



# CLEAN ENERGY INNOVATION & DEEP DECARBONIZATION IN A TIME OF POLITICAL & TECHNOLOGICAL CHANGE

Roger Ballentine & Jim Connaughton, Co-Chairs

Dave Grossman, Rapporteur

---

For all inquiries, please contact:

Energy & Environment Program  
The Aspen Institute  
2300 N Street, NW | Suite 700  
Washington, DC 20037  
Phone: 202.736.2933  
Fax: 202.467.0790

Copyright © 2018 by The Aspen Institute

The Aspen Institute  
2300 N Street, NW | Suite 700  
Washington, DC 20037

Published in the United States of America in 2018 by The Aspen Institute

All rights reserved

# CLEAN ENERGY INNOVATION & DEEP DECARBONIZATION IN A TIME OF POLITICAL & TECHNOLOGICAL CHANGE

Roger Ballentine & Jim Connaughton, Co-Chairs

Dave Grossman, Rapporteur



**The Aspen Institute** is an educational and policy studies organization based in Washington, D.C. Its mission is to foster leadership based on enduring values and to provide a nonpartisan venue for dealing with critical issues. The Institute has campuses in Aspen, Colorado, and on the Wye River on Maryland's Eastern Shore. It also maintains offices in New York City and has an international network of partners.

*[www.aspeninstitute.org](http://www.aspeninstitute.org)*

**The Aspen Institute Energy and Environment Program** challenges thought leaders to test and shape energy and environmental policies, governance systems, and institutions that support the wellbeing of both nature and society. The Program's forums and dialogues are designed to cultivate trust and leadership, and develop collective solutions based on the ideal that both humankind and the natural world have intrinsic value. Like the Aspen Institute as a whole, EEP seeks to inspire and explore new ideas that provoke action in the world.

# TABLE OF CONTENTS

CO-CHAIRS' FOREWORD.....	v
EXECUTIVE SUMMARY .....	1
RUNNING THE NUMBERS ON CLEAN ENERGY TRENDS .....	5
CURRENT POLITICS & POLICIES ON CLEAN ENERGY & CLIMATE CHANGE.....	7
RETAIL MARKETS IN TRANSITION .....	14
WHOLESALE MARKETS IN TRANSITION.....	20
RELIABILITY, RESILIENCY, AND SECURITY.....	24
DEEP DECARBONIZATION.....	30
APPENDICES	
PARTICIPANT LIST.....	37
AGENDA .....	39
SPONSORS.....	42



# CO-CHAIRS' FOREWORD

At the dawn of the internet, no one saw Facebook coming, and certainly no one submitted a resource development and deployment plan that pledged “Facebook by 2010”. With relatively few regulatory constraints and with no incumbent economic or physical legacy systems to overcome, innovation occurred in a non-linear fashion. While we certainly recognize the limits of this analogy, The Aspen Institute Clean Energy Innovation Forum continues to be the place where the tough questions are asked about how we can more fully empower innovation to modernize our energy system. Our mantra in exploring the potential for an energy system that is cleaner, smarter, and better is to eschew the mindset of “no, because” in favor of “yes, if”.

Innovation in the face of the constraints posed by our legacy energy system is our ongoing theme. We don't come up with all the answers, but we seek to ask all the tough questions. And again in 2018, we convened some of the brightest minds and most influential players to engage in the discussion.

Questions we explored included: Can we really do “long-term planning” in the electricity sector in an age of rapid innovation and low to zero marginal cost electricity? What are the regulatory and business model impediments to innovation? Is the road to “deep decarbonization” just a long trip on the same road that leads first to “shallow” decarbonization — or do we need to make hard choices now? Are utilities really an obstacle or do we just need to rethink how to better allow them to innovate? What functions really should be assigned to monopolies? Is it realistic to expect utilities to replace their capital investments with third party services? Is there necessarily a conflict between core obligations under the social compact and innovation? Should the traditional permission-based regulatory model of FERC/utility commissions be replaced (or joined with) more of a Federal Trade Commission-type regulatory model whereby consumer protections/climate protections are the sideboards within which industry innovates and competes? By what metrics do we plan the electricity system in the age of innovation? Do we “plan” for — or even mandate — low carbon outcomes and let energy transitions, innovation and financing develop in service of that end? Do important concerns about reliability, resiliency and cybersecurity cut against some otherwise attractive innovation pathways? And so forth.

As can be seen in this report of our 2018 Forum, we dove deep into these issues. We sought to look around the corner to identify change already baked into the system and to contemplate changes that can be made today to get to a better future.

Few discussions on virtually any aspect of the economy today avoid Blockchain; we were no different. Some have gone as far to say that Blockchain could pose an existential threat to the regulated utility model. We came to no conclusion, but transactive energy markets at the end-user level do seem to have the potential for efficiencies and great optionality for customers and almost certainly could benefit clean energy access.

We thank all those who provided the great input we received and look forward to continuing the discussion.

**Roger Ballentine**  
**Jim Connaughton**



# EXECUTIVE SUMMARY

Despite significant uncertainty about the direction of policy and regulation, the trends for clean energy are remarkably clear. Since 2008, renewable power generation in the United States (including hydropower) has doubled, from 9% to 18%, nuclear has maintained its share of U.S. power generation at 20%, and coal's share has shrunk from 48% to 30%. Over the past decade, energy efficiency improvements have led to the effective decoupling of U.S. economic growth from primary energy consumption, with GDP rising and energy consumption falling. In addition, lithium-ion battery prices have plummeted and are expected to keep declining, which is leading to increased deployment of battery storage and plans in several countries to ramp up deployment of electric vehicles. In terms of greenhouse gas emissions, U.S. power sector emissions have decreased, bringing down overall U.S. emissions, though the country is still far from its Paris Agreement commitment trajectory – and far from being on track to achieve a 2°C trajectory.

Political and policy changes will continue to affect the deployment of energy technologies and the achievement of climate objectives. At the federal level, the Trump Administration has worked to repeal the Clean Power Plan, leave the Paris Agreement, and roll back a sweeping range of regulations, in addition to imposing trade tariffs that threaten to reduce growth in U.S. solar deployment. The Department of Energy also proposed that the Federal Energy Regulatory Commission (FERC) issue a ruling to support coal and nuclear plants – a proposal that FERC rejected, although it opened a new debate about grid reliability.

In Congress, the new tax reform legislation has clouded the future of financing for clean technologies, particularly those reliant on tax equity, but has also put hundreds of billions of dollars of equity back on corporate balance sheets that could theoretically be deployed to replace outdated infrastructure and install more efficient technologies. Furthermore, the February 2018 budget deal increased the caps for discretionary domestic spending, which led to more federal money going into clean energy R&D. This budget deal also extended and expanded a range of important tax credits, including the 45J tax credit for nuclear and the 45Q tax credit for carbon capture and storage (CCS). In particular, the expanded 45Q credit should be large enough to get CCS projects going, help make the technology ubiquitous and cheaper, move significant capital into the space, and create a gigatons-scale sequestration opportunity over the next couple of decades.

At the state level, governors and legislators of both parties are increasingly exploring how to build out clean energy economies and attract growth markets, startups, and capital to their states. Several renewable portfolio standards will be coming up for renewal over the next couple of years in a mix of red and blue states, and there will be battles over increasing their ambition and/or expanding the scope of included technologies. States are also pursuing a range of interesting carbon policy efforts, particularly on the West Coast. Beyond government, the private sector has been a driving force on these issues, both in terms of renewables procurement and making operational changes to account for climate risks.

Changing policies and behind-the-meter technologies have led to significant debates about appropriate business models, regulatory structures, and jurisdictional boundaries in retail electricity markets. Regulators can either lead or respond to

**The future is in many ways about how the power of incumbency and the desire for innovation intersect with each other and with regulations.**

market developments, and innovation can favor either incumbents or insurgents – and the future is in many ways about how the power of incumbency and the desire for innovation intersect with each other and with regulations. As clean energy continues to grow on the distribution side, questions are surfacing about what stays a utility function and what gets carved away. It is less clear today where the monopoly should stop and competition should start. Utilities need to continue providing reliable service for low-income consumers and serve as a backstop for those generating

their own power, while at the same time embracing and enabling the future by making the distribution system more flexible and rethinking their business models. One of the major drivers of activity and disruption at the grid edge could be blockchain, which could eventually enable a peer-to-peer, transactive energy market platform and let grids balance from the bottom up – which, in turn, would require a very different model of regulation and role for regulators.

In wholesale electricity markets, meanwhile, prices have been declining in real terms, and some wholesale market operators have been struggling to address tensions created by state policies that favor clean energy sources in the generation resource mix. While things seemed to operate relatively smoothly with state policies to support renewables, new state policies to support nuclear power have highlighted the issue of whether providing out-of-market revenues to resources is distorting the market or just paying for a preferred attribute as expressed by a state policy. These state policies generally affect capacity markets, even though many clean generation sources get most of their revenues from energy markets – which has led some to argue for shifting the conversation away from capacity and toward energy markets. As a range of energy debates swirl, FERC has come down repeatedly on the side of markets – trying to help

markets handle the different attributes that the growing deployments of renewables provide, trying to figure out how best to promote grid reliability and resilience, and trying to enable planning to address the growing incorporation of distributed energy resources (DERs) on the grid. As in the retail markets, blockchain, transactive DERs, and other innovations could disrupt wholesale markets as well by creating the potential to dispatch load, storage, and generation all from the customer upward into the grid. Figuring out how to meld the conventional wholesale markets reliant on big generators with highly distributed behind-the-meter generation in a way that works will require robust planning and supportive political action.

At FERC and beyond, discussions around reliability, resiliency, and security are getting a lot of attention and bipartisan interest. Some would argue that a modernized grid with robust deployment of DERs that are interconnected but can also be islanded would be more reliable and more resilient – a mesh network instead of a radial/linear system. In addition to enhancing resilience by designing a smarter and more distributed grid, there is also a great deal of focus in the industry on hardening the grid against potential disruptions, though there is a need for a balance between hardening and smartening. Utility planning and investments also need to better factor in both the acute and chronic impacts of climate change, as these assets will last decades. Furthermore, security is becoming another aspect of resilience, with cybersecurity of both critical infrastructure and the smart devices on the edge of the grid growing in importance. While there have been pockets of progress, and many actors have important roles to play, jurisdictional questions about who is and who ought to be in charge of cybersecurity are slowing action. There is also risk that grid vulnerabilities could steer the adoption of innovations in ways that favor incumbents and attempt to maintain the status quo.

