at work. It's not just one oar in the water—but lots of them, all pulling in the same direction.[381]

And finally, as EVs – particularly shared, autonomous EVs – penetrate the U.S., they bring with them numerous impacts. In terms of benefits, autonomous EVs, along with all other autonomous vehicles, "have the potential to take 60-70% of cars off the road," make driving safer and "reduce road fatalities by up to 90%," and siginificantly reduce emissions from vehicles.[382] The introduction of autonomous EVs would allow those who are currently not able to drive – such as the visually-impaired – to do so;[383] traffic congestion would likely decrease from fewer cars on the road and more efficient driving habits.[384] This could also reduce demand for and funding of public transportation as well as an increase in total vehicle miles per year in the U.S. as the cost of driving decreases.[385]

https://www.greentechmedia.com/articles/read/sce-tests-electric-vehicles-for-demand-response.

[379] Ibid.

[380] RAND Report, 158.

[381] McKinsey EV Report, 6.

[382].Mayor's Office. "Mayor Walsh announces autonomous vehicle initiative." *City of Boston*. September 14, 2016. Available at https://www.boston.gov/news/mayor-walsh-announces-autonomous-vehicle-initiative, citing joint research by the World Economic Forum, The Boston Consulting Group, and The Future of Cities group.

[383] RAND Report, xv.

[384] RAND Report, xv.

[385] RAND Report, xv-xvii.

VI. Lessons from the (Failed) 2016 Electricity Policy Modernization Act

A. Introduction

The issue of transmission grid security remains one of the most important facing the electricity industry. While cybersecurity is a hot topic in many areas of the economy, the transmission grid's vulnerability to cyber, physical, and other threats receives particular attention because, unlike other industries and actors, the grid's importance to the American economy and welfare of its people is difficult to overstate. For example, in his recent, *New York Times* bestselling book, "Lights Out," published in 2015, Ted Koppel, in discussing the potential impact of an electromagnetic pulse attack on the U.S. electric grid, noted a congressional commission report which estimated that "only one in ten of us would survive a year into a nationwide blackout, the rest perishing from starvation, disease, or societal breakdown."[386]

The risk Mr. Koppel highlights may be a "black swan" type of risk: very low probability of occurring, but potentially catastrophic in its results. A congressional commission report[387] referenced in Mr. Koppel's book noted that an attack on the "electric power infrastructure" could "seriously impact…the financial system; means of getting food, water, and medical care to the citizenry, trade; and production of goods and services…[which] could have irreversible effects on the country's ability to support its population."[388] The commission's second report, issued in 2008, echoed these findings: "Should significant parts of the electrical power infrastructure be lost for any substantial period of time, the Commission believes that the consequences are likely to be catastrophic, and many people may ultimately die for lack of the basic elements necessary to sustain life."[389]

While Mr. Koppel's book has its critics,[390] his description of the potential impact of long-term grid outages is less controversial. Moreover, recent attacks including cyberattacks on

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[386] Ted Koppel. "Lights Out." 2015, 22.

[387] John S. Foster, Jr., et al. Report of the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack, Volume 1: Executive Report 2004. Available at http://www.empcommission.org/docs/empc_exec_rpt.pdf. ("2004 EMP Report").

[388] 2004 EMP Report, pages 1 to 2.

[389] Dr. John S. Foster, Jr., et al. Report of the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack, Critical National Infrastructures. April 2008, vi to vii. Available at http://www.empcommission.org/docs/A2473-EMP_Commission-7MB.pdf.

[390] For example, in a 2017 review of Koppel's book, attorney Jonathan Schneider claims Mr. Koppel provides an "inaccurate representation of the machinery already in place to address cyber threats" and that "Koppel's notion that the electric industry is beholden to no one in the manner in which the grid is protected is wrong, as is the implication that measures now being taken are grossly out of step with known risks." Jonathan Schneider. "Ted Koppel: Right and Wrong" *Public Utilities Fortnightly*. January 2017. Available at https://www.fortnightly.com/fortnightly/2017/01/ted-koppel-right-and-wrong. ("Schneider Review")

utilities in Ukraine[391] and the physical attack on a Pacific Gas & Electric substation serving Silicon Valley in California,[392] highlight that the grid will remain a target.

Given the attention raised by Mr. Koppel's book and recent grid attacks, it was therefore not surprising that Congressional efforts to pass an energy bill in 2016 – which included House and Senate bills to be combined into one comprehensive energy bill – featured various grid hardening and cybersecurity measures. Specifically, late in 2016, the Senate and House tried to win approval for a comprehensive energy bill that would address grid security, whether that threat comes from electromagnetic pulses ("EMPs"), cybersecurity, physical threats, or other potential causers of long-term outages, plus other energy and electricity issues. However, Congressional efforts to pass a bill failed, and according to Lisa Murkowski (R-AK), author of the Senate bill, the parties are "starting over."[393]

It is impossible to know if Congress will propose, let alone pass, another comprehensive energy bill in 2017; the change in administration from President Obama to President Trump has shaken up the executive branch's approach to regulating the energy and electricity industries, and that impact may have ripple effects in the U.S. Congress. Moreover, many state legislatures have pursued new energy and electricity laws, as we detail elsewhere in this report, creating a particularly fluid legislative atmosphere across the U.S. Nevertheless, if such a bill is advanced – and that is a big if – its passage could lead to a significant amount of planning and analysis by RTOs, including SPP. To get an idea of what might be included in the next energy bill, we reviewed both the House and Senate bills for key provisions related to SPP. The most notable and potentially relevant to SPP are provisions related to grid hardening and security and provisions related to markets and distributed energy resources. Those provisions would introduce obligations for SPP and its members. In this chapter, we provide an overview of some of those provisions as a potential starting point of what may be found in the next significant energy bill.

B. Brief Timeline of Senate (S.2012) and House (H.R. 8) Bills

Late in 2016, members of the U.S. House of Representatives and Senate sought to forge a consensus, through conference committee, of two separate energy bills. One was Senate Bill S.2012, which passed the Senate on April 20, 2016 by a vote of 85 to 12.[394] The Congressional Budget Office ("CBO") estimated that implementation of the legislation would have resulted in outlays of $32 billion over the 2016 to 2020 period, and additional spending of about $11 billion

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[391] Rebecca Smith. "Cyberattacks Raise Alarm for U.S. Power Grid." *Wall Street Journal*. December 30, 2016. Available at https://www.wsj.com/articles/cyberattacks-raise-alarms-for-u-s-power-grid-1483120708.

[392] 2015 Looking Forward Report, 58.

[393] Molly Christian. "Lawmakers vow to work for consensus in energy bill conference." *S&P Global Market Intelligence*. September 8, 2016.

[394] S.2012 – North American Energy Security and Infrastructure Act of 2016. 114th Congress (2015-2016). *Congress.gov*. Available at https://www.congress.gov/bill/114th-congress/senate-bill/2012/all-info.

after 2020.[395] The other was House Bill H.R. 8, which passed the House on December 3, 2015, by a vote of 249 to 174.[396] The CBO estimated H.R. 8 would increase direct spending by $414 million over the 2016 to 2025 period.[397]

The goal of the committee was to forge the two bills into one, which would become the "first major energy reform bill to be enacted since the Energy Independence and Security Act of 2007."[398] Together, these bills were referred to generally as the Energy Policy Modernization Act.

By December 7, however, Congress announced that the efforts to pass an energy bill in 2016 had failed. It should be noted that the failure of the bill had no one specific cause, but that the bills themselves had areas of controversy, such as the inclusion of language that would have expedited DOE's approval process for LNG exports.[399]

Looking forward, there is some expectation that Congress will try again to re-introduce energy legislation. Republicans "are expected to push for a bill that more closely aligns with their priorities rather than pass the compromise legislation pieced together" in the 2016 bills."[400] There will be challenges to passing the legislation, of course, including the fact that there will be new members of the House and Senate energy committees, and the to-be-determined impact of the new administration on the likelihood of a comprehensive energy bill.

C. Key Content of the House and Senate Bills

The text of S.2012 is 798 pages; H.R. 8 is 806 pages. The purposes of this section is not to provide the Board with a detailed description of every aspect of the two bills, but rather to highlight for the Board issues that relate to SPP and the grid. Moreover, while the next energy bill's content and timing is impossible to predict, the similarities in the two bills could be read as the most likely areas that will serve as a starting point in the next energy bill.

1. Grid Hardening and Cybersecurity

H.R. 8 would have given the DOE authority, in the event of a grid security emergency declared by the President and caused by events such as cyber or physical grid attacks, to

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[395] Congressional Budget Office Cost Estimate, S.2012 Energy Policy Modernization Act of 2015. October 15, 2015. Available at https://www.cbo.gov/sites/default/files/114th-congress-2015-2016/costestimate/s2012.pdf.

