2015 ASPEN INSTITUTE CLEAN ENERGY INNOVATION FORUM

The New Energy Innovation Economy

Roger Ballentine & Andy Karsner, Co-Chairs

Dave Grossman, Rapporteur

THE ASPEN INSTITUTE
ENERGY & ENVIRONMENT
PROGRAM

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PREFACE

Innovation is not always about eureka moments. Rather, the creativity necessary for innovation is more often the result of time to reflect upon a situation or question, or of changing environments and circumstances that instigate thought and reaction. It is also the case, given the complex nature of our modern world, that innovation frequently is not the product of a solitary mind – like Newton under the proverbial apple tree. In fact, innovative ideas in this age are more likely to arise from collaboration – many minds thinking as one.

No longer merely a new form of energy, clean energy has come to embody a whole range of innovations, from new consumer technology to new business, financial, and policy models, which are challenging the existing model of monopolistic, one-way creation and delivery of electrons and related energy services. Our structured discussions among experts with diverse views trained in different disciplines that is central to all our forums provides a unique context and perspective to enable new, collaborative, cross-disciplinary thinking and directional intensity that moving innovation forward requires. It is in this spirit that this year's forum (our sixth) had "innovation" added to its name. This addition was reflective, we believe, of the nature of our previous forums; the great participants we have assembled over the years have consistently ended up forecasting many of very innovations that have since come to pass in the clean energy sector.

Critical to creating the conditions for a successful discussion of this kind are our forum co-chairs, Roger Ballentine and Andy

Karsner. With their deep and varied experience, they helped construct the agenda and identify the right speakers and participants. They also guided and prodded our discussions during the forum and helped bring forward key ideas and observations. We are grateful to work with them again.

This Forum could not take place without the support of sponsors, and the Institute is grateful for their generosity and commitment to our work:

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Dave Grossman again served as rapporteur and, with the input of the Co-Chairs, wrote this report. Though no written report can capture all the depth and nuance of a multi-day, fast-moving conversation, he has captured the key points and distilled them into this highly readable summary.

Avonique DeVignes and Shelbi Sturgess handled logistics for the Forum. Tim Olson and Nicole Alexiev provided important input and guidance on the development of the agenda and speaker management. I am deeply thankful for their continued dedication and support.

The speakers, participants, and sponsors are not responsible for the contents of this report. It is an attempt to represent ideas and information presented during the Forum, but not all views could be included, the views expressed were not unanimous, and participants were not asked to agree to the wording of this report.

David Monsma
Executive Director
Energy & Environment Program
The Aspen Institute

FOREWORD

It is fair to say that the last few years have ushered in an era of dynamic change in the electricity sector the likes of which we have not seen in decades. The late 1970s, thanks largely to the Public Utilities Regulatory Policies Act (PURPA), brought a new set of players into the electricity sector as smaller generators flourished and began to change what we traditionally thought of when we considered how new generation was added to the grid. In the following decades, wholesale and some retail markets were opened to competition, again bringing a new set of players into the sector. These changes were significant and, to an extent, altered the traditional model of regulated monopolies providing centralized generation and distribution services to customers. Independent power producers, non-utility project developers, and new retail businesses were "insurgents" taking advantage of new market opportunities provided by changes in policy.

Today, however, we are beginning to see changes that promise to be much more fundamental than the developments of the past. Today's insurgents are not just "energy companies" that, while operating under a different risk-return framework, are seeking to do just what traditionally utilities have always done – generate electrons and sell them to customers. Instead, we see technologists, software companies, financing providers, and information technology companies seeking to redefine the very nature of energy services and to challenge the century-old-model of a one-way grid enabling centralized generation and distribution of electrons to customer meters whose primary function is to record and report consumption.

We are starting to see distributed generation, data analytics, and connected, smart devices being offered to customers not just to optimize consumption, but to position customers as full participants on a grid or distribution system where both electrons and information can flow freely in two directions. The promise is for customers to make choices and for the grid to have new options to meet the balance of supply and demand while lowering carbon intensity and reducing the need for new, centralized generation.

The cutting edge of disruption in the electricity sector today is the growth of distributed generation, primarily rooftop solar. This has led to fervent debates across the country as to how and whether behind-the-meter generation should be encouraged, financed, and charged. Yet even that debate is rapidly falling behind the cutting edge of change. Distributed generation is growing at the same time that information and control technologies are ushering in a market beyond "DG" to a more comprehensive suite of distributed energy resources (DER) that promise a more complex and potentially highly beneficial two-way grid that may ultimately blur the lines between the binary construct of "centralized" versus "distributed".