**Blockchain could eventually enable a peer-to-peer, transactive energy market platform and let grids balance from the bottom up.**

The proliferation of clean energy technologies has contributed to shallow decarbonization, but achieving deep decarbonization is much more difficult. The climate math is daunting, and the world is far, far off-track for limiting warming to 2°C. Most deep decarbonization studies suggest the need to optimize energy efficiency, decarbonize the electricity supply, electrify as many end-uses as possible, use zero-carbon fuels for the rest, and capture and sequester the residual carbon. There has been progress in energy efficiency, and tremendous potential remains, especially from integrative design options generally left out of decarbonization studies and forecasts because they are not new technologies. At the same time, zero-carbon generation's share of electricity is growing as renewable energy's costs continue to plummet. If electricity providers can decarbonize their electricity, then electrifying residential and industrial heating, transportation, refining, manufacturing, and other adjacent markets

both decarbonizes and creates increased demand for clean electricity. Decarbonized electricity could likewise spur the manufacturing of zero-carbon fuels. Given that it is very hard to scrub carbon out of some sectors, most deep decarbonization models show a need for both CCS and carbon removal as well. Large scale carbon

**The climate math is daunting, and the world is far, far off-track for limiting warming to 2°C.**

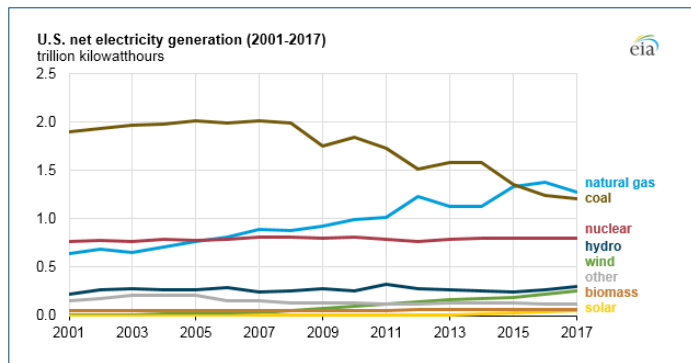
management will require carbon removal through engineered approaches (e.g., direct air capture), turning carbon into products of value (e.g., cement, chemicals, fuels, carbon fibers), commercial CCS deployment (e.g., for industrial processes), and natural carbon uptake (e.g., by forests and soils). Policies and procurement at the federal and state levels can help

create markets and improve the economics for these carbon management technologies. More broadly, government policies need to treat climate change with the urgency it requires, keep as many options as possible on the table in light of the uncertainties about what the energy future will be, and support R&D and innovation in this space.

# RUNNING THE NUMBERS ON CLEAN ENERGY TRENDS

There have been some promising trends in clean energy over the past decade. For instance, improved energy efficiency is one of the main reasons that U.S. GDP has effectively decoupled from primary energy consumption, with GDP rising 15% over the past 10 years while primary energy consumption has fallen about 2%. Energy demand, in fact, is flat or declining in almost all OECD countries. Not all sectors are the same, however. In the U.S. power sector, primary energy consumption has dropped even more – 7% – over the past decade, and utilities are seeing flat or dropping demand for electricity in all but a few sectors and places (e.g., datacenters, the potential for more electrified agriculture). Primary energy consumption in the residential sector has dropped 16%. Primary energy consumption in the transportation sector, on the other hand, has risen 2%, due to cheap gasoline and recent increases in vehicle-miles traveled.

The U.S. electricity sector experienced significant change over the past decade. In 2008, about a third of U.S. electricity generation came from renewables and natural gas and about half came from coal. Those ratios reversed by



2017, with about half from renewables and natural gas and a third from coal, and that trajectory is not expected to change. This year will be the second-largest year for coal plant retirements, as 12 gigawatts (GW) of retirements have already been announced for 2018, primarily because coal plants have not been able to compete with natural gas (and in part, because of competition from renewables). At the same time, the rise of renewables is ongoing. Wind has enjoyed tremendous growth, and solar installations are growing, yet system costs are not increasing. In ERCOT, for

example, regulation costs – the costs of ensuring grid reliability – dropped despite increasing wind capacity, due to shifts in market design, geographic dispersion of resources, more granularity in markets (through better technology and forecasting), and other factors.

Increases in clean energy deployments and reductions in cost are not limited to wind and solar. Lithium-ion battery prices, for instance, have declined about 80% since 2010 to about \$200 per kilowatt-hour (kWh) and are expected to keep declining to an implied price of around \$70/kWh by 2030. Partly as a result, several countries are looking to seriously ramp up their deployment of electric vehicles (EVs), which is projected to flatten out an otherwise declining demand curve in some countries in the post-2025 (or post-2030) period.

In terms of greenhouse gases, power sector emissions have plunged, bringing down overall U.S. emissions. The United States is already very close to meeting the national goal laid out in the Clean Power Plan (CPP); the CPP was projected to get the nation's power sector to 32% below 2005 levels by 2030, and the sector is already at about 28% below 2005 levels. In some ways, current and future debates surrounding the fate of the CPP are a bit immaterial. On the other hand, the CPP's oft-reported national goal was really an aggregation of specific state goals, and lagging states may continue to lag if the CPP is successfully repealed by the Trump Administration. Either way, economy-wide, the United States is still a long way from meeting the Paris Agreement commitment laid out by the Obama Administration, due in no small part to the transportation sector, which is now the largest contributor to U.S. emissions. The United States as a whole is about 13% below 2005 levels, and the commitment (which has been disavowed by the Trump Administration) was to achieve a reduction of about 26% by 2025.

# CURRENT POLITICS & POLICIES ON CLEAN ENERGY & CLIMATE CHANGE

This is a critical time nationally on energy, as both the private and public sectors have been very active in the clean energy space, with many opportunities for important decision making to come.

## FEDERAL POLICY

At the federal level, 2017 was a year of change for policies related to energy, with the Trump Administration and the Republican Congress focused on rolling back many Obama-era regulations. The Trump Administration began the repeal of the Clean Power Plan and announced its intent to leave the Paris Agreement; while walking away from the CPP could impact particular states, it probably will not have much impact on the overall trajectory of clean energy deployment in the country in the short term. There have also been rollbacks or attempted rollbacks of rules on hydraulic fracturing, stream protection, sage grouse protection, and more. In addition, the Department of Energy proposed that the Federal Energy Regulatory Commission (FERC) issue a ruling to support “secure fuel” technologies (i.e., coal and nuclear plants with 90 days of on-site fuel); while FERC rejected that proposal, debates about grid reliability are now front and center, and the course that FERC’s exploration of reliability takes could certainly affect clean energy (positively or negatively).

At the end of 2017, Congress passed tax reform legislation, which could have wide-ranging impacts on clean energy, though many of the implications of the legislation are still being sorted out. On the potentially negative side, the tax reform legislation clouded the future of financing for clean technologies, particularly those reliant on tax equity. Renewables developers have tried a range of things to reduce the cost of capital for clean energy (e.g., securitization, secondary markets, yieldcos), but in the end it comes down to debt, tax equity, and sponsor equity; whatever is not covered by the first two has to be invested by the sponsor of the project. The tax law had a major effect on the availability and price of tax equity in the United States. Many people think the supply of tax equity is about the same as it was, and the large players are indeed still in the market, but tax equity is in a bit of a pause right now.

Everyone in solar is working on value engineering, looking for higher-efficiency solar modules and better ways of integrating the various components.

Large companies cannot make tax equity decisions at this point without consulting with their big accounting firms. With the corporate tax rate going down and 100% depreciation, the accounting is complicated, and the likely outcome is that project sponsors will have to come up with 3-5% more capital, which is a lot of extra money. Similarly, the flow of low-cost, long-duration capital coming from Europe, Asia, the Middle East, and elsewhere is now waiting as well, as investors around the world are talking about political risk in the United States in what is typically seen as a safe part of a diversified portfolio.

On the potentially positive side, the tax reform package means that hundreds of billions of dollars of equity will be back on corporate balance sheets, which will go either to share buybacks, dividends, or

redeployed investments. Redeployed investments can be used to replace outdated infrastructure, and share buybacks could likewise improve the value of companies, lower the cost of capital, and let companies redeploy more capital. The tax reform also allows for immediate expensing of 100% of capital expenditures, which could similarly have a positive impact on asset turnover and the deployment of more efficient technologies (though it reduces the effectiveness of tax equity). The potential dollar amounts of redeployed capital are huge. The question is who will be deploying that capital and for what purposes; if it is deployed in the right way, the clean energy and environmental equation could be quite positive.

The federal policy changes have continued into 2018. Early in the year, the Trump Administration imposed ad valorem solar trade tariffs – 30% in 2018, stepping down to 15% in 2021 – that threaten to reduce growth in U.S. solar deployment, arguably while delivering neither increased jobs nor increased investment in the United States. Some impacts of the solar trade case will be diluted through the supply chain, but overall, the tariffs are expected to add 10 cents to the cost of modules in 2018, increasing system prices by 8%. The effect declines to a 4-cent module cost increase in 2021, adding about 4% to system costs. The solar tariffs will increase the cost of solar projects, pausing project economics. The tariffs are expected to impact utility-scale solar more than residential; in the early years, there is expected to be demand destruction and construction delays, with a boom in 2020 before the last step-down in the sunseting investment tax credit. (Wind deployment is similarly expected to boom in 2020 to capture the last year of the sunseting production tax credit; a lot of wind build is driven not by state mandates but by economics.) Still, everyone in solar is working on value engineering, looking for higher-efficiency solar modules and better ways of integrating the various components (i.e., racking, inverters, panels). These product improvements could potentially cut costs more than enough to offset the tariffs.