[396] H.R.8 – North American Energy Security and Infrastructure Act of 2015. 114th Congress (2015-2016). *Congress.gov*. Available at https://www.congress.gov/bill/114th-congress/house-bill/8.

[397] Congressional Budget Office Cost Estimate, H.R. 8 North American Energy Security and Infrastructure Act of 2015. October 19, 2015. Available at https://www.cbo.gov/sites/default/files/114th-congress-2015-2016/costestimate/hr8.pdf.

[398] Molly Christian. "Lawmakers vow to work for consensus in energy bill conference," *S&P Global Market Intelligence*, September 8, 2016.

[399] Rachel Adams-Heard. "House wants to drop LNG export language in energy bill." *S&P Global Market Intelligence*. November 28, 2016.

[400] Molly Christian. "Energy bill dies amid policy differences, time limits." *S&P Global Market Intelligence*. December 7, 2016.

"issue…orders for emergency measures as are necessary in the judgment of the Secretary [of the DOE] to protect or restore the reliability of critical electric infrastructure during such emergency."[401] This new DOE authority would have allowed the DOE to act without notice, hearing, or report.[402] Congress and, to the extent practicable, Canada and Mexico would be consulted in such an event. Moreover, the DOE would have had the ability to share classified information with entities such as SPP to "enable optimum communication between the entity and the Secretary and other appropriate Federal agencies regarding the grid security emergency."[403] (S.2012 contains similar provisions, but focuses more on cybersecurity.)[404]

H.R. 8 also would have required the DOE (in consultation with other agencies) to determine "critical defense facilities," which are electric infrastructure facilities that are critical to the defense of the U.S.; these facilities would be subject to their own rules and procedures.[405]

If FERC were to identify "a grid security vulnerability" that "has not adequately been addressed through a reliability standard," H.R. 8 would have required FERC to issue an order "directing the Electric Reliability Organization to submit to the Commission for approval" a "reliability standard requiring implementation by any owner, operator, or user of the bulk-power system in the United States, of measures to protect the bulk-power system against such vulnerability. Any such standard shall include a protection plan, including automated hardware-based solutions."[406] If the ERO's proposed reliability standard is insufficient, FERC would have the authority to develop and require implementation of its own standard.[407]

Regarding the threat of "geomagnetic storms" and "electromagnetic pulse," H.R. 8 would have required EROs to submit to FERC for approval "reliability standards adequate to protect the bulk-power system from any reasonably foreseeable geomagnetic storm or electromagnetic pulse event."[408] H.R. 8 would have required similar action from EROs regarding large transformers, requiring EROs to develop reliability standards that would assure "adequate availability of large transformers to promptly restore the reliable operation of the bulk-power system in the event that any such transformer is destroyed or disabled…"[409]

H.R. 8 would have required DOE, in consultation with FERC, NERC, and the EROs, to develop a "Strategic Transformer Reserve" plan "for the storage, in strategically located facilities, of spare large power transformers and emergency mobile substations in sufficient numbers to temporarily replace critically damaged large power transformers and substations that

[401] H.R.8, Sec. 1104.
[402] H.R.8, Sec. 1104.
[403] H.R.8, Sec. 1104.
[404] S.2012, Sec. 2001.
[405] H.R.8, Sec. 1104.
[406] H.R.8, Sec. 1104.
[407] H.R.8, Sec. 1104.
[408] H.R.8, Sec. 1104.
[409] H.R.8, Sec. 1104.

are critical electric infrastructure or serve defense and military installations."[410] Such a plan would require sufficient spare large transformers to restore the grid after physical or cyberattack, electromagnetic pulse attack, geomagnetic disturbance, severe weather, or seismic events.[411]

H.R. 8 would have required the establishment of a "voluntary Cyber Sense program to identify and promote cyber-secure products intended for use in the bulk-power system."[412] DOE would oversee and develop rules for testing, supporting, and deploying these cyber-secure products.[413]

H.R. 8 also would have required "each electric utility" to develop a plan "to improve the resilience of electric infrastructure, mitigate power outages, continue delivery of vital services, and maintain the flow of power to facilities critical to public health, safety, and welfare…related to current and future threats, including physical and cyber attacks, electromagnetic pulse attacks, geomagnetic disturbances, seismic events, and severe weather and other environmental stressors."[414] These utility plans would have used grid hardening, advanced grid and cybersecurity technologies, distributed generation, microgrids, storage, and other equipment.[415] Rate recovery was to be considered and authorized by the states.

Utilities, meanwhile, would have to "ensure…reliable generation into its integrated resource plan to assure the availability of electric energy over a 10-year planning period," which includes generation with an adequate supply of fuel on hand to operate "for an extended period of time."[416]

H.R. 8 also would have required that FERC and the EROs conduct "an independent reliability analysis" of any proposed or final rule issued by a federal agency (e.g., FERC, EPA) "for which compliance with the rule may impact an electric utility generating unit or units, including by resulting in closure or interruption to operations of such a unit or units."[417] S.2012 contained a similar requirement, but would have required the ERO to submit a "reliability impact statement" to FERC and Congress on any proposed rule that "may significantly affect the reliable operation of the bulk-power system."[418]

H.R. 8 also had a section on "Reliability and Performance Assurance in Regional Transmission Organizations," requiring all RTOs that operate capacity markets to file a report showing how that market "utilizes competitive market forces" while also ensuring "sufficient

[410] H.R.8, Sec. 1105.
[411] H.R.8, Sec. 1105.
[412] H.R.8, Sec. 1106.
[413] H.R.8, Sec. 1106.
[414] H.R.8, Sec. 1107.
[415] H.R.8, Sec. 1107.
[416] H.R.8, Sec. 1107.
[417] H.R.8, Sec. 1108.
[418] S.2012, Sec. 4301.

capacity from physical generation facilities" that have sufficient fuel on-site to enable operation for an extended period of time.[419]

S.2012 contained a provision that would have required the DOE to consult with federal agencies, the states, and the energy sector "to develop advanced cybersecurity applications and technologies for the energy sector," "leverage electric grid architecture as a means to assess risks to the energy sector," "perform pilot demonstration projects with the energy sector," and "to develop workforce development curricula for energy sector-related cybersecurity."[420] S.2012 would have appropriated $65 million per year for nine years for this purpose, plus another $15 million per year to "cybertest" the grid.[421]

2. Energy Efficiency, Storage, and Markets

H.R. 8 contained a provision requiring the U.S. GAO to submit to Congress "a report on the potential of battery energy storage" that addresses the barriers, benefits, and potential impacts of widespread battery storage adoption in the U.S.[422]

H.R. 8 also would have required the GAO to submit to Congress "a report describing the results of a study of whether and how the current market rules, practices, and structures of each [RTO] produce rates that are just and reasonable" by "facilitating fuel diversity…resource adequacy, and reliability," "promoting the equitable treatment of business models, including different utility types, the integration of diverse generation resources, and advanced grid technologies," "identifying and addressing regulatory barriers to entry, market-distorting incentives, and artificial constraints on competition," "providing transparency regarding dispatch decisions," "facilitating the development of necessary natural gas pipeline and electric transmission infrastructure," "ensuring fairness and transparency in governance structures and stakeholder processes," "ensuring the proper alignment of the energy and transmission markets by including both energy and financial transmission rights in the day-ahead markets," facilitating…self-supply," "considering, as appropriate, State and local resource planning," and "mitigating…disruptive effects of tariff revisions on the economic decisionmaking of market participants."[423] S.2012 had a similar requirement.[424]

S.2012 would have required the DOE to submit to Congress a report with "an evaluation of the performance of the electric grid" including development of "metrics for evaluating and quantifying the electric grid."[425] S.2012 also would have required a report by RTOs on "diversity of supply" and the performance and operation of the RTO's generating resources.[426]

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[419] H.R.8, Sec. 1110.

[420] S.2012, Sec. 2002.

[421] S.2012, Sec. 2002.

[422] H.R.8, Sec. 3114.

[423] H.R.8, Sec. 3221.

[424] S.2012, Sec. 4503.

[425] S.2012, Sec. 2305.

[426] S.2012, Sec. 4302.