Central to this potential revolution is the reimagining of the "customer". Electricity policy and market innovations in the past were made with only a static view of the customer – the idea that all relevant changes to the system would occur up to the point where the electrons hit the customer's meter. That is no longer the case. Yet new technologies and insurgent businesses can only be disruptive if somebody demands the products. Skeptics of this new "energy innovation economy" continue to believe that customer interests in energy do not go far beyond reliability and price – and in many cases today that is true. Evangelists, on the other hand, might remind us that Henry Ford and Steve Jobs changed the world by bringing to customers products that they did not know they wanted or needed. The simplified but instructive construct of incumbents defending the legacy system and insurgents pursuing disruption is based on a perception of companies, regulators, and other stakeholders as either propelling innovation and risk-taking or blocking evolution to a new clean energy economy. The reality, of course, is not so black and white. Today, while still a distinct minority, we are beginning to see some "incumbents" adding a more robust suite of distributed energy and clean energy services to their customer offerings, and others are partnering with non-utility insurgents to meet changing consumer demand. And, of course, all of the related policy debates must occur with recognition of the need for universal, reliable, and affordable energy and energy services.

For the sixth year in a row, the Aspen Institute's Clean Energy Forum focused squarely on the cutting edge of change, and we benefitted from participants from every node of the evolving energy marketplace. Utilities, renewable energy innovators, technologists, information technology companies, policymakers, and academics joined us for our annual look at the future. Our half a decade of these discussions has shown us that the things we discuss in a given year in Aspen become *de rigueur* at energy conferences and dialogues a few years hence. In this era of historic change, we look forward to continuing to push at the cutting edge.

Roger Ballentine	**Andy Karsner**
President	CEO
Green Strategies	Manifest Energy

THE NEW ENERGY INNOVATION ECONOMY

Dave Grossman
Rapporteur

EXECUTIVE SUMMARY

Rapid innovation and business model disruption are driving change – and controversy – in the new energy innovation economy.

Technology, financing options, and new entrants have become the principal drivers of change in the electricity sector. Grid infrastructure is now being stressed, stretched, and rebuilt due to a range of factors, including declining costs and rising deployment rates for wind, solar, energy efficiency, and behind-the-meter energy generation and management. The technologies that are likely to be part of the U.S. electricity system, though, are still diverse – a mix of old and new, including natural gas combined cycle, wind, nuclear, solar, and a range of distributed energy resources and smart devices. In addition to the technologies, the past few years of the clean energy transformation have seen new finance innovations – including yieldcos, green bonds, and energy as a service – help clean energy reach the mature capital markets and the low-cost capital that utilities have enjoyed for decades. Policy in general is lagging the developments occurring in energy technology and finance, though state efforts to advance clean energy and reform utility business models can drive clean energy deployment. Even the most traditional state energy regulatory models have begun to face pressures to expand distributed generation and to move toward lower carbon alternatives, and federal climate regulations are likely to only increase those pressures.

Clean energy has begun penetrating markets in ways little imagined even a few years ago. Yet certainly when measured in terms of capacity, clean energy remains challenged by scale. Even with the boom in clean energy deployment, technologies are still not getting adopted and deployed at scale fast enough. In the power sector, technologies have generally needed big players to get deployed at scale, including industrial giant partners, large commercial and industrial customers, the military, governments, or utilities. In the transportation sector, the electric vehicle (EV) adoption curve in the United States has been flattening despite all the options available, extensive incentives, and state regulations trying to push a market into existence. It will take continued uptake and innovation of technology, policy, and finance for clean energy to achieve "escape velocity".

Still, disruption can be brutally quick, and disruptors are converging on the electricity industry from all sides. With "incumbents" running the system and "insurgents" pursuing disruption, the key question is whether companies are propelling the innovation and risk-taking essential to the clean energy transformation or are getting in the way. While there are active incumbent forces trying to be obstacles to accelerating clean energy to escape velocity, other incumbents are partnering with insurgents or actively working to morph themselves into disruptors.

There may not be a bigger driver of change and spirited engagement in the electricity sector right now than distributed generation. Rooftop solar, though still a very small percentage of U.S. electricity generation, has been growing exponentially, driven by third-party financing and increasingly controversial net metering policies. The opportunities from distributed energy go beyond generation to include a range of other functions and technologies, including: demand response; frequency regulation and other grid services; energy efficiency and demand management; and energy storage. For the foreseeable future, the incumbent centralized and emerging distributed systems will need to co-exist, and optimal coexistence will mean a robust two-way flow of data, operability and, of course, electrons. From a technical perspective, there are currently important issues around integrating the various distributed technologies – such as solar panels, batteries, inverters, and control systems – together into a system. Such a cohesive and systemic approach seems within reach; the challenges lie in reforming policies and business models to enable the incentives to make it all work.