The budget deal reached by Congress in February 2018 will also have significant effects on clean energy deployment, in multiple ways. For instance, the deal increased the caps for discretionary domestic spending, which opens up the possibility of having more money going into clean energy R&D (or at least makes it easier to preserve current levels). The deal also included several relevant tax measures. First, it extended the 48C tax credits for the “orphan” energy technologies left out of the 2015 tax extenders deal, though most of them were only extended one year retroactively (i.e., changing the tax credit expiration date from the end of 2016 to the end of 2017), so there will be no prospective impact – except for the few technologies (e.g., combined heat and power) that got multi-year extensions. The short-term, retroactive extension means that the tax extender fight will be coming back again for the Section 48 orphans. Second, there was a big extension of the 45J tax credit for nuclear, including eliminating the time-based cap. It is expected that the Vogtle plant under construction in Georgia will take about 2 GW of the credit, leaving about 4 GW for developers of small modular and advanced nuclear reactors. Third, and perhaps most impactful, the budget deal extended and expanded the 45Q tax credit for carbon capture and storage (CCS). The credit had been very weak, at \$10 per ton captured and used for enhanced oil recovery (EOR) and \$20 per ton captured and sequestered, and the credit had been capped volumetrically. The new extension removed the volumetric cap, replaced it with a time-based cap, and expanded the size of the incentive – carbon captured for EOR went from \$10 to \$35 per ton (after tax), while carbon captured for geologic sequestration went from \$20 to \$50 per ton (after tax). Direct air capture gets an extra \$35 per ton.

**The expanded credit is likely to represent a gigatons-scale sequestration opportunity over the next couple of decades and to move billions of dollars into the CCS space.**

The expanded 45Q credit is enough money that it should get projects going and make things profitable now that were not before. In the United States, there are 43 million tons of high-purity CO<sub>2</sub> within 100 km of a place to store it, and it can all be done for less than \$50/ton, and most at \$25-35/ton, so the tax credit can make those profitable. Not only will this reduce emissions and help clean manufacturing, but it will also help make the technology ubiquitous and cheaper, which can then help make CCS a more viable option for decarbonizing existing coal-fired and gas-fired power plants around the world and for decarbonizing industry (where the CCS opportunity is many times the size of any other sector). The expanded credit is likely to represent a gigatons-scale sequestration opportunity over the next couple of decades and to move billions of dollars into the CCS space. Interestingly, this is occurring at a time when the wind and solar tax credits are ramping down, which means in the 2020s, CCS could be the big clean energy tax opportunity, and tax

equity markets will spring up around it. (Not all entities that own energy assets, though, have a tax appetite – such as co-ops.) On a cost performance basis, CCS for gas plants (which are cheaper to do CCS with than coal plants) may well crowd out some renewables, as gas-with-CCS is easier than siting transcontinental transmission lines to move renewables to where loads are.

The budget deal represents a breakthrough moment that required significant coalitions working for several years on both sides of the aisle to overcome opposition and build champions. (Some NGOs, though, left the coalition due to discomfort with capturing carbon and using it for EOR, though it is worth noting that EOR gets roughly one pound of carbon out of the ground for every two stored.) The budget deal is also a signal that there could be opportunities to continue the discussion on the Hill. Good conversations are starting to happen behind the scenes in congressional energy committees. There is potential for bipartisan climate and energy plans to be put forward this year that will highlight the diversity of thought about how to address these issues across the aisle. There is also some potential interest in exploring a grand bargain to bring together fiscal conservatives, people concerned about debt, and clean energy advocates to phase out all energy subsidies.

Going forward, appropriations and infrastructure policies will be key areas for engagement. The Trump Administration's proposed budget, like last year's, again seeks numerous cuts that could be detrimental to clean energy, but there has been bipartisan pushback on these proposed cuts. As for infrastructure, the Administration's plan includes no mention of resilience, adaptation, climate, clean energy, or a modernized grid, but non-profit and private sector advocates will likely push for that to change if the plan makes progress toward becoming a bill.

## STATE & LOCAL POLICY

At the state level, there have been many developments over the past year that could be considered good news for clean energy. New governors were elected in New Jersey and Virginia, with each having significant policy initiatives centered around clean energy. In contrast to the partisanship at the federal level, many Republican governors – including in Illinois, Iowa, Maryland, Massachusetts, Michigan, and New Hampshire – are trying to understand how to build out clean energy economies and attract growth markets, startups, and capital to their states. Governor Brian Sandoval (R-NV) signed nine clean energy bills last year. Governor John Kasich (R-OH) vetoed an effort to extend moratoriums on state clean energy mandates. Bipartisan governors in the Intermountain West – a rather fossil-fuel-focused part of the country – formed an agreement to build out EV infrastructure. These developments represent a pretty significant shift from the recent past.

Gubernatorial races this year will matter a lot in terms of the clean energy initiatives states pursue going forward, and clean energy could be a wedge issue in a few close gubernatorial races. Notably, California will be losing Gov. Jerry Brown, who has been serving as the de facto U.S. climate diplomat for the world; people may underestimate what he as a person has done in California to hold coalitions together. Mary Nichols will be leaving as the head of the California Air Resources Board too. Some fear that California will not be as huge a leader as it has been on these issues going forward, while others remain confident that the strong support for clean energy from both state businesses and the public means California's leadership will continue to grow.

In state legislatures, too, Republicans have been introducing clean energy measures, and there are possibilities of passing bipartisan legislation in red and blue states. Within the American Legislative Exchange Council (ALEC), which has set a lot of conservative policy in recent years, there has been conflict and infighting about clean energy.

Several renewable portfolio standards (RPSs) will be coming up for renewal over the next couple of years, in a mix of red and blue states. RPSs started with lots of bipartisan support, but Republicans fell back around 2008-10 as President Obama pushed clean energy more, the economy took a downturn, and there was overpromising on clean energy jobs in the recovery act. RPSs became a serious political wedge issue, with a narrative about mandates splitting Democrats and Republicans. Now, however, Republicans are starting to come back to the table and are expanding RPSs, but in a more limited way. There is a brewing challenge on the horizon, though, as there are numerous groups in various states looking to run ballot measures that would increase RPSs, including some to 100% – which could fail in more conservative states and potentially set the conversation back. Those pushing 100% renewables ought to stop and think about the market, politics, and feasibility of that goal. Others are hoping to work in states to reform RPSs to be more technology-neutral (i.e., Clean Energy Standards) or to at least increase the scope of technologies that are allowed in, but local politics are very distinct and influential, and developments in states will be very idiosyncratic. In addition, there are market power considerations that should be recognized in determining whether a few large-scale nuclear plants should compete directly with hundreds of renewables providers or, as they are in New York, be supported separately.

With regard to carbon policy, states are pursuing a range of interesting efforts, particularly on the West Coast. In Oregon, which is exploring a cap-and-trade bill that is unlikely to pass during a short session, there was a need to pursue a broader coalition than in California, and a significant percentage of carbon price revenues were proposed to be directed toward land-based carbon sequestration in order to bring timber and agriculture on board. In Washington, businesses have been at the forefront

of crafting potential legislation (again in a short session) to try to get a design that will work, ramp up over time, reinvest revenues in carbon reduction, and deal fairly with other jurisdictions; the ballot initiative coming this fall will not be as conducive to tradeoffs. The role of businesses in both Oregon and Washington sidelined some of the typical opposition to carbon policy and led to some interesting policy innovations, though the environmental justice community is still a strong opponent to many of these initiatives. In California, the new Buy Clean California law could be a big deal, using state procurement related to state-funded infrastructure projects to create markets for materials with low levels of embedded carbon emissions.

At the local level, too, there is a lot being done to advance clean energy and reduce emissions, which is causing some upward pressure on states. It is harder, though, to execute clean energy policy in local governance. For example, unless a city has its own municipal utility, it will have difficulty affecting the power generation mix to meet climate targets. However, the localized effects of sea-level rise, extreme heat, and other climate impacts are things that people are and increasingly will be living with, and that will change local political conversations. At the same time, communities reliant on fossil fuel extraction are subject to both physical climate risks and a total loss of markets from the clean energy transition, and these communities can have significant political power; simply calling for a “just transition” is not enough. A big area of opportunity is exploring how states, regulatory commissions, utilities, city councils, mayors, and counties can work together on mitigation, adaptation, and transition; that is a conversation that has not really occurred in America, and there are opportunities in both urban and rural areas.

**Corporations are, in some cases, paying millions of dollars to leave their utilities in pursuit of cleaner energy.**

## PRIVATE SECTOR ACTION

Governments have not been the only ones making important decisions that affect clean energy. Corporate procurement has also made a big difference in clean energy deployment, even in places where there is hostility to clean energy. Corporations are, in some cases, paying millions of dollars to leave their utilities in pursuit of cleaner energy. Some leading corporations are engaging in multi-year conversations with utilities and state

regulators to reduce some of the friction and to negotiate arrangements whereby the corporations can pay utilities for services provided, whether transmission and distribution (but not generation) services or market-based rates for clean energy. If the constraint of relying on volumetric sales to recover fixed costs is removed, then utilities would be better able to have conversations with companies about green tariffs or other arrangements that would ensure their fixed costs are met. There is also

work to be done to get corporate procurement to expand to include CCS (or other zero-carbon options) and to recognize that in the early 2020s, CCS may be a key part of a low-cost clean energy portfolio.

On the climate front, those in the private sector – investors and corporations – are actively starting to deal with climate risks. The private sector faces physical risks from climate impacts as well as transition risks (i.e., the risks of not paying attention). There are coordinated efforts by investors and NGOs to engage with the largest corporate greenhouse gas emitters via shareholder actions to pressure them to improve governance on climate change, reduce emissions, and improve climate-related risk disclosures, and these efforts are having an impact. Companies are changing internal operational approaches because of it, and the conversation has moved from the sustainability office to the boardroom and from a focus on global diplomacy to one on operational change. Agricultural companies, for instance, are looking at projections of yield and production declines and are starting to move operations accordingly. Companies are also beginning to factor climate impacts into decisions about manufacturing facility locations and suppliers. Place-based climate risks are changing company behavior (though most fund managers are not educated on this yet).

# RETAIL MARKETS IN TRANSITION

There are increasingly significant questions being debated about appropriate business models, regulatory structures, and jurisdictional boundaries as behind-the-meter activity increases in retail electricity markets. Regulatory innovation generally has not kept up with technological innovation and, perhaps, business model innovation (though that is closely tied to regulatory innovation).

## INTERSECTION OF REGULATION & INNOVATION

The future is in many ways about how the power of incumbency and the desire for innovation intersect with each other and with regulations. The intersection of utility regulation and technology innovation can be thought of as creating quadrants, defined by whether regulation is leading or responding to market developments and by whether innovation favors incumbents or insurgents.