H.R. 8 would have amended PURPA to require each state regulatory commission to have a hearing or otherwise consider community solar and net metering, in the event that the state had not already done so.[427] S.2012 would have required the DOE to conduct a study on net metering in general.[428]

S.2012 would have required the DOE to "establish and facilitate a collaborative process to develop model grid architecture and a set of future scenarios for the electric system to examine the impacts of different combinations of resources (including different quantities of distributed energy resources and large-scale, central generation) on the electric grid."[429] This process would have served to "account for differences in market structure, including an examination of the potential for stranded costs in each type of market structure"[430] and, based on the results of the process, the DOE would have to determine if "any additional standards are necessary to ensure the interoperability of grid systems and associated communication networks."[431]

S.2012 also would have required each RTO to "file a report with [FERC]" that (a) "identifies distributed energy resources and micro-grid systems that are subject to dispatch" by the RTO, (b) "describes the fuel sources and operational characteristics of such distributed energy resources and micro-grid systems," (c) "evaluates…the potential for distributed energy resources and micro-grid systems to be deployed to the transmission organization over the short- and long-term periods in the planning cycle of the transmission organization," and (d) "identifies…barriers to the deployment" of such resources and ways to reduce those barriers.[432]

3. DOE Research Areas

H.R. 8 also would have required the DOE to "carry out programs of research, development, demonstration, and commercial application on distributed energy resources and systems reliability and efficiency…integrating advanced energy technologies with grid connectivity."[433] H.R. 8 called for similar DOE initiatives for "electric transmission and distribution research and development,"[434] "nuclear energy research and development programs,"[435] including a "small modular reactor program,"[436] "energy efficiency,"[437] electric

[427] H.R.8, Sec. 6002.
[428] S.2012, Sec. 2311.
[429] S.2012, Sec. 2302.
[430] S.2012, Sec. 2302.
[431] S.2012, Sec. 2302.
[432] S.2012, Sec. 2309.
[433] H.R.8, Sec. 611.
[434] H.R.8, Sec. 612.
[435] H.R.8, Sec. 623.
[436] H.R.8, Sec. 624.
[437] H.R.8, Sec. 641.

vehicles,[438] renewable energy,[439] fossil energy,[440] and coal[441] and "high efficiency gas turbines research and development,"[442] among others. S.2012 also would have required the DOE to establish a microgrid development program.[443]

D. What Might Happen, and Why it May Impact SPP

Summing all this up, the energy bills – S.2012 and H.R. 8 – are dead, but potentially instructive, bills. Notably, they contained substantial new roles and obligations for the DOE, FERC, EROs, and RTOs regarding hardening of the grid and planning for a diverse resource portfolio that includes renewable resources, reliable capacity, and distributed energy resources. Had either been passed, SPP would have been tasked with some of these new obligations.

Again, it is impossible to know if Congress will pass a major energy bill in the near term, particularly with the new administration in place. For example, the idea of expanding DOE authority may be at odds with the administration's stance on executive branch agency power and new Secretary of Energy Rick Perry's agenda. Nevertheless, the Board should be prepared for the possibility of a future, comprehensive energy bill and, to the extent possible, what may be in it. At this point, a reasonable starting point for the Board is to anticipate some of the same responsibilities and obligations placed on SPP in H.R. 8 and S.2012 as those potentially being part of a future energy bill.

Other potential areas of Congressional focus may emerge, too, such as support for nuclear power; indeed, one bill has already been introduced in the House which would require the DOE and the Nuclear Regulatory Commission to ensure they are prepared to begin reviewing "requests for regulatory approval for advanced [nuclear] reactors," and to "develop a [regulatory] framework for licensing advanced [nuclear] reactors."[444] The likelihood that the administration would get behind support for nuclear is not clear: according to Law360, "[t]he most the [nuclear power] industry might reasonably expect would be renewed focus on the cost of existing and new regulations, in order to improve the operating plant cost structure."[445]

Going forward, given both the interest in and uncertainty surrounding U.S. Congressional and Executive Branch action in the electricity industry, the Board should stay up to speed on what Washington intends for regulators and transmission operators going forward.

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[438] H.R.8, Sec. 644.

[439] H.R.8, Sec. 647.

[440] H.R.8, Sec. 661.

[441] H.R.8, Sec. 662.

[442] H.R.8, Sec. 663.

[443] S.2012, Sec. 2303.

[444] H.R. 590: Advanced Nuclear Technology Development Act of 2017. January 24, 2017. Available at https://www.govtrack.us/congress/bills/115/hr590/text.

[445] David Repka and Tyson Smith, Winston & Strawn LLP. "The Trump Administration and Nuclear Energy." *Law360*. January 18, 2017. Available at https://www.law360.com/articles/882331/the-trump-administration-and-nuclear-energy.

VII. RTO Spot Markets and the Early Retirement of Existing Nuclear Generation

A. Introduction

In chapter 3 of our Report, we discuss the "changing resource mix" of the U.S. generation portfolio.[446] That changing resource mix includes significant new investment in natural gas-fired combined cycle resources and renewable generation resources, particularly wind and solar. Further, as we also explain in chapter 3, potential new investment in distributed energy resources is, while very much in its early stages, looking to compete with traditional investments in generation and transmission. In short, there is significant new entry and competition in the production of kilowatt hours.

In this chapter, we turn to the casualties of this changing resource mix: older, baseload generation, and in particular, nuclear generation. Such resources are "casualties" in many cases because they are retiring before the end of their useful lives or are considering doing so. The issue is succinctly summarized by attorneys Raymond Gifford and Matthew Larson who explain:

> Base load power from coal-fired and nuclear generation is exiting wholesale power markets, and no organized market is immune. Coal and nuclear base load power are exiting – or threatening to exit – ISO New England, NYISO, MISO, PJM, and ERCOT. The loss of base load generation raises serious concerns about the electric reliability and fuel diversity in at least some organized markets.[447]

Our focus in this chapter is on existing nuclear generation, since unlike coal or aging natural gas-fired generation, it provides emissions-free, baseload generation, which means that as it retires, the grid loses both a significant contributor to its emissions targets and reliability needs. This is critical since unlike gas-fired generation, new nuclear is not being built to any significant degree.

Most of these retirements involve existing nuclear generators without guaranteed, long-term cost recovery in the form of long-term power purchase agreements or cost-of-service recovery, but are instead participants in and reliant on wholesale power markets for their cost recovery. [448] This development has thus led to another manifestation of the useful and honest

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[446] *Supra*, 56.

[447] Raymond L. Gifford and Matthew S. Larson. "State Actions in Organized Markets." *Wilkinson, Barker, Knauer, LLP*. September 2016, 1. ("Gifford Paper")

[448] We note that in non-organized market areas, nuclear generation under long-term contracts could also be at risk. See, for example, Matthew Bandyk. "UBS analysts: Long-term contracted nuclear plants also at risk of shutdown." *S&P Global Market Intelligence*. June 24, 2016. The non-organized market areas are also experiencing new units coming online; according to the U.S. DOE, "Watts Bar 2 entered service in Tennessee in 2016, and four additional reactors are under construction in Georgia and South Carolina that are projected to enter commercial operation in the 2019-2020 timeframe." U.S. Department of Energy. "Quadrennial Energy Review: Transforming the Nation's Electricity System: The Second

debate about wholesale power markets themselves and whether the changing resource mix is evidence of the market working as it should, or of a market failure. On the one hand, markets should send price signals to generation resources to retire once they are unable to recover their going forward costs; on the other hand, one could argue that the markets are not working because they fail to send adequate long-term price signals to attract a reliable, diverse fleet of generation resources.

Regardless of the debate, many parties are taking action. Some states, for example – most notably Illinois and New York – are seeking to keep in-state, uneconomic nuclear generation online through state policies that address perceived wholesale market failures. FERC is also taking action, and it has initiated a proceeding that is considering implementing changes to the way prices are determined in wholesale power markets. The expected net effect of FERC's actions would lead to higher market prices that could help struggling existing generation remain economic. Meanwhile, a new generation of nuclear generator developers are at work on new, smaller, safer reactors that has attracted investors like Bill Gates and Peter Thiel and has been called the "key" to future nuclear power in the U.S. by researchers at the University of Chicago.