Often asked in the debates around policies designed to promote distributed resources is “who is going to pay?”, but the more relevant question is increasingly “who is going to get to make money providing what customers want?”. Customers are becoming key drivers of change in the electricity world, as technologies enabling the servicing of customers’ energy desires and the tailoring of offerings to individual consumer preferences are being imagined and offered. There are many kinds of consumers, though, including ones that want to take control of their energy and ones that want others to do it for them; utilities and other companies in this space have to be very conscious of which consumers will actually engage in which areas. Certainly, bringing customers to the center of the conversation is still a relatively new thing for the electricity sector, and regulatory structures are not in any way optimized to encourage innovation of the customer/provider model. Some state regulators are pursuing initiatives to create space in the electricity sector for experimentation and for the development of customer-focused partnerships between technologists and energy providers. Such partnerships could allow utilities – or, depending on regulatory approaches, non-utility players – to provide a range of potential new services to their customers (including both energy and non-energy services), dramatically increase customer engagement and interaction, and provide consumers with a bundle of products that will be sustained and supported.

Technology and policy choices all have tradeoffs, and there may be no more compelling organizing principle by which to evaluate choices than climate change. Climate action and clean energy innovation have both been key priorities of the Obama Administration, and the Administration’s Climate Action Plan includes mitigation (e.g., the Environmental Protection Agency’s Clean Power Plan), resilience/preparedness, and international efforts, each of which is likely to be highly impactful in the energy sector. Political polarization has stymied efforts to advance climate action and clean energy innovation in Congress, but the clean energy revolution has the potential to be trans-ideological, as clean energy makes sense and money for a wide range of interests and priorities, including jobs, national security, "Creation Care", individual choice, climate change, and public health. Outside of Washington, DC, U.S. states and cities are taking increasing action on climate change, including directly regulating carbon emissions, incentivizing energy efficiency and clean energy generation, and serving as test beds for technologies. China, meanwhile, is pursuing policies that include climate change at their core that will drive trillions of dollars of investment in clean energy markets. It seems clear that, outside of Congress, action on clean energy and climate change is moving at a nearly unprecedented pace.

Major highlights from the 2015 Aspen Institute Clean Energy Innovation Forum included the following:

- *Technology, new entrants, changing consumer demands, and financial innovation are all driving change in the clean energy sector; policy is both a reaction to and factor in these changes.*
- *The growing cost-effectiveness of distributed generation is challenging the legacy electricity sector, though the rate and direction of change vary across the country.*
- *The changing expectations of customers, enabled by technology and finance, are forcing the reassessment of incumbent business models and leading to a growing class of "insurgent" new participants in the energy sector.*
- *Climate action and clean energy innovation are not the same thing, but they are inextricably connected, and the clean energy revolution is showing increasing signs of becoming trans-ideological, beyond the confines of the climate debate.*
- *Achieving scale in the deployment and adoption of clean energy technology depends on the ability to integrate into existing systems and meeting the diverse needs of energy consumers.*

STATUS OF TECHNOLOGY, POLICY & FINANCE

Technology, policy, and finance are the three traditional underpinnings of the energy sector. Policy and capital markets are generally not very agile in responding to the evolution of technology, and technology tends not to be very agile in the byzantine world of policy. While each leg of the stool is important, technology and finance have become the principal drivers.

Status of Technology

The electricity grid has been optimized over the course of a century to be safe, reliable, and cost-effective. The grid infrastructure is now being stressed, stretched, and rebuilt due to a range of factors, including the advent of solar and other renewables. In the United States, costs have declined and deployment rates have increased for wind, solar, LEDs, electric vehicles (EVs), and batteries, though the markets for the latter two have not fully taken off yet. LEDs have gotten brighter, cheaper, and more efficient. Solar photovoltaic (PV) modules have gotten 80% cheaper in five years. Lithium-ion battery storage is already a $10 billion business, improving slowly at a few percent a year (a key question is whether it can improve faster). With little new demand growth, these new assets largely displace incumbent assets that are already in place, creating a risk of stranded assets. The technologies that are likely to be in the U.S. fuel mix, though, are still diverse – a mix of old and new.

When considering technology options for new power generation in the United States, it is important to recognize that "levelized cost of energy" (LCOE) is a fundamentally flawed framework. LCOE excludes environmental impacts, geographic variability, the time-varying nature of markets and prices, and transmission and distribution infrastructure. If at least geographic variability and environmental impacts from generation and construction are considered, as well as the traditional direct costs of electricity (e.g., CAPEX, OPEX, fuel), then analysis indicates the cheapest technology options for new power plants around the nation