- When regulation responds to developments and innovation favors incumbents, investor-owned utilities (IOUs) continue to dominate the market, letting third parties in as part of the IOUs' business plans. An example would be demand-side management (DSM) on the utility side of the meter, where the utility is driving the train; it is their DSM and their grid.
- When regulation responds to developments but innovation favors insurgents, IOUs start to see revenue erosion, such as through distributed generation with storage or third parties delivering DERs to customers on their own. When in this quadrant, traditional regulatory practices (e.g., rates and recovery based on cost of service) are stressed, and one might see performance-based ratemaking or incentives. Utilities are sharing space with insurgents, but regulators are still not the ones spurring action.
- When regulators are leading the way (albeit with caution, so their authority is not challenged or removed by governors or legislatures) and innovation favors incumbents, IOUs are still leading but are pressured to compete. The distribution system can be evaluated, with discrete pieces or functions of the system

isolated and put out for bid so the market can provide information about what DERs, targeted DSM, or other competitively provided services could do.

- When regulators are leading the way (still cautiously) but innovation favors insurgents, that is the most dynamic system, in which IOUs face truly existential questions. IOUs then have to explore either how to retrench to being the owners and/or operators of a platform-based system or how to move toward competing in non-regulated markets.

Depending which metrics one is trying to optimize, one could end up in different quadrants. Many regulators view their primary objective as providing the lowest-cost electricity possible – period. Although many acknowledge the eventual need to lead the way and enable insurgents, they do not want to go so far or so fast that utilities go into fear mode, commissions get attacked in the media, or other political ramifications materialize. Regulators are wildly risk averse – and the average length of their tenure is dropping as well. In addition, many commissions do not appropriately explain to the public that there are choices to be made, and all futures come with consequences; there is no status quo option where everything is fine and does not cost more.

## MONOPOLY, COMPETITION, & JURISDICTION

The distribution side is getting much more dynamic and decentralized – and thus more complicated. The new distribution system is starting to involve serious flows of intelligence, data, value, energy, and money. The acceleration in new technologies – with declining costs and rising deployment curves – is making utilities rethink the tools they have at their disposal and changing how they operate the grid. At the same time, there are more things hanging off utility wires that are not owned by them, yet they all have to coexist. As clean energy continues to grow on the distribution side, questions are surfacing about what stays as a utility function and what gets carved away. It is increasingly unclear where the monopoly should stop and competition should start.

**It is increasingly unclear where the monopoly should stop and competition should start.**

Power utilities need to respect their past – maintaining the poles and wires, making sure the lights stay on, ensuring resource adequacy, answering the phone when customers call, and similar things that there may not be a need for more than one entity to do. For instance, there is a risk of low-income consumers getting left behind in the distributed-everything vision. Uber, for example, has led to bus lines getting dropped in some cities, which is fine for those who can do ride-sharing but not for low-income populations. While the distributed-everything scenario enables a more targeted social response to particular populations (versus to everyone), it still has to be someone’s job to provide

that response. The social compact still has to exist, and the job of the retail system operator still has to include providing reliable service and a backstop for low-income consumers. While it is true that, over millennia, one of the biggest contributors to the well-being of the poor has been technological change, technological advances and the ability to leverage greater system efficiency have to co-exist with the foundational requirements of service.

At the same time, power utilities need to enable and embrace the future. For instance, utilities have to make the distribution system more flexible; this starts with having good visibility into what is happening in the distribution system (which utilities generally do not, although things are improving). Technologies are also forcing electricity providers to rethink their business models – to figure out how to

**Power utilities should explore how to pursue smart electrification of other sectors, in places and times that fit their load profiles and make their systems more efficient.**

get the revenue needed to maintain poles and wires while still lowering costs and enabling more innovation and clean energy. They have to rethink rate designs to move away from volumetric sales. They have to be able to provide multiple power supply options, think about new business models with more fixed-cost components, and perhaps pay customers to provide voltage support. (There is also a need to figure out how to deal with legacy assets and legacy contracts, as, for instance, a lot of co-ops are stuck with assets or are stuck in contracts with generation and transmission providers that limit their ability to

rethink business models and move into clean energy.) In addition, the utility sector is told regularly that it is not allowed to spend more than an incremental 3% per year, one-third of which is environmental regulatory cost and one-third of which is operations and maintenance, which is an indictment when thinking of clean energy innovation; if any other sector had the same institutional constraints on deploying capital, a host of innovations would never have occurred. Furthermore, power utilities should explore how to pursue smart electrification of other sectors, in places and times that fit their load profiles and make their systems more efficient.

Deciding where the line between monopoly and competition lies cannot be as simple as just testing for contestability – whether other parties are in the market or could enter it. That could be applied to effectively everything utilities do, would put an unnecessary burden on regulators, and could freeze progress (as it did in the case of smart meter deployment). Contestability is also temporal in nature; things do not become 100% contestable overnight. New technologies, such as solar plus storage and smart buildings, can allow for competition in areas where it was not possible 20 years ago, and the same will be true with new technologies going forward, which can make it challenging to continually figure out where the boundary line between monopoly and competition should be drawn. The blurring of the line between mo-



nopoly and competition is also reflected in jurisdictional questions, as it is increasingly unclear where the grid ends. For example, some utility regulators have decided that they do not have jurisdiction over EV charging infrastructure, others are saying utilities should not be allowed to own it, and still others are saying it seems like a natural extension of distribution infrastructure. Furthermore, what is centralized and what is distributed can change over time. For instance, in the early 1980s, computers were centralized. When the PC came out, what decentralization looked like became clearer, but there were still centralized data services and computers. By 1990, the direction of things seemed clearer, and by 2000 it seemed certain. What was not foreseen, however, was re-aggregation – remaining unbundled while rebundling (e.g., Uber). Electricity will still have big centralized somethings, though what is centralized may well change over the horizon.

With regard to jurisdiction more broadly, it may be that the jurisdictional arrangements that currently exist for electricity, which were established long ago and have not changed much, may not be the right kind of jurisdictional arrangements for the future. There is no reason the current arrangement needs to be thought of as sacred or untouchable. Some suggest that a catalytic wake-up call is the only way to unleash distribution system operators, empower state regulators to be umpires and not managers, and spur real innovation – a wake-up call such as a lawsuit declaring the electricity jurisdictional system and the monopoly rate of service approach to be unconstitutional for allowing states to make distorting choices that affect the flow of electrons in interstate commerce.

## BLOCKCHAIN DISRUPTION

It is unclear who gets to decide what is allowed to hang on the edge of the grid. The internet, as an analogy, has been a platform for permissionless innovation. It is unclear if the intelligence at the edge of the electricity network (DERs, etc.) should follow in the same mold.

Blockchain could become a major driver of activity at the grid edge. It is in many ways an outgrowth of the breakdown of trust in institutions writ large and has the potential to disrupt previously undisruptable monopolies (e.g., currency), and it has been said that blockchain will disrupt energy as well. Blockchain has interesting characteristics, fusing physical and financial markets and creating levels of automation and security that are unique. Its cryptography and ledger security ensure the highest level of cybersecurity available, and its immutable ledgers mean everyone can see who is doing what (although not everything will happen on transparent ledgers). It is clearly technological innovation that favors insurgents, as it enables people to interact in peer-to-peer ways. Blockchain's earliest applications in the energy space will likely be things like certificates of origins (e.g., for renewable energy certificates), but it could eventually enable a move to a peer-to-peer grid.

Some feel blockchain could be the demise of the state-based public utility system in the United States, as it will pull so much of the economics away to the unregulated edge. Digital technologies such as blockchain are transaction-cost reducers; they let people engage in more transactions, more seamlessly, and in a more automated way. Falling transaction costs bring changes in vertically integrated business models; innovation happens in vibrant, dynamic, open retail markets, and falling transaction costs mean it is cheaper to do transactions in markets, which in turn provides greater impetus for retail competition. Falling transaction costs also make it cheaper and easier for consumers to use digital and smart grid devices on the grid edge to interact

**Blockchain could be the demise of the state-based public utility system in the United States, as it will pull so much of the economics away to the unregulated edge.**

in a technology-rich, interoperable, transactive energy market platform. This is the platform economy (e.g., AirBnB) come to electricity. Blockchain allows for automation through smart contracts, which can be executed at fractions of a cent. Local markets can be created that involve EV storage, electric water heaters, rooftop renewables, and more, automatically looking at the financial status of who is transacting, the physical status of the grid, voltage requirements, and the like. Companies could push software upgrades to smart devices that let them start talking to any device around them that is willing to talk, and

those devices could then start transacting on the electricity grid, allowing the owners of the devices to start saving or making money. Blockchain will enable people to make individual trading decisions to make money, without caring about the effects on the overall system.

It is possible, though, to design a blockchain model that makes sense for the electricity system. The grid could be managed in a low-cost, high-speed transactional environment. As DERs and blockchain proliferate, distribution system operators will need to know what is happening on their distribution systems – to know where the people (or, perhaps more likely and more accurately, the automated, interoperable devices) are that are engaging in transactive energy. Blockchain will give utilities an incentive to put the right kind of smart monitoring systems on all their circuits so they can be measured and traded in the right way. It is possible that distribution operators would just define the desired load shape and then let the devices sort it out among themselves; that would provide assurance that the grid will behave in a certain way for reliability while keeping the system essentially permissionless. Blockchain has the potential to let markets clear and grids balance from the bottom up, which could have transformational effects.

As peer-to-peer transactions increase, more things could occur outside the sphere of regulatory approvals, unless regulators are prepared to address them. In some states, peer-to-peer energy transactions currently are unambiguously illegal, and in many

others it is just ambiguous. Every blockchain, though, is a trust engine and needs a consensus mechanism about what the truth is that is logged on the chain. Currently, this is largely done by unknown people with massive computing power, but that does not have to be where the computational authority lies. It is possible to create a secure system with some limited set of authorities that validate each other's transactions, in a way that can be trusted by the public and that allows regulators to sit in and see what is happening on the network. This would clearly involve a different model of regulation and a different role for regulators (e.g., a move to algorithmic-type regulation).

All of these changes are moving at the speed of software deployment, not at the speed of infrastructure deployment. The changes wrought by blockchain will come really, really fast.

# WHOLESALE MARKETS IN TRANSITION

Policy debates and technological disruption are in no way confined to retail markets. Wholesale markets, too, are in transition.

## TRENDS

Wholesale electricity prices have been declining in real terms, which is bad news for electricity producers. The decline has been principally because of natural gas and renewables. Solar is now at the point where it can compete with natural gas (if solar subsidies are included, though it is worth recalling that the whole energy sector is heavily subsidized and that subsidies are built into the prices of other energy sources too).