B. The Early Retirement of Existing U.S. Nuclear Generation

In its most recent Quadrennial Annual Review update, published on January 6, 2017, the U.S. DOE stated:

> Nuclear power currently provides 60 percent of U.S. zero-carbon electricity, but existing nuclear merchant plants are having difficulty competing in restructured electricity markets due to low natural gas prices and flat or declining electricity demand. Since 2013, 6 nuclear power reactors have shut down earlier than their licensed lifetime, and 10 others have announced plans to close in the next decade.[449]

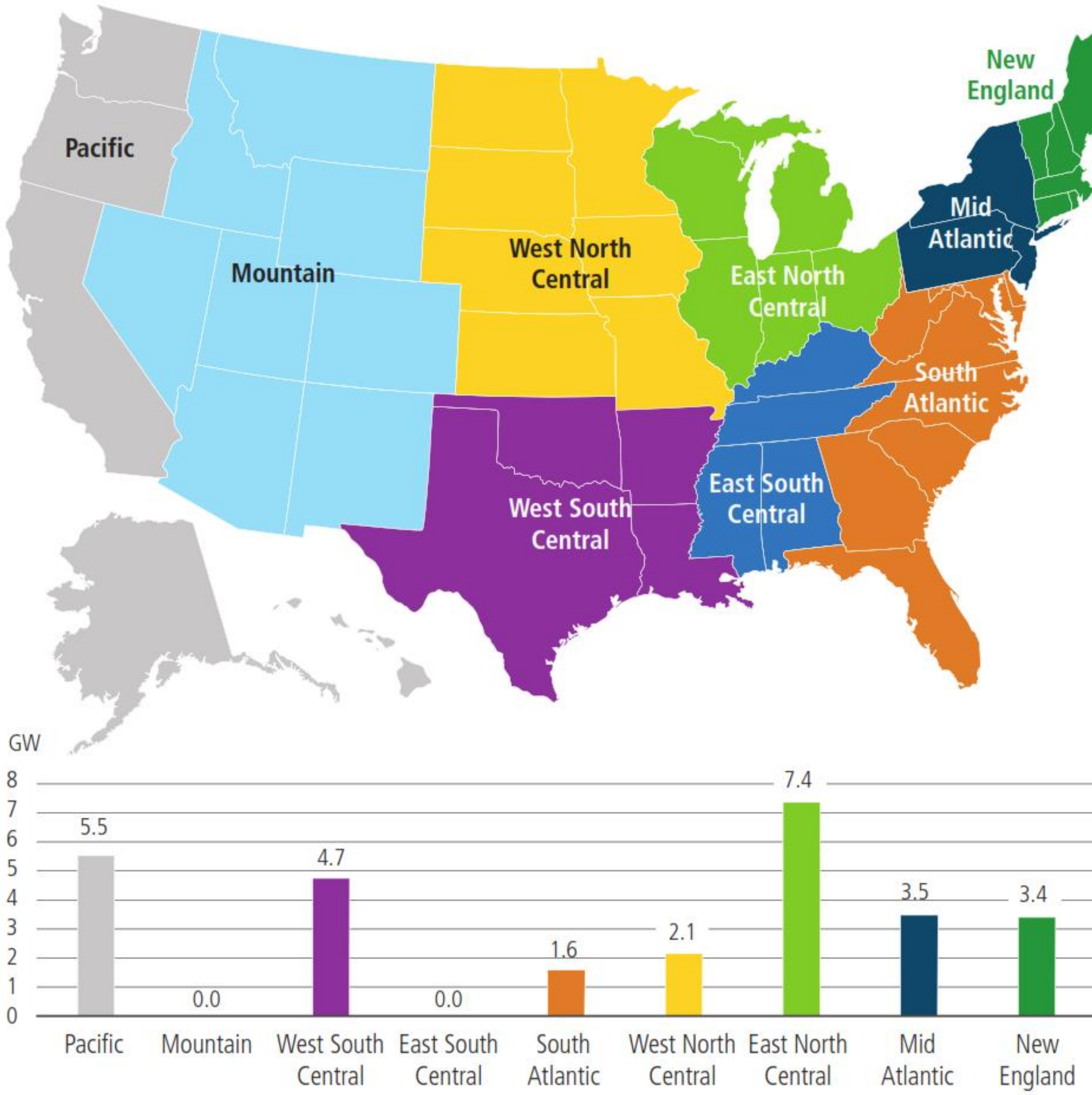
In all, the U.S. DOE estimates that 28 GW of U.S. nuclear capacity is either recently retired or at-risk of retirement by 2030, representing about 28 percent of total U.S. nuclear generation;[450] Figure 23 below shows DOE's estimates of such retirements, in GW, as broken down by region.

Installment of the QER." January 2017, 3-22. Available at https://www.energy.gov/epsa/downloads/quadrennial-energy-review-second-installment. ("2017 QER"),

[449] 2017 QER, S-10 (footnote omitted).

[450] 2017 QER, 3-19, 3-22.

Figure 23: Nuclear Units at Risk or Recently Retired by Region



Source: U.S. DOE Quadrennial Energy Review, Figure 3-11.

Figure 24 below shows further detail for a selection of nuclear facilities that have been recently retired, have recently announced retirements, or are considering retirement. Figure 24 is not meant to cover every nuclear generator in the U.S., but rather to demonstrate the scope, location, and size of the generators that have, or may soon, retire. Figure 24 shows that large nuclear generators across the U.S. – as large as 2,100 MW – are recently retired, are scheduled to retire, or are considering retirement.

Figure 24: Selected Retired, Scheduled-to-Retire, and Considering-Retirement U.S. Nuclear Facilities[451]

Facility	Owner	Location	Capacity (MW)	Retirement Date
Crystal River	Duke	Florida	860	2009
San Onofre 2	Southern California Edison	California	1,070	2012
San Onofre 3	Southern California Edison	California	1,080	2012
Kewaunee	Dominion	Wisconsin	556	2013
Vermont Yankee	Entergy	Vermont	615	2014
Fort Calhoun	Omaha Public Power District	Nebraska	500	2016
Clinton	Exelon	Illinois	1,078	2017
FitzPatrick	Entergy	New York	853	2017
Ginna	Exelon	New York	583	2017
Quad Cities 1	Exelon	Illinois	1,009	2018
Quad Cities 2	Exelon	Illinois	1,009	2018
Palisades	Entergy	Michigan	811	2018
Oyster Creek	Exelon	New Jersey	625	2019
Pilgrim	Entergy	Massachusetts	685	2019
Indian Point 2	Entergy	New York	1,031	2020
Indian Point 3	Entergy	New York	1,047	2021
Diablo Canyon 1	PG&E	California	1,122	2024
Diablo Canyon 2	PG&E	California	1,118	2025
Millstone	Dominion	Connecticut	2,100	Considering
Nine Mile Point	Exelon	New York	1,900	Considering

Source: Authors' compilation from public resources, particularly SNL Financial.

While not impacted as much as other RTOs, SPP has also seen a nuclear generator in its fleet recently retire early. On October 24, 2016, Omaha Public Power District ("OPPD") retired the Fort Calhoun Nuclear Generating Station;[452] according to the EIA, 29 percent of all kilowatt-hours generated in Nebraska in 2016 came from nuclear generation, and Fort Calhoun is one of two nuclear generators in the state.[453] OPPD explained that its leadership "decided it was in the best financial interests of the utility and its customer-owners" to retire the plant,[454] despite the fact that the facility's NRC-issued operating license was effective until 2033.[455] According to "extensive modeling conducted by a third party, Pace Global" the retirement of Fort Calhoun

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[451] Figure 24 makes no assumptions regarding the potential for, or impact of, legislation in states such as Illinois, New York, and others meant to help keep existing nuclear facilities online.

[452] "Fort Calhoun becomes fifth U.S. nuclear plant to retire in past five years." *Energy Information Administration*. October 31, 2016. Available at https://www.eia.gov/todayinenergy/detail.php?id=28572.

[453] Ibid. Figure titled "Electricity generation in Nebraska (January 2014 – August 2016)."

[454] "OPPD's Fort Calhoun Station, About the Plant." Omaha Public Power District. July 2016. Available at http://www.oppd.com/media/207570/about-the-plant.pdf.

[455] "Fort Calhoun Station." *U.S. Nuclear Regulatory Commission*. February 10, 2017. Available at https://www.nrc.gov/info-finder/reactors/fcs.html.

would "save the district between $735 million and $994 million over the next 20 years."[456] According to the OPPD Board of Directors, "market conditions," "[h]istorically low natural gas prices," "consumers…using less energy," "[s]low load growth," "increasing regulatory and operational costs," and "economies of scale"[457] were all factors in the decision to retire Fort Calhoun.[458]

With the retirement of Fort Calhoun, there are two[459] remaining nuclear generators in SPP's footprint: Cooper Nuclear Station and Wolf Creek. Cooper is a 771.5 MW facility in Nemeha, Nebraska owned by the Nebraska Public Power District.[460] Wolf Creek is a 1,205 MW facility in Coffey, Kansas, and is owned by Kansas Gas and Electric Company (47 percent), Kansas City Power and Light (47 percent), and Kansas Electric Power Cooperative (6 percent).[461] Cooper's NRC operating license expires in 2034, while Wolf Creek's expires in 2045; both generators receive regulated cost recovery.[462]

A 2016 report from Moody's stated that both Cooper and Wolf Creek "could face 'a similar fate'" as Fort Calhoun.[463] SNL Energy published an analysis – shown in Figure 25 below – which showed "that all three SPP nuclear plants produce electricity at a cost that is often higher than the hourly electricity price at the SPP North pricing hub."[464]

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[456] "OPPD Board Votes to Decommission Fort Calhoun Station." *Omaha Public Power District*. June 16, 2016. Available at http://www.oppd.com/news-resources/news-releases/2016/june/oppd-board-votes-to-decommission-fort-calhoun-station/. ("OPPD News Release")

[457] Fort Calhoun, with a capacity of 478 MW, was the smallest active nuclear power plant in the U.S. at the time of its retirement.