Since 2004, the price of wholesale commodity electricity has fallen by a little more than 40%, while retail customer bills have increased by roughly the same amount over the same period. Retail electric rates have been going down, but higher fixed fees and other issues are leading to rising bills. At the same time, some data suggest that electricity bills are making up a smaller share of household expenditures than ever before.

Wholesale markets, in the purest sense, are where buyers and sellers meet and commodities – energy and power – are exchanged.

## STATE PREFERENCES & WHOLESALE MARKETS

Wholesale markets, in the purest sense, are where buyers and sellers meet and commodities – energy and power – are exchanged. They are designed to provide the lowest-cost resources for end-use consumers, with certainty, transparency, and fuel neutrality, while supporting reliability and resilience.

Regional transmission organizations (RTOs) and Independent System Operators (ISOs) manage wholesale markets and create a more efficient utilization of resources. They are also a great platform for renewable sources to interconnect. All RTOs/ISOs move energy around on a least-cost basis, optimizing the transmission they have, but

they differ in how resource mix decisions are made. In the Midcontinent Independent System Operator (MISO) and the Southwest Power Pool (SPP), resource decisions are made by the states generally, and there are no lawsuits about specific technologies chosen. The capacity payments are done through state markets; they are not relying on the wholesale market for revenue. Other RTOs, like PJM and ISO New England, have seen tensions related to state policies, as the RTOs say their energy and capacity market prices should be instructive to and respected by states, who should not tinker with the resource choices of the market. That, of course, is not how things work in reality, given state policies such as RPSs and zero-emission credit (ZEC) programs that shape the generation resource mix. While the PJM model worked in harmony with RPSs for years, the new ZEC programs to compensate nuclear plants for their zero-carbon generation (an environmental attribute not otherwise compensated by the market) have highlighted the issue of providing out-of-wholesale-market revenues to resources and the question of whether that is distorting the market or just paying for a preferred attribute as expressed by a state policy. As states continue to implement RPSs and ZEC programs, more and more explicit and implicit carbon prices will arise in various state laws and regulations, which will be challenging for wholesale market redesigns to incorporate and get ahead of. The NY ISO, which is a single-state RTO, may be the best option for putting a carbon price into dispatch – an issue that will play out in 2018 – but multi-state RTOs are way more complicated. The question of states’ abilities to shape the attributes they want in the grid is now front and center, and the enormous tensions are working their way through the courts.

The question of states’ abilities to shape the attributes they want in the grid is now front and center.

## CAPACITY MARKETS

Debates about renewable energy credits, zero-energy credits, and the like are all about the capacity markets. For a wind farm, approximately 90% of revenues come from energy markets, with the remaining 10% from capacity markets. A nuclear plant is also highly reliant on energy markets, the source of about 75% of its revenues. An old fossil-fuel steam peaking plant, though, which runs only a fraction of the time, gets something like 90% of its revenues from capacity markets, so capacity prices mean that resource will stick around for a long, long time. There is a need to shift the conversation in organized markets away from capacity – to de-emphasize it – and toward energy markets. Doing so could have a profound impact on how the grid evolves.

The existence of capacity markets is a political question about how much people are willing to let wholesale markets sort everything out. They are entirely an artifact of

price caps in wholesale markets; if those did not exist, there would not be a need for an artificial construct to replace them. Texas has already let capacity markets and NERC's 1-day-in-10-year reliability standard go. (That standard is the one to challenge; once it is overlaid on the market, the only way to solve for it is with capacity markets.)

## FERC

FERC used to be a sleepy, technical, boring place, but not anymore. It has played a central role in a range of energy debates, and it has done many things well. For instance, in recent years, FERC has done a good job with respect to gas-electric coordination and in attempting to grapple with the growing deployment of renewables (understanding that renewables do not necessarily have the same attributes as other generation sources). FERC terminated its consideration of Secretary of Energy Rick Perry's Notice of Proposed Rulemaking (NOPR), which he sent in September 2017 to support coal and nuclear plants in the name of reliability and resilience; FERC decided instead to engage in a broader discussion about reliability and resilience pricing. FERC also gave the California ISO greater visibility into what aggregations of DERs look like. In addition, FERC has had a diligent focus on state-federal jurisdictional tensions. In February, FERC finalized a rule on energy storage as a market participant, directing ISOs and RTOs to develop tariffs to let storage compete in wholesale markets; that rule split out DERs, so commissioners could be better educated on the DER aspects of storage, and FERC is holding a technical conference on it in April.

There are, of course, areas where FERC could do better. For instance, FERC's efforts on a number of market reform issues have been tortured and ongoing for years, though it is good that FERC is trying to focus on ensuring certainty in market operations. All in all, though, FERC has done well in repeatedly coming down on the side of markets. FERC commissioners, many of whom are new, have to keep building their competence and fighting to remain independent in the face of stronger political forces.

## DISRUPTION

Electricity markets are not on the cusp of change or on the brink of something big; they are already right in the middle of it – and are behind in responding to it.

Blockchain, transactive DERs, and the other innovations described earlier as disrupting retail markets could disrupt wholesale markets as well, at least as currently structured. The current market system is based on the notion of large centralized assets and the need to manage power all the way to the edge of the grid, but new technologies create the potential to dispatch load, storage, and generation all from the customer upward into the grid. There could be a recursive market flowing from

the bottom up, changing the nature of the demand curve that comes into wholesale markets. As with distribution system operators, wholesale operators would need to have visibility into the resources in the distribution network and project what the net load will be, at which point the wholesale market could take care of the rest. Another variant would be for the distribution system operator to transact with the wholesale market just on net load shape, giving the operator flexibility on how to populate that shape. Under such a system, a capacity market would not be needed; instead, ISOs and RTOs could ask distribution system operators to perform certain functions.

None of this could happen immediately, but there is a need to start moving in this direction. Figuring out how to meld the old-school wholesale market reliant on big generators (whether green or brown) with highly distributed behind-the-meter generation in a way that works will not just happen by magic. There is a need to find a way to do really good, robust planning at a regional level about how to make the transition work and how to incentivize distributed resources to perform in a way that provides for system reliability. Political action will likely be required. Distributed energy should appeal to core Republican ideology, as should strong markets, and robust behind-the-scenes dialogues are starting to occur across the aisle. Members of Congress are starting to ask questions about whether RTOs are getting it right and have the right governance, which opens the door to potential support for a bottom-up market based on distributed energy. As part of those discussions, it may be beneficial to move the dialogue away from discussions of baseload, which is a term that may now be obsolete and potentially damaging, as people are not arguing about the same definition. Instead, it may be desirable to shift to a supply-following mindset rather than a load-following mindset and to emphasize flexibility and the resilience of a distributed system.

**Electricity markets are not on the cusp of change or on the brink of something big; they are already right in the in middle of it – and are behind in responding to it.**

# RELIABILITY, RESILIENCY, AND SECURITY

In DC and beyond, discussions around reliability, resiliency, and security are getting a lot of attention and bipartisan interest.

## DEFINING THE TERMS

Some use the terms reliability, resiliency, and security almost interchangeably, while others see them as distinct. In general, though, the terms appear to be broadly understood as follows:

- *Reliability* concerns whether the grid is up or down (i.e., whether the lights are on). From a regulator's perspective, reliability is baked into the social compact – the expectation of 99.x% service that is always there – and will remain a requirement (likely within the domain of incumbents) going forward.
- *Resiliency* concerns how buildings, locations, or the grid as a whole are prepared for and respond to disruptions or threats (i.e., the ability to withstand and recover). From a regulator's perspective, resiliency is principally about the time it takes to get back to normal following a disruption, and the public's expectations in this regard are growing in the wake of significant natural disasters (e.g., Puerto Rico still not having power fully restored many months after Hurricane Maria hit). Resiliency is becoming more of a customer-driven conversation, as those that really need resiliency (e.g., hospitals, datacenters) are building in redundancy, creating microgrids, and otherwise pursuing solutions. There is clearly starting to be market segmentation based on customer needs and expectations, and in a future regulatory structure, those who want and need resiliency may well have to pay for it.
- *Security* concerns how to protect the grid from people trying to harm it, whether through cyber or physical attacks. The role for regulators regarding security is less clear and more in flux, although public utilities commission do have some role – including trying to get a handle on the current sense that almost anything goes cost-wise in pursuit of security. Security is in some ways becoming a new



part of resiliency, and it is worth exploring whether there are ways to isolate and carve out pieces of resiliency and security for provision by competitive actors.

## DESIGNING A MODERN, DISTRIBUTED, RESILIENT SYSTEM

As the grid modernizes, with more variable generation, more bidirectional energy flow at the distribution level, more energy storage, and more smart devices, it is essential to think about resilience, reliability, and security (as well as affordability, flexibility, and sustainability). There has been a concept of resilience around for decades suggesting that a system that is resilient should have many fine-grained elements that are dispersed in space, each with a low cost of failure, and that are interconnected by redundant links but can also stand alone if needed. In contrast, centralized generation requires dependence on the grid, which is where most power failures originate. There is a need to think less about a radial/linear system and more about a mesh network, with smart switching, breakers, situational awareness, and data gathered from micro-synchrophasors.

**A DER future can be a more reliable, more resilient future.**

Many would argue that a DER future can be a more reliable, more resilient future, at multiple scales. Isolated communities, for example, can increasingly use rooftop solar plus storage to improve resiliency and reliability, as in the case of the microgrid project being pursued in Borrego Springs, California. The same can be true with larger solar, storage, and microgrid projects, such as the “smart city” being developed near the Denver International Airport. In contrast, a community that relies on a single corridor of transmission lines is less resilient, as there is a clear single point of failure that could be affected by wildfires or other events, leading to multi-day outages. While it can be a challenge to figure out the appropriate criteria and metrics for individual projects, smartly designing and optimizing islandable DER projects can advance resiliency and reliability.

There are many elements involved in designing a modern, resilient grid. Islanding is one key component. For several years, the IEEE 1547 standard and the corresponding UL standard have provided criteria and requirements for interconnecting distributed generation resources into the power grid, and IEEE recently approved an auto-islanding extension of that, rules for which should emerge over the next year. In the meantime, there should be efforts to work with state regulators and utilities to make sure no one prohibits auto-islanding capability. Most utilities do not explicitly allow islanding – or do not know what their policy is on it – but resilient design that allows things that hook up to the grid to work with or without the grid should be the default. With auto-islanding, a smart inverter will isolate from the grid when necessary and continue serving critical loads and vital services in communities, leading to less social stress and hassle; when the grid comes back, the inverter will

detect it, resync, and reconnect without interrupting load. With a widely dispersed system of auto-islanded generators, smart circuits, and the necessary algorithms, those distributed resources can serve as the nucleus for a black start that re-energizes the system.