[458] OPPD News Release.

[459] A third nuclear generator – the 622 MW Duane Arnold Energy Center, in Linn, Iowa – also provides a small minority of its power to SPP, but it is located in MISO's footprint. While it is a merchant, unregulated facility that is majority-owned by NextEra, the Duane Arnold generator has the majority of its capacity under contract through a power purchase agreement that expires in 2025; its NRC license expires in February 2034. Source: *S&P Global Market Intelligence*.

[460] *S&P Global Market Intelligence*. According to the NPPD website, Cooper has a generating capacity of 791MW: http://www.nppd.com/about-us/power-plants-facilities/cooper-nuclear-station/.

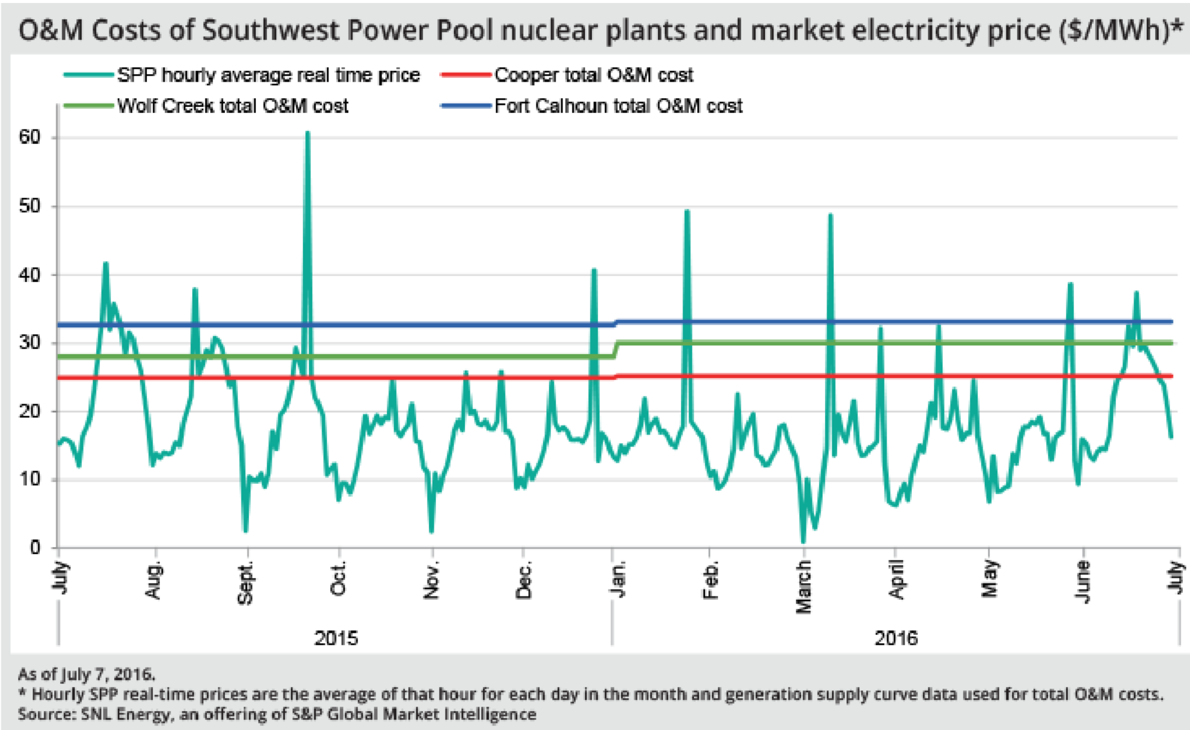
[461] *S&P Global Market Intelligence*.

[462] *S&P Global Market Intelligence.*

[463] Matthew Bandyk. "Nebraska nuclear plant under pressure, but utility sees it as long-term asset." *S&P Global Market Intelligence*. July 14, 2016. ("SNL Nuke Article")

[464] SNL Nuke Article.

Figure 25: SNL Energy's Analysis of SPP's Nuclear Units' O&M Cost versus SPP North LMP



Source: SNL Energy

Nevertheless, there are reasons to think that SPP's remaining nuclear generation – which provided 8.1 percent of SPP's total energy consumed in 2015, inclusive of Fort Calhoun[465] – will not retire early. First, both Cooper and Wolf Creek have lower O&M costs, according to SNL Energy's Figure 25 above. This is driven at least in part by economies of scale, as Fort Calhoun (478 MW) was the smallest active nuclear generator in the U.S. at the time of its retirement; Cooper (771.5 MW) and Wolf Creek (1,205 MW) are considerably larger. Second, according to S&P Global Market Intelligence, OPPD had a capacity surplus that did not require them to replace Fort Calhoun: "The plant generated 3.5 million MWh in 2015 and the district's energy needs are about 11 million MWh annually, compared to a total of 15.4 million MWh generated that year."[466] This implies that OPPD could absorb the loss of Fort Calhoun's firm capacity better than others. Third, Nebraska Public Power District's CEO – Pat Pope – stated that "[e]xisting nuclear…is going to be very valuable in the not-too-distant future."[467] He expects "a capacity-short environment" in SPP, meaning nuclear generation, like Cooper, "continues to be a good long-term strategy."[468]

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[465] "SPP Fast Facts." *Southwest Power Pool*. February 11, 2016. Available at https://www.spp.org/documents/28500/spp%20fast%20facts.pdf.

[466] SNL Nuke Article.

[467] SNL Nuke Article.

[468] SNL Nuke Article.

C. The "Problem" of Nuclear Generation Early Retirements

With over 28 percent of U.S. nuclear generation recently retired, retiring, or at risk of premature retirement, the potential negative implications may be obvious.

First, nuclear is a baseload capacity that has, since 1990, provided about 20 percent of generated electricity in the U.S. each year.[469] According to the U.S. DOE, "[n]uclear plants generally only shut down for maintenance activities, and forced outages are very rare."[470] Thus, significant nuclear retirements could have a negative impact on U.S. resource adequacy and reliability, more generally. We also note here that it is not just nuclear baseload that is retiring. Approximately 11 GW of natural gas-fired generation is scheduled to retire by 2026,[471] while retirement of coal-fired generation has been highly publicized, with over 14 GW retiring in 2015 alone.[472] These non-nuclear retirements could exacerbate any resource adequacy and reliability concerns.

Second, unlike other baseload capacity like natural gas and especially coal, nuclear generation has zero air pollution emissions. In fact, as noted above, nuclear generation currently provides 60 percent of the zero-emissions generation in the U.S.[473]

Third, reductions in nuclear capacity potentially reduce the diversity of the U.S. generation portfolio, particularly for baseload power. Developers are turning almost exclusively to natural gas-fired combined cycle generation to replace retiring baseload capacity. In fact, 100 GW of natural gas-fired combined cycle generation is under development, with about 60 GW of that total scheduled to come online by 2019.[474]

These potential negative implications suggest, perhaps, that the early retirement of nuclear generation is a bad thing, and may be worthy of special attention by legislators, regulators, and policymakers to consider preventative measures. Indeed, actions like these are occurring right now, as we further explain below. However, it may also be argued that these retirements are part of the natural course of generation investments. As plants age, uneconomic plants give way for new, more efficient generation to take their place. We discuss this topic in the next subsection.

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[469] "Nuclear Explained, U.S. Nuclear Industry." *U.S. Energy Information Administration*. September 2016. Available at http://www.eia.gov/energyexplained/index.cfm?page=nuclear_use.

[470] 2017 QER, 3-23.

[471] Aina Tan. "Aging steam turbines driving natural gas capacity retirements through 2026." *S&P Global Market Intelligence*. January 11, 2017.

[472] "Coal made up more than 80% of retired electricity generating capacity in 2015." *U.S. Energy Information Administration*. March 8, 2016. Available at https://www.eia.gov/todayinenergy/detail.php?id=25272.

[473] 2017 QER, S-10.

[474] Hira Fawad. "100 GW of natural gas combined-cycle capacity scheduled to be installed in US." *S&P Global Market Intelligence*. November 16, 2016.

D. The Causes of Nuclear Retirements, and Markets' Role

According to the U.S. DOE, the U.S. nuclear generating fleet totals about 99 GW, with 45 GW located in wholesale market regions, and 54 GW in regulated regions.[475]

In general, premature nuclear retirements in the RTO market regions are being driven by rising costs for nuclear generation and lower wholesale market prices. The so-called "quark spread" – the difference between the average wholesale monthly electricity price and the average annual nuclear fuel price – has been getting smaller,[476] leaving nuclear generation with thinner margins. This, when combined with nuclear generation's "large recurring fixed costs"[477] has made some units uneconomic.

The decreasing wholesale price of electricity has been well documented. For example, in FERC's most recent "State of the Markets" Report released in 2016, FERC noted that wholesale day-ahead energy prices were down 27 to 35 percent year-over-year across the U.S.[478] This, according to FERC, was "largely attributable" to large decreases in natural gas prices; FERC noted that prices fell year-over-year by 30 to 46 percent at the major U.S. trading hubs and reached their lowest levels in 20 years.[479]

To echo FERC's point regarding wholesale power market prices, others have noted that they are primarily driven by (a) the shale gas revolution,[480] (b) flat demand for electricity,[481] and (c) increased penetration of renewable generation, which is often subsidized and has zero operating cost, meaning it will operate when able.[482] The U.S. DOE notes:

> In states with restructured electricity markets, nuclear operators have found it to be increasingly difficult to compete under today's market conditions where electricity demand is flat or declining, natural gas prices and capital costs for new generation are low, wind and solar costs are declining, and state policies favor renewable generation.[483]

Regarding existing nuclear generation's large recurring fixed costs, the U.S. DOE explains that:

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[475] 2017 QER, 3-20.

[476] Matthew Bandyk. "Study: More nuclear plants vulnerable to forced retirement." *S&P Global Market Intelligence.* July 17, 2013.

[477] 2017 QER, 3-22.

[478] "State of the Markets Report 2015." *Federal Energy Regulatory Commission*. March 17, 2016, 18. ("FERC State of the Markets Report")

[479] FERC State of the Markets Report, 4, 18.

[480] 2017 QER, 5-20, 3-22.

[481] 2017 QER, 3-22.

[482] Alex Gilbert. "How solar growth will wreck the economics of existing power markets." *Energypost*. July 18, 2016. Available at http://energypost.eu/solar-growth-will-wreck-economics-existing-power-markets/. ("Energypost Article")

[483] 2017 QER, 3-22.

> Some of these costs are due to post-Fukushima requirements, but many are simply the costs of operation, such as security, salaries, etc. Several plants have also needed large capital expenditures; faced with these significant costs, plant operators/owners have chosen to shut them down. Since 2012, when 104 reactors were operating, six units totaling 4.7 GW have shut down earlier than their licensed lifetime. Two retirements, San Onofre and Crystal River, have been driven by mechanical failures that were deemed too costly to repair; the others were market decisions. As of December 2016, ten other units totaling 8.6 GW of capacity have announced plans to close in the next decade (though 6 of these units may not close because of recent state actions); 8 of those closures, with the exception of 2 units at Diablo Canyon, would occur prior to the expiration of the unit's existing licenses. Seven of the announced retirements, all those except Oyster Creek and Diablo Canyon, were attributed to market conditions.[484]

Given the tightened "quark spread," and the high recurring fixed costs, some existing nuclear units in wholesale markets have sought additional revenue to remain economically viable. In some markets, that additional revenue is available in organized capacity markets. However, some experts believe that capacity markets have been unable to keep baseload generation – including nuclear – online.[485] This can be related to the short-term nature of FERC capacity markets, which often offer no more than a one-year contract to supply resources. In any event, it may be that what is happening in the organized markets is not a failure at all, but exactly how the markets were intended to work. That is, aging nuclear (and other baseload generation), as it gets more expensive and must compete with newer resources, *should* be retired.

However, others have argued that the existing wholesale markets may not capture the full value of existing nuclear generation, including its high level of reliability and its contribution to baseload fuel diversity,[486] to say nothing of its zero-emissions profile. The Nuclear Energy Institute's recent paper on the Millstone nuclear facility in Connecticut argues that Millstone provides substantial benefits to Connecticut and New England, including clean electricity, reliability benefits, low-cost electricity, and various economic, tax, and employment benefits.[487] (Connecticut is said to be considering legislation that would allow the 2,100 MW Millstone facility to compete for a long-term power purchase agreement to provide zero-emissions, reliable power to the state in a move that would likely save the Dominion-owned resource from being retired.)[488]

The U.S. DOE, for its part, argues for the benefits of keeping existing nuclear generation operating. In its most recent QER, the U.S. DOE claimed that, assuming a social cost of carbon[489] of $41/metric ton, and assuming that the "at-risk" nuclear generators it identified were

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[484] 2017 QER, 3-22.

[485] See, for example, Gifford Paper, 2.

[486] See, for example, Gifford Paper, 2, 12.

[487] "Economic Impacts of the Millstone Power Station." *Nuclear Energy Institute*. January 2017, 3.

[488] Andrew Coffman Smith. "Conn. Lawmakers seek to rescue Millstone nuclear plant." *S&P Global Market Intelligence*. January 11, 2017.

[489] It should be noted that in a March 28, 2017 Executive Order, the White House disbanded the Interagency Working Group on

to be replaced by natural gas-fired generation, "keeping all but one of the nuclear units open would have higher benefits than costs."[490] The U.S. DOE concedes that "[t]he carbon intensity of the replacement generation for retiring nuclear plants is a key unknown," and that "if the replacement generation is less carbon intensive than natural gas, fewer plants would pass this cost-benefit test," while "[i]f the replacement generation is more carbon intensive, more plants would pass this cost-benefit test."[491]

Whichever it is, the fact remains that there is significant action going on around this issue today. As we explain in the next subsection, some states are directly intervening to prevent nuclear generation in their states from retiring, while FERC is looking into the way prices are formed, which could result in higher market prices and additional revenue opportunities for existing nuclear generation. And in the private sector, innovation could seek to bypass issues related to existing nuclear generation and instead drive a new era in nuclear generation.

E. How Some States, FERC – and the Private Sector – Are Responding

1. State Actions in Illinois, New York, and Elsewhere

In response to the pending retirements of nuclear generation in their states, some states are considering – or have already taken action – to prevent those retirements.

In Illinois, for example, new legislation (which was passed and signed into law in December 2016) will provide up to $235 million annually in support for otherwise-uneconomic nuclear generation in Illinois. That support would provide a "zero-emissions credit" – based on the U.S. EPA's "social cost of carbon" – meant to make up the difference between the wholesale market prices for energy and capacity and existing nuclear generation's costs. The zero-emissions credit will start at $16.50/MWh and are "based on assumed energy and capacity prices of $31.40/MWh."[492]

Another example comes from New York, where, in August 2016, the New York Public Service Commission approved a plan to pay otherwise-uneconomic nuclear plants "an initial two-year rate of $17.48/MWh, or $482 million annually, before increasing to a rate of $29.15/MWh, or almost $805 million annually in the final two years. The payments will be administered by the New York State Energy Research and Development Authority, which in turn will trade the associated credits to load-serving entities. The ZEC prices factor into the U.S.

Social Cost of Greenhouse Gases and withdrew documents that established a social cost of carbon as "no longer representative of governmental policy." Instead, the Executive Order directs use of 2003 guidelines from the Office of Management and Budget "when monetizing the value of changes in greenhouse gas emissions resulting from regulations…" *See* The White House. "Presidential Executive Order on Promoting Energy Independence and Economic Growth." March 28, 2017. Section 5.

[490] 2017 QER, 3-23.

[491] 2017 QER, 3-24.

[492] Andrew Coffman Smith. "Illinois passes bill to save Exelon nukes, boost efficiency and renewables." *S&P Global Market Intelligence*. December 2, 2016.