Many types of storage and distributed generation assets can contribute to a distributed, resilient grid. Datacenters, for instance, need 24/7 power, so many of them have batteries and backup generation in case of grid disruption. Some companies are looking at how to use those datacenter assets more dynamically to help the grid, such as making backup generation assets available to utilities for when the grid is stressed and deploying more energy storage and fuel cells to provide greater reliability to both the datacenters and the grid. Storage and distributed resources could also help accelerate recoveries after events. For example, in recoveries after recent major storms, one of the biggest obstacles has been that first responders and genset operators

**Climate change needs to be a bigger part of utility planning and investments.**

could not get fuel – not just because gas stations do not work without the grid, but also because the wiring of the pump, the sales terminal, and the convenience store are all intermingled, which means there is a need for a huge generator just to pump gas. It would behoove utilities to work with gas station owners/operators to retrofit every gas station with a small PV and battery array, with a breaker box, so gas can be pumped in an emergency without the grid or a truck-mounted generator. Furthermore, clean and distributed assets could support the grid with synthetic inertia. Grid operators (e.g., ERCOT) rely on rotational inertia to provide frequency regulation and reliability, but wind and solar provide no rotational inertia, which could limit the grid's ability to self-correct in the case of an event. Synthetic inertia from renewables and batteries, however, could be an option if regulations, rules, and standards are designed to allow it. Experiences in some countries and states suggest that synthetic inertia from storage or solar may be bigger, faster, and cheaper than from combustion turbines.

In addition to enhancing resilience by designing a smarter and more distributed grid, there is also a great deal of focus in the industry on hardening the grid against potential disruptions (e.g., by raising the level of substations). Most outages are caused at the transmission and distribution level, and hardening makes sense there, but there has to be a balance between hardening and smartening – a balance that thus far seems overly tilted towards hardening. There are also elements of hardening that are getting overlooked, as there are many different ways a system can fail. For example, a nuclear explosion over North America would generate an electromagnetic pulse (EMP) that would cripple the grid, but there has been appalling institutional lethargy in responding to these types of threats. Inverters are not even being made EMP-resistant unless they are for the military, but every single inverter could and

should be, and it would not cost much. Fixing the EMP problem is a \$5 billion investment, which is a small amount given the scale of the potential problem.

There are other key considerations as well. For one thing, resilience is not just about the supply side; the most cost-effective bounce-back capability comes from efficient end use, which stretches the impacts of resilient resources. Additionally, because utility investments last decades, climate change needs to be a bigger part of utility planning and investments. Most of the talk about resilience is in regard to acute events and the time it takes to get back to normal, but climate change risk has both acute and chronic aspects, and the latter also have to be part of the resilience conversation. Sea-level rise, precipitation and temperature changes, wildfires, and more all have to be factored in, and investors are increasingly asking for disclosure on both types of climate risks at the asset level. One has to think about how to build and retrofit energy infrastructure for the climate of 2030-2040 and beyond. Likewise, at the federal level, the Stafford Act requires rebuilding the grid and other infrastructure back to what it was after events, but that is not acceptable in the face of climate risks.

## CYBERSECURITY

A grid that has more digital access points and more communications also has more cyber-vulnerability. Cybersecurity in a modernized grid involves at least two aspects: the critical infrastructure and the proliferation of smart devices on the edge of the grid (the Internet of Things). It is important to get this fusing of the digital and physical worlds right. These two aspects of cybersecurity, though, are not the same. Some would argue that it is important to avoid extending the model used to protect critical infrastructure to cover every DER device as well.

**Cybersecurity in a modernized grid involves at least two aspects: the critical infrastructure and the proliferation of smart devices on the edge of the grid.**

The Electricity Subsector Coordinating Council is a partnership of federal government and industry stakeholders focused on protecting the grid through consensus-based voluntary metrics and standards for substations and other critical infrastructure (though some maintain that cybersecurity is too important for voluntary standards). It has only been in the past couple of years that utility CEOs and a designee could get security clearances so they could learn from the FBI about attacks coming into their systems – and clearances still take more than a year to get. The classified nature of some of the information has been a real hurdle to actually getting prepared to address those threats.

There are important questions about who is and who ought to be in charge of cybersecurity. Congress has been active in this area, with cybersecurity being a key bipartisan issue. Legislation in 2015 gave some new authorities in this space to the

Department of Energy and included new procedures to encourage information-sharing. Although Congress enshrined in statute that DOE is the lead on cybersecurity, that has not meant a lot in the actual execution of things, as many believe the Department of Homeland Security or others (e.g., state public utilities commissions) should be taking the lead. The jurisdictional lines on these issues are blurred – between federal and state agencies and between federal agencies.

There is even less consensus on who should be in charge behind the meter. It still has not been resolved who is responsible for DER cybersecurity, and the jurisdictional morass is stopping progress. PUCs might feel it is their responsibility, while others would argue it is a national security threat to be handled by the federal government. There may simply be multiple roles, with grid operators having one set of responsibilities (e.g., planning) and the people connecting devices to the grid having some different measure of responsibility (e.g., good cyber-hygiene and practice). As things move up the chain, the responsibilities get more aggressive. Visibility is the

**Enemies are in the grid right now; they just have not pulled the trigger.**

key for grid operators, otherwise it will be challenging to detect disturbances so that devices can be isolated or directed to behave appropriately. Interoperability standards will also be key, which means the National Institute of Standards and Technology (NIST) plays a crucial role. NIST can be a focal point around which the industry can coalesce to do bottom-up industry

standards (e.g., changing default settings on devices to promote better cyber-hygiene). Interoperability is a layered concept, with standards at the device level, layering up to cover the full system. NIST has been very involved in the Internet of Things and has a role in standardizing grid architecture that can be deemed resilient and secure and that everyone can build to.

Utilities need to recognize cybersecurity as an enterprise risk – not as something relegated to IT or someone focused on minimizing cost expenditures. Companies have to be aware of their cyber-posture and practice optimal cyber-hygiene. The best starting posture is to assume one is already compromised – and then to figure out how to still operate. Enemies are in the grid right now; they just have not pulled the trigger.

Great things are indeed starting to happen in cybersecurity in the electricity sector, but far too slowly, and only in small corners and pockets of excellence. The best utilities on cybersecurity are still connected on the system to the next utility over that is doing little of the necessary preparation. In addition, most distribution co-ops are not engaged in these conversations, even though most of the reliability and resilience impacts fall at the distribution level. That has to be reconciled, in a way that does not require every co-op to staff up with a huge cybersecurity team (which it cannot afford) or to get top secret security clearances. There is a need to figure out how to share threat information and appropriate responses and defenses. Some large

utilities are in fact starting to volunteer to go into smaller utilities and help provide education, staff support, and information – because those smaller entities end up becoming, due to size and lack of resources, the weakest link.

Cybersecurity is in some ways like the Y2K problem: a lot needs to change, architectures need to be adjusted, and institutions will use process to hide and will always be late. The technology world, meanwhile, has solved the problem in a substantial way, with trust networks and zero-knowledge algorithms. This solution is not easy and requires some reworking of architecture, but it needs to be in the conversation.

## POLICY

Policy related to reliability, resiliency, and security can either further or hinder innovation. The push for policies to promote grid resiliency and security could be used to steer the adoption of innovations in ways that favor incumbents, out of a sense of fear. Innovation could be seen as promoting vulnerabilities, which could lead to limits on third-party access and attempts to hold to the status quo. It is important to examine the full suite of motivations behind particular policy proposals in this area. When people invoke reliability and security, it is like invoking the flag, and it pays to be skeptical. A lot of policy prescriptions in this area seem to be trying to come up with strategies to protect the 20th century grid, not the 21st. Someone has to manifest a broader vision of an innovative clean energy grid that shows how resiliency and security fit in.

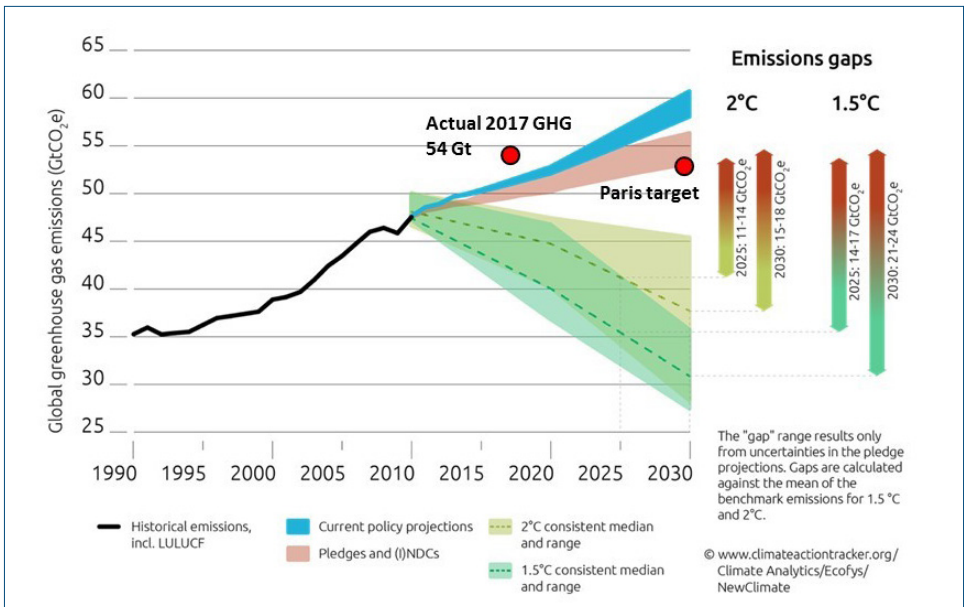
**Someone has to manifest a broader vision of an innovative clean energy grid that shows how resiliency and security fit in.**

# DEEP DECARBONIZATION

Shallow decarbonization, while difficult to achieve in its own right, is relatively easy compared to deeper decarbonization. Rather than focus on the various aspects of clean energy and decarbonization in isolation, it would be helpful to figure out a broader strategic plan for moving forward – determining who does what in the battle plan on carbon. Deep decarbonization has to be the foundation, focusing on the future humanity is trying to achieve and then thinking about the paths, policies, changes in capital deployment, and innovations needed to get there.

## CLIMATE MATH & DECARBONIZATION PATHWAYS

The climate math is bad – much worse than most think. Looking out to 2030, the world is on track to emit about 60 gigatons (Gt) of greenhouse gas emissions that year, compared to about 54 Gt in 2017. That is well above the trajectories consistent with limiting warming to 1.5°C or 2°C. However, this is not just a perfor-



mance problem; this is also an ambition problem. Even if every country met their Paris commitments, the world would still be emitting about the same amount of GHG in 2030 as it is now – and that is still 15 Gt above a 2°C trajectory. The gap could grow even larger. Extending the OECD outlook for business as usual suggests that projected emissions could rise to 80 Gt, yet the goal is to get to 18 Gt by 2050. That is a huge gap.

If the energy system is in the midst of a massive transformation toward deep decarbonization, it is very difficult to discern from most macro data. Because the energy system continues to grow at a tremendous pace, the percentage of global and U.S. primary energy from fossil fuels has declined only slightly since the 1970s, and the global economy remains tremendously reliant on fossil fuels. The main transition in the United States has been from coal to gas, which is not enough from a climate perspective – and some would argue is a net loss, given displacement of other zero-carbon resources, methane leakage, and the export of the coal that was domestically displaced. Low-carbon energy deployment sometimes happened faster in countries before they made climate commitments than after, and while the costs of renewables have declined impressively, deployment is leveling off in some places at fairly low levels of penetration (often because countries had fiscal distress, were overpaying for renewables at the start and pulled back, or made other policy changes).

Nearly all of the discussion on decarbonization is about electricity, which globally is only about a quarter of the problem.

Furthermore, nearly all of the discussion on decarbonization is about electricity, which globally is only about a quarter of the problem – and addressing all the emissions from the U.S. power sector would address about a quarter of that quarter. Global land use represents about another quarter, industry around a fifth, and transportation about a fifth. There are a lot of emissions that are very hard to address; the power sector is in many ways the easiest. Accordingly, most deep decarbonization studies suggest the need for the same basic process steps: optimize energy efficiency to make energy go as far as it can, decarbonize the electricity supply, electrify as many end-uses as possible, and then use zero-carbon fuels for the rest. There is also a need to manage the residual carbon – whether geologically, biologically, or mechanically.

California has arguably been as much of a climate leader as any jurisdiction, so it can provide an instructive example of the challenges of deep decarbonization. While California has been a leader in energy efficiency, renewable energy, and rooftop solar, business as usual will not be enough to achieve state emission reduction goals. The state is at about 40% carbon-free energy at the moment, and it might be possible to get to 80% by 2030. Achieving that goal will likely involve a lot of energy efficiency, customer solar, energy storage, and more, including potentially existing hydro and

some out-of-state nuclear. Energy storage is forecast to mostly involve short-duration balancing in the California market in the near term, but in later years, heading toward 2030, residential applications, as well as commercial and industrial, are expected to dominate. The California power supply, though, is only responsible for about 20% of the state's greenhouse gas emissions, and over time that percentage will decrease. Getting to state climate targets will have to be a cross-sector effort, which will involve using clean energy to electrify things. On the transportation side, several million EVs have to be on the roads in California by 2030, and hundreds of thousands of electric medium- and heavy-duty trucks. A sizable portion of water and space heating in buildings has to become electric. As a consequence, utility bills on average across the state will increase incrementally about 2-3% per year, each year. This transition is not free, but it is affordable. It is also hard.

## ENERGY EFFICIENCY & ZERO-CARBON ELECTRICITY

Some see reasons for optimism. The drop in global energy intensity has sped up, getting closer to the level of annual intensity decrease envisioned in 2°C scenarios. U.S. energy savings since the 1970s are also many times greater than the amount of renewable energy output. In addition, optimizing buildings, vehicles, and factories as whole systems (not just parts) can yield huge energy savings, and integrative design is improving even more than the individual technologies are. Many energy saving design options, however, are not included in decarbonization studies or forecasts because they are not new technologies. For example, properly designing pipes and ducts could reduce 80-90% of their friction, which reduces the needed pump energy an amount equivalent to about half the world's coal-fired electricity. Integrative design combined with modern technologies can save several-fold more energy than models assume, and at much lower cost. Energy efficiency is an

Energy efficiency is an infinitely expandable assemblage of ideas, and huge amounts of U.S. electricity can be saved across sectors for far below retail prices.

infinitely expandable assemblage of ideas, and huge amounts of U.S. electricity can be saved across sectors for far below retail prices. Much of the action to reduce emissions can be on the demand side.

At the same time, zero-carbon generation's share of electricity is growing again. The global zero-carbon share of electricity in 2000 was about 35%, dipped to 31% through nuclear power retirements, but is now back up to 35% and rising. Global generation by modern renewables pulled ahead of nuclear in 2016, as renewable energy's costs continue to plummet. U.S. wholesale electricity prices often now exceed the long-term fixed prices of both wind and solar, and renewables are now winning in unsubsidized global markets. Several models show it is possible to get to 60-70%



renewables penetration at reasonable cost and in a reasonable timeframe, though that depends on assumptions about where transmission can get built and how resources over large geographic scales can be synchronized. In addition to lots of transmission, getting to higher levels of renewables penetration in the U.S. power sector will require lots of storage, though EV proliferation could make integrating variable renewables easier, as cheap batteries will soon be available for the grid. New battery chemistries could also be game-changers (e.g., enabling rooftop solar plus storage to provide 24/7 power). The pathway for nuclear power in the United States (and elsewhere), meanwhile, will likely be small, modular, next generation reactors that can be built in small GW chunks, can be project financed, and can be manufactured.

It is possible that this kind of deep decarbonization could be profitable, not costly – saving trillions of dollars while growing the economy and strengthening national security.

## ELECTRIFYING OTHER SECTORS & USING ZERO-CARBON FUELS

If electricity providers can decarbonize their electricity, then they can push it into heating, transportation, refining, and other adjacent markets both to get revenue and create societal good. Companies could take curtailed zero-carbon power and make other things with it – enabling a distributed manufacturing base built on clean technology. Zero-carbon heat will be a particularly challenging but important thing to tackle in coming decades with regard to industrial applications. Most of the electrification attention tends to be directed towards transportation. Replacing all light-duty vehicles with electric vehicles would replace something like 16 quads of gasoline with 8 quads of electricity. There are efficiency benefits to this, and those quads would presumably come from wind, solar, and natural gas (if they are supplied by new build), though the increased electricity demand could also keep legacy plants alive longer. Policies are driving markets and behavior changes in this regard. For instance, China is buying large numbers of EVs and has set requirements for EV production that could drive global markets.

Decarbonized electricity could also help spur the manufacturing of zero-carbon fuels. Cheap renewables, for instance, could be used to create hydrogen (or ammonia). This electrofuels manufacturing could serve as both flexible load and a means of creating energy storage.

## CARBON REMOVAL & MANAGEMENT

The Paris agreement sharpened everyone's pencils on the carbon math and highlighted the need for serious, large-scale carbon management. Most deep decarbonization

models show a need for both CCS and carbon removal. There is a need to get to zero net emissions, and since some sectors are very hard to scrub carbon out of – such as industry, steel mills, and cement plants – there is a need to get to negative emissions in other sectors even earlier.

There are four planks to large-scale carbon management. The first is carbon removal through engineered approaches, such as direct air capture. This is the backstop technology; it never gets more expensive than scrubbing the air with a big machine. Direct air capture has been very expensive, but the first commercial project is up and

Direct air capture has been very expensive, but the first commercial project is up and running in Zurich, selling captured carbon at \$600/ton to a greenhouse.

running in Zurich, selling captured carbon at \$600/ton to a greenhouse. In Iceland, there is a negative emissions power plant that pulls CO<sub>2</sub> out of the air and stores it. Another company in Canada pulls CO<sub>2</sub> from the air and turns it into diesel fuel. These are all expensive right now, but the more cheap, clean power there is, the easier this gets, and costs are coming down fast.

The second plank in large-scale carbon management is CO<sub>2</sub> conversion and use – or turning carbon into value. As it gets cheaper and cheaper to get power from zero- and low-carbon sources, more and

more possibilities will be unleashed for turning carbon into stuff. The investment community is serious about this, and while it provides a modest amount of climate abatement in the near term, it could open up whole new industries going forward. Carbon-to-value has three distinct kinds of markets. The nearest-term opportunity is in cement and aggregates, the medium-term opportunity is in the chemicals and fuels markets, and the long-term opportunity is the market for durable carbon fibers. Lots of companies are pursuing this area now, creating products such as cement that can cure in a couple hours, carbon nanotubes and composites, and more. Engineered systems will continue to get cheaper, and the potential markets are large. The emissions abatement potential is also large – and can come from the “value” part as well as the “carbon” part. For instance, if carbon can be taken out of the air and turned into carbon fibers for use in lighter-weight vehicles, additional emissions savings could come from that. Similarly, emissions can be turned into cement and displace the sizable emissions from the cement market.

The third plank is commercial CCS deployment, which is the only real option for lots of current industrial action. The prospects for CCS deployment are looking up given recent policy developments (as described earlier).

Finally, the fourth plank in large-scale carbon management is natural carbon uptake. Some maintain that investing in carbon removal by natural systems might enable

reaching 1.5°C. Restoration of degraded rainforest, for instance, can occur within the space of a few years and provide positive cash flow for local populations – integrating economic, environmental, and cultural restoration. Others, however, argue that doing natural carbon uptake at scale, while important and vital, is harder than many people think. The reduction rates are highly contested in the literature, and there are serious land, water, fertilizer, and other costs (both environmental and economic). It is also worth recalling that forests are still being cut down. It is possible that engineered solutions will be able to suck up more carbon with a smaller footprint than natural ones.

The real near-term constraints for carbon management – particularly direct air capture and carbon-to-value – are customers. Carbon management is still expensive. Policy can help shift the economics. In addition to the recent extension and expansion of the 45Q tax credits, policy – federal and state – can help create markets and make financing possible. For example, many advanced technologies started with government procurements, which can be a path out of the woods and a lever to get innovation going. If, for instance, the Department of Defense said it wanted some percentage of its armor to come from low-carbon carbon fiber, companies would spring up overnight. CCS advocates also have much work to do to fill out the rest of the pieces of the policy ecosystem that so benefited renewables. For example, in addition to federal tax credits for wind and solar, there were also corporate renewables goals, state policies, low-cost financing, and more. CCS needs similar support to get down the cost curve, which will require maintaining and rebuilding NGO support so all are advocating for CCS like they have been for energy efficiency and renewable energy.