EPA's definition of the 'social cost of carbon' and are designed to decrease if wholesale electricity prices rise above $39/MWh."[493] The payments would continue through 2029.[494]

In addition to Illinois and New York, other states are beginning to consider steps to keep nuclear generation online. In Connecticut, as noted above, legislators are said to be "preparing to reintroduce legislation to save Dominion Resources Inc.'s Millstone nuclear plant from closure through a power purchase agreement."[495] In Michigan, in response to "unprecedented power plant retirements in the state and region," the Michigan Public Service Commission has directed all Michigan-regulated electric utilities to file a resource adequacy assessments for the coming five-year period by April 21, 2017.[496]

Many of these state efforts to support nuclear generation may look similar to other state actions taken in recent years to keep other baseload generating facilities online. Examples include (a) the 2012 baseload RFP in Maryland, (b) the 2011 Long-Term Capacity Agreement Pilot Program ("LCAPP") legislation and RFP New Jersey, and, more recently, (c) Ohio's approval of a plan that would provide eight-year revenue guarantees for seven coal-fired generators. And, because these state efforts impact wholesale electricity market prices, each has been legally challenged on jurisdictional grounds. The Maryland and New Jersey efforts have been voided after the *Maryland* decision, which we discuss in chapter 4, while the Ohio effort was voided by FERC.[497]

Like those other baseload efforts by states, the Illinois and New York efforts to keep nuclear generation online may face similar challenges; for example, the ZEC standard in New York has already been challenged at FERC,[498] while Illinois' legislation is the subject of a complaint in Illinois District Court.[499] Notably, in the Illinois complaint case, the plaintiffs reference the *Maryland* case as precedent for "invalidat[ing]" the Illinois program, and state that Illinois' program "is unlawful because it operates in the area of FERC's exclusive jurisdiction, and federal law thus field preempts it under the Supremacy Clause of the United States Constitution."[500]

2. FERC Initiatives on Price Formation in Organized Markets

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[493] Andrew Coffman Smith. "NY PSC approves nuclear subsidy to save at-risk plants, renewables standard." *S&P Global Market Intelligence*. August 1, 2016.

[494] Ibid.

[495] Smith. "Conn. Lawmakers seek to rescue Millstone nuclear plant."

[496] State of Michigan. "MPSC directs electric utilities to file assessments on meeting customer demand over the next five years." January 12, 2017. Available at http://www.michigan.gov/som/0,4669,7-192-47796-402137--,00.html.

[497] Gifford Article, 4-5.

[498] Federal Energy Regulatory Commission. *Independent Power Producers of New York, Inc. v. New York Independent System Operator, Inc.* Docket No. EL13-62-002.

[499] United States District Court for the Northern District of Illinois Eastern Division. *Electric Power Supply Association, et al., v. Anthony M. Star, et al.* Case No. 17-cv-01164. February 14, 2017.

[500] Ibid., paragraph 12.

At the federal level, FERC has initiated a comprehensive look at price formation in energy and ancillary services markets operated by RTOs and ISOs across the U.S.[501] In short, FERC launched its price formation efforts because, according to FERC, RTO markets are not "reflecting the marginal cost of production."[502] Specifically, FERC's actions could result in higher wholesale prices in RTOs, which could help existing nuclear generation.

FERC identified several areas of potential improvement in RTO pricing, including (a) decreased reliance on uplift payments, which according to FERC "can undermine the market's ability to send actionable price signals," (b) use of offer price mitigation and price caps that use inaccurate marginal cost data, which can result in "energy and ancillary services prices [that] may be artificially low," (c) scarcity and shortage pricing that may fail to "reflect the economic value of scarcity" of operating reserves, and (d) operator actions – such as out-of-market commitments and dispatches – that "may artificially suppress energy and ancillary service prices."[503]

Relatedly, FERC has opened two specific proceedings that could provide new, additional revenue support for existing nuclear generation. The first began with a Notice of Inquiry in February 2016, in which FERC sought comment on whether it should revise its regulations to address the provision of and compensation for frequency response services.[504] In its NOI, FERC noted that the U.S.'s "changing generation resource mix" – that is, increasing penetration of renewable resources and retirement of conventional baseload generation – may "adversely affect reliability" because of a reduction in frequency responsive generation online.[505] This NOI is instructive because it shows that FERC is paying attention to the issue of retiring baseload generation – including nuclear – and its impact on reliability; it also may result in new requirements and compensation mechanisms for resources that provide frequency response service.

The second proceeding is FERC's December 2016 Notice of Proposed Rulemaking regrading fast-start pricing in RTO markets.[506] In its NOPR, FERC proposes to incorporate the offers from fast-start resources – that is, resources that can start up within ten minutes or less, that have a run time of one hour or less, and that submitted an economic energy offer to the market – in RTOs' energy and ancillary services markets.[507] In general, fast-start resources are ineligible to set market prices in RTO markets; instead, such resources are typically dispatched

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501 Federal Energy Regulatory Commission. "Notice." Docket No. AD14-14-000. June 19, 2014. ("FERC Price Formation Notice")

502 FERC Price Formation Notice, 2.

503 FERC Price Formation Notice, 3.

504 Federal Energy Regulatory Commission. "Notice of Inquiry." Docket No. RM16-6-000. February 18, 2016. ("FERC Frequency Response NOI")

505 FERC Frequency Response NOI, paragraphs 11 to 13.

506 Federal Energy Regulatory Commission. Notice of Proposed Rulemaking. Docket No. RM17-3-000. December 15, 2016. ("FERC Fast-Start NOPR")

507 FERC Fast-Start NOPR, paragraph 1.

committed out-of-market, leading to uplift payments.[508] FERC's NOPR would require RTOs to reflect the offers of such fast-start resources in their prices, meaning higher prices – and thus, more support for existing nuclear generation.

3. Private Sector Innovation: New, Smaller, Safer Nuclear

While this chapter has focused on *existing* nuclear generation and the efforts underway to keep that fleet operating, there is a "new breed" of nuclear reactors at various stages of design and development that could be the next generation of nuclear generators in the U.S. And this new breed of reactor looks much different than the existing U.S. nuclear generation fleet.

One such type of reactor is a Small Modular Reactor, or SMR, which is a topic we have covered in past Looking Forward Reports.[509] SMRs are one-tenth the size of traditional nuclear units and require less capital investment. They are also scalable and safer because they use "passive" safety systems, meaning they are not dependent on external electrical power during plant shutdowns and thus do not require backup station power.[510] Experts have long recognized the potential of SMRs; for example, in a paper published in November 2011, authors from the University of Chicago suggested that SMRs are the key to future nuclear power generation in the U.S.[511] The authors stated that "a robust U.S. commercial SMR industry is highly advantageous to many sectors in the United States" and would "strengthen U.S. leadership in a post-Fukushima world, on matters of nuclear safety, nuclear security, nonproliferation, and nuclear waste management."[512]

While no such SMRs have been built to date, on December 31, 2016, NuScale Power submitted to the Nuclear Regulatory Commission its design certification application – the first such application to be filed with the federal nuclear regulatory agency.[513] The NuScale SMR is designed to produce 50 MW of electricity, and a NuScale power plant can house up to twelve of the SMRs, meaning a total plant capacity of 600 MW.[514] Each 50 MW SMR module is estimated to take 36 months to construct (with parts built in a factory and shipped by train or barge), and a SMR power plant's capacity can be increased in stages to meet growing demand. This modular aspect of construction also can help break down the capital investment needed into smaller chunks than would be required for a conventional nuclear generator, and allows for earlier cost recovery as each new module is placed into service.[515]

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[508] FERC Fast-Start NOPR, paragraphs 2 to 3.

[509] See, for example, 2013 Looking Forward Report, 59 to 61; 20144 Looking Forward Report, 98 to 101.

[510] Ibid.

[511] Robert Rosner, et al. "Small Modular Reactors – Key to Future Nuclear Power Generation in the U.S." *University of Chicago Energy Policy Institute at Chicago*, November 2011. Available at https://energy.gov/sites/prod/files/2015/12/f27/ECON-SMRKeytoNuclearPowerDec2011.pdf. ("Chicago Paper")

[512] Chicago Paper, 43.

[513] "NuScale makes history with SMR design application." *World Nuclear News*. January 13, 2017. Available at http://www.world-nuclear-news.org/NN-NuScale-makes-history-with-SMR-design-application-13011701.html.

[514] Ibid.

[515] Ibid.

Regarding safety, NuScale claims that in its design, the reactor can, under abnormal conditions, shut itself down and cool itself without any human intervention, water addition, or external power supplies.[516] In fact, the claim is that the reactor *cannot* melt down, due to its small size.[517] Moreover, these safety features of SMRs mean avoidance of safety expenditures faced by traditional nuclear generation, such steel and concrete needed to guard against accidents.[518]

The NRC will take up to 40 months to review NuScale's application before it issues a design certification, which, if issued, would allow NuScale to construct and operate its SMR design.[519]

Another example of SMR development comes from the Tennessee Valley Authority, which, earlier in 2016 submitted an "early site permit application" with the NRC for potential future SMRs at its Clinch River Site in eastern Tennessee.[520] The NRC accepted and docketed the application in January 2017, and can now begin its technical review.[521] While according to TVA, "there are several evaluations and business decisions that remain before the utility would commit to building SMRs," and that such a commitment is "years away,"[522] TVA's application is noteworthy as it represents the first early site permit application exclusively for SMRs, and is at a location – the Clinch River Site – which has advantageous site characteristics, such as access to transmission lines and a water source.[523]

In terms of SMR technology, the NuScale SMR design uses the existing fleet's technology choice of pressurized water reactor modules to moderate nuclear reactions, and TVA is said to be considering four potential SMR designs, each of which uses a type of pressurized water reactor;[524] however, there is another private innovation design underway that uses molten-

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516 Ibid.