Many advanced technologies started with government procurements, which can be a path out of the woods and a lever to get innovation going.

## POLICIES, MARKETS, & CAPITAL

Actually decarbonizing a modern economy is really hard. Lots of countries and jurisdictions have prices on carbon now, and carbon initiatives at all levels are developing faster than ever (with China's new cap-and-trade market perhaps the highest profile now). Government policies, however, have not been commensurate with the scale of the climate challenge. For example, if climate was truly to be treated as an existential threat, some would argue that there would be no interest in messing around with incentives. If there was an asteroid heading for the planet, incentives would not be the response; instead, governments would mobilize the armies of the world and blow it up.

Given that something like nationalizing the economy to quickly mobilize zero-carbon resources at scale is not going to happen, policies on electricity, energy, and climate should probably at least be robust to the high uncertainties about what the energy future will be. Converting state-level RPSs to zero-carbon standards, for instance, would be more technology-neutral and allow for deferral of debates about whether the future is renewables, nuclear, natural gas with CCS, or something else; they would all be allowed onto the field to compete, and whichever zero-carbon technologies win in the market would get deployed. Likewise, it makes sense for policies to keep as many options as possible on the table, which suggests a need to keep the existing nuclear fleet, advanced nuclear, carbon capture and removal, energy storage (at the seasonal, not daily, level), and many other decarbonization pathways as potential parts of the solution set. Similarly, careful thought has to be given to how to avoid being locked into particular pathways that may hinder achievement of climate objectives, such as pushing for high renewables penetrations that might lock in a renewables-gas hybrid power sector for a long time. Studying geoengineering also might make sense, to understand the tradeoffs.

While really tackling greenhouse gas pollution (like air and water pollution) requires top-down declarations from governments in many respects, market drivers also matter. Both are needed. Governments can help seed what will become a market, providing real signals – such as state procurement budgets for low-carbon cement or fuels – that can get private capital flowing. At the same time, market inefficiencies can short political ambitions and frustrate momentum. There is also always the possibility of solutions that are good and also cheaper without policy; there are market drivers that can race ahead.

Mobilization of capital to advance clean energy is a serious concern. With lots of technologies yet to be invented in this space, there is an open question about who will fund the R&D. A major failing of collective governance worldwide is the lack of an innovation agenda in this space. Leading advocates have called for a quadrupling of the innovation budget, but the only country even close to doing that is Japan; everyone else is grotesquely short. There are breakthroughs out there in solar, 3-D printed bespoke reactors, and more, and no one is funding that innovation, except where it is being paid for out of military budgets. The government does not like to fail in public, which means when it looks over the horizon at technologies, it generally will only invest small amounts; there is a need to figure out how to get large investments in over-the-horizon technologies. Viable technology R&D funding and partnerships have to be explored, and there is a need for greater engagement with a range of investors.

# APPENDIX I: PARTICIPANT LIST

**Jeffrey Ackermann**, Chairman, Colorado Public Utilities Commission  
**Roger Ballentine**, President, Green Strategies Inc. (Co-Chair)  
**Bill Berg**, Vice President, Wholesale Market Development, Exelon Corporation  
**Jackie Birdsall**, Senior Engineer, Toyota Motor North America  
**Bill Brown**, CEO, NET Power, LLC  
**Steve Clemmer**, Director of Energy Research and Analysis,  
Union of Concerned Scientists  
**Jim Connaughton**, President and CEO, Nautilus Data Technologies (*Co-Chair*)  
**Jon Creyts**, Managing Director, China Program, Rocky Mountain Institute  
**Noah Deich**, Executive Director, Center for Carbon Removal  
**Dan Delurey**, President, Wedgemere Group  
**Julio Friedmann**, Distinguished Associate, Energy Futures Initiative  
**Kate Gordon**, Senior Advisor, Paulson Institute  
**Amy Grace**, Head of North America Research, Bloomberg New Energy Finance  
**Juan Grobler**, Founder and Executive Vice President, FridgeWize, Inc.  
**Dave Grossman**, Principal, Green Light Group (*Rapporteur*)  
**Bryan Hannegan**, President and CEO, Holy Cross Energy  
**Tom Hassenboehler**, Executive Director, Energy Consumer Market  
Alignment Project  
**Christopher Herbst**, Vice President, Government Programs, Eaton  
**Colette Honorable**, Partner, Reed Smith LLP  
**Mitch Jackson**, Vice President, Environmental Affairs and Sustainability,  
FedEx Corporation  
**Lynne Kiesling**, Associate Director, Purdue University Research Center in Economics  
**Amory Lovins**, Co-founder and Chief Scientist, Rocky Mountain Institute  
**Ron Nichols**, President, Southern California Edison  
**Ted Nordhaus**, Co-founder and Executive Director, The Breakthrough Institute  
**Justin Ong**, Policy Associate, ClearPath Foundation  
**Michelle Patron**, Director, Sustainability Policy, Microsoft

**Rich Powell**, Executive Director, ClearPath Foundation

**Bill Ritter**, Director, Center for the New Energy Economy, Colorado State University

**Mike Smith**, VP, Business & Technology Strategy, The Electric Cooperatives of South Carolina

**Martha Symko-Davies**, Laboratory Program Manager, NREL

**Steve Vavrik**, Chief Commercial Officer, Apex Clean Energy

**Michael Webber**, Deputy Director, Energy Institute, The University of Texas at Austin

**Jeff Weiss**, Co-Chairman and Managing Director, Distributed Sun

**Rhem Wooten**, Executive Vice President, Hannon Armstrong Sustainable Infrastructure/President, HASI Partners

## THE ASPEN INSTITUTE

**David Monsma**, Vice President, Aspen Institute; Executive Director, Energy and Environment Program (*Moderator*)

**Greg Gershuny**, Managing Director and James E. Rogers Energy Fellow, Energy and Environment Program, The Aspen Institute

**Anna Giorgi**, Program Manager, Energy and Environment Program, The Aspen Institute

**Maggie Carroll**, Program Associate, Energy and Environment Program, The Aspen Institute

# APPENDIX II: AGENDA

## Session I: The Data Room

What do the numbers tell us about the US energy system now? Where does it want to go? What are the current signals from US and foreign capital markets in terms of momentum and caution?

Moderators: **Jim Connaughton**

Discussants: **Amy Grace**, Head of North America Research,  
Bloomberg New Energy Finance

**Jeff Weiss**, Co-Chairman & Managing Director, Distributed Sun

**Michael Webber**, Deputy Director and Professor,  
Energy Institute, UT Austin

## Session II: The Impact of Political Change on Clean Energy

Political ideologies and energy sector arguments regarding reliability and security concerns are being used to justify policies that work against clean energy technology innovation and competitive markets. What do the recent actions by the Administration and Congress mean for clean energy? How does the tax bill, the infrastructure proposal, and the President's budget request impact the future of clean energy?

Moderator: **Roger Ballentine** and **Jim Connaughton**

Discussants: **Rich Powell**, Executive Director, ClearPath Foundation

**Bill Ritter**, Director, Center for the New Energy Economy,  
Colorado State University

**Kate Gordon**, Senior Advisor, Paulson Institute

## Session III: Retail Energy Markets in Transition: New Technology, New Market Players and Changing Customer Expectations

Are we adequately rounding the square hole of traditional retail markets for the round peg of new technology, new market players, and changing customer expectations? In the past decade, wholesale energy prices are down but total

energy bills to consumers are up. What is the disconnect? Increasingly, non-wires alternatives such as DERs and storage can solve problems usually addressed by traditional utility capital expenses; are we maximizing these new options? Can we accommodate transactive/peer-to-peer energy transactions and block chain? Is competition still on the rise or are vertically-integrated utilities regaining the high-ground vis a vis DERs and non-utility providers?

Moderator: **Roger Ballentine**

Discussants: **Jeffery Ackermann**, Chairman, Colorado Public Utilities Commission

**Bryan Hannegan**, President and CEO, Holy Cross Energy

**Ron Nichols**, President, Southern California Edison

#### **Session IV: Reliability, Security, and Resiliency: Does Policy Further or Hinder Energy Innovation**

The energy sector has always been concerned with reliability (a pillar of the social compact), resiliency has become a bigger issue in the age of extreme weather, the growth of DERs changes the equation, and the energy sector has been drawn to the center of larger policy concerns around cyber security. What is the right approach to these related, but different challenges? Do we risk intentional or unintentional negative policy consequences for clean energy in the process?

Moderator: **Roger Ballentine**

Discussants: **Martha Symko-Davies**, Laboratory Program Manager, NREL  
**Jeffery Ackermann**, Chairman, Colorado Public Utilities Commission

**Michelle Patron**, Director, Sustainability Policy, Microsoft

**Tom Hassenboehler**, Executive Director, Energy Consumer Market Alignment Project

#### **Session V: Wholesale Markets: Transition in a Time of Low Cost Energy Generation**

What should wholesale markets do? Is inexpensive, zero marginal cost renewable energy a problem or a building block for rethinking the answer to that question? Are competitive markets waxing or waning? Markets must form prices, but what other attributes do we want to value?

Moderator: **Jim Connaughton**



Discussants: **Colette Honorable**, Partner, Reed Smith LLP  
**Lynne Kiesling**, Professor and Associate Director,  
Purdue University Research Center in Economics  
**Bill Berg**, Vice President, Wholesale Market Development,  
Exelon Corporation

## **Session VI: Decarbonization: Mid Century Value Proposition and the Social Compact**

Beyond the market-driven shallow decarbonization occurring now in the US electricity system, how does the US make the leap to deep decarbonization? What role does energy efficiency play? What role does CCS and carbon removal play?

Moderator: **Roger Ballentine** and **Jim Connaughton**

Discussants: **Amory Lovins**, Co-founder and Chief Scientist,  
Rocky Mountain Institute  
**Ted Nordhaus**, Co-founder and Executive Director,  
The Breakthrough Institute  
**Julio Friedmann**, Distinguished Associate,  
Energy Futures Initiative

The Energy and Environment Program thanks our  
2018 Sponsors for their generosity:



## CLEARPATH