517 James Conca. "NuScale First to Submit SMR Nuclear Application to NRC." *Forbes*. January 15, 2017. Available at https://www.forbes.com/forbes/welcome/?toURL=https://www.forbes.com/sites/jamesconca/2017/01/15/nuscale-first-to-submit-smr-nuclear-application-to-nrc/&refURL=https://www.google.co.kr/&referrer=https://www.google.co.kr/. ("Conca Article"). On March 15, 2017, the NRC officially provided NuScale with receipt of its application, indicating it will be under review. Fluor. "Fluor's NuScale Power Small Modular Nuclear Reactor Design Certification Accepted for Review by U.S. Nuclear Regulatory Commission." March 15, 2017. Available at http://newsroom.fluor.com/press-release/fluor/fluors-nuscale-power-small-modular-nuclear-reactor-design-certification-accepted.

518 Kevin Bullis. "Safer Nuclear Power, at Half the Price." *MIT Technology Review*. March 12, 2013. Available at https://www.technologyreview.com/s/512321/safer-nuclear-power-at-half-the-price/amp/.

519 Ibid.

520 Nuclear Energy Institute. "TVA Files Historic Application for Small Modular Reactors." May 17, 2016. Available at https://www.nei.org/News-Media/News/News-Archives/TVA-Files-Historic-Application-for-Small-Modular-R.

521 Tennessee Valley Authority. "TVA Clears Next Hurdle for Small Modular Reactors." January 13, 2017. Available at https://www.tva.com/Energy/Technology-Innovation/TVA-Clears-Next-Hurdle-for-Small-Modular-Reactors.

522 Ibid.

523 AECOM, on behalf of the Tennessee Valley Authority. "Small Modular Reactor Final Siting Study Revision 1." June 2016. Page 1-2. Available at: https://www.nrc.gov/docs/ML1618/ML16188A075.pdf.

524 Barry Cassell. "Four Nuclear Designs Being Evaluated for TVA's Clinch River Project in Tennessee." *Power Engineering*. June 22, 2016. Available at: http://www.power-eng.com/articles/2016/06/four-nuclear-designs-being-evaluated-for-tva-s-

salt reactors. The advantage of molten salt reactors is that they "operate under normal atmospheric pressure."[525] This means less chance of explosions in the event of an accident and no need for costly containment vessels to be built around the pressurized water reactors.[526]

Regardless of their design, SMRs also offer the potential for another benefit in the modern resource mix: the ability to efficiently load-follow. In a recent paper titled "Can Nuclear Power and Renewables be Friends?," authors from NuScale and other organizations suggest that SMRs are "more readily adaptable to integration with inherently variable generating resources such as wind."[527] The authors suggest that increasing renewables penetration has "dramatically changed the economics and realities of grid management in ways that now encourage some level of load-following capabilities of historically baseload plants," and that the SMR "is well suited for integration with renewables."[528] Others have claimed that SMRs "are better than natural gas to load-follow the intermittency of wind and solar because SMRs have no emissions and use a million times less fuel to produce the same amount of power as a gas or a coal plant."[529]

Nuclear innovation is also receiving attention and investment from high-profile individuals. Bill Gates' TerraPower has developed a "traveling wave reactor," which, according to TerraPower, "simplifies the necessary nuclear energy infrastructure, reducing overall costs and enabling a safe, secure form of nuclear energy."[530] The traveling wave reactor uses depleted uranium as its primary fuel, meaning the need to store and dispose of nuclear waste is greatly reduced.[531]

Venture capitalist Peter Thiel has also invested and supported nuclear innovation. Thiel famously wrote in a New York Times op-ed that nuclear technology has been "frozen in time" and that had the U.S. not stopped building nuclear generators after the Three Mile Island accident in 1979, "our power grid could have been carbon-free years ago."[532] Thiel invested in Helion Energy, which is working on developing a way to generate electricity through nuclear fusion rather than the existing commercial process that uses nuclear *fission*. According to Bloomberg:

> Helion hopes to make a fusion generator that's 1,000 times smaller, 500 times cheaper, and 10 times faster than more conventional, massive projects, according to its website. The company is building a "magneto-inertial fusion" generator. It produces power by

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clinch-river-project-in-tennessee.html.

[525] Jonathan Tirone. "Smaller, Safer, Saltier: Next-Gen Nuclear Draws Thiel and UN." *Bloomberg*. December 6, 2016. Available at https://www.bloomberg.com/news/articles/2016-12-07/smaller-safer-saltier-next-gen-nuclear-draws-thiel-and-the-un

[526] Ibid.

[527] D.T. Ingersoll, et al. "Can Nuclear Power and Renewables be Friends?." *Proceedings of ICAPP 2015*. May 3-6, 2015. Available at http://www.nuscalepower.com/images/our_technology/nuscale-integration-with-renewables_icapp15.pdf. ("Ingersoll Paper")

[528] Ibid, 1.

[529] Conca Article.

[530] "Ideas to Change the World." *TerraPower*. Available at http://terrapower.com/pages/benefits.

[531] "Addressing Nuclear Energy's Challenges." *TerraPower*. Available at http://terrapower.com/pages/design.

[532] Peter Thiel. "The New Atomic Age We Need." *New York Times*. November 27, 2015. ("Thiel Op-Ed")

injecting heated hydrogen and helium at high speed (a million miles an hour) into a "burn chamber," where a strong magnetic field compresses the plasma to a temperature high enough to initiate fusion. Energy from the reaction is used to generate electricity.[533]

Thiel was a member of President-Elect Trump's transition team[534] and (in 2015) called on the office of the president to "clear the path for a new atomic age;"[535] and it has been reported that Trump's transition team was looking for ways to support nuclear generation.[536]

Going forward, some caution is needed in considering the future of SMRs. First, all SMR designs will be subject to first-of-a-kind technology risk. This risk means that until demonstrated on a commercial scale, these investments may not work as designed, or may cost substantially more than originally estimated. Second, the NRC review process of SMRs is also uncertain. NuScale's pending SMR application is the first SMR application ever submitted and reviewed by the NRC. Third, the timing of any new investment in SMRs is not expected to be in the near term; for example, NuScale's target commercial operation date is 2026, and the NRC review process of NuScale's 12,000 page application[537] could take significant time. According to Bill Dean, director of the NRC's Office of Nuclear Reactor Regulation, the NRC spent "more than 200,000 hours" reviewing the application and conducting safety reviews of the most recently issued nuclear operating license applicant, for TVA's Watts Bar Unit 2; that application was filed in March 2009 and received approval in October 2015.[538]

F. Conclusion

For the Board, the implications of this chapter could be many. First, any rulemakings by FERC that change the way wholesale market prices are calculated will likely have a direct impact on SPP's markets. Second, as more states consider special action to "save" existing nuclear (and other baseload) generation, there will likely be additional litigation and decisions regarding the jurisdictional limitations of state governments. Third, while SPP is less exposed to the threat of the shutdown of existing baseload generation, it is not immune, especially as existing power purchase agreements with SPP resources expire over time. Fourth, and longer-term, the Board should also be aware of the development of SMRs because they may represent

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533 Eric Roston. "Peter Thiel's Other Hobby is Nuclear Fusion." *Bloomberg*. November 22, 2016.

534 Tony Romm. "Thiel could gain from Trump transition." *Politico*. December 6, 2016. Available at http://www.politico.com/story/2016/12/peter-thiel-trump-transition-benefits-232233.

535 Thiel Op-Ed.

536 Mark Chediak and Catherine Traywick. "Trump Team's Asking for Ways to Keep Nuclear Power Alive." *Bloomberg*. December 8, 2016. Available at https://www.bloomberg.com/news/articles/2016-12-09/trump-s-team-is-asking-for-ways-u-s-can-keep-nuclear-alive.

537 "NuScale Submits First Ever Small Modular Reactor Design Certification Application (DCA)." *NuScale Power*. January 12, 2017. Available at http://newsroom.nuscalepower.com/press-release/company/nuscale-submits-first-ever-small-modular-reactor-design-certification-applicat.

538 U.S. Nuclear Regulatory Commission. "NRC Issues License for Watts Bar Unit 2, Oversight Continues." October 22, 2015. Available at https://www.nrc.gov/docs/ML1529/ML15295A145.pdf.

the future of nuclear generation and zero-emissions reliable generation in the U.S., even if they are years away from being realized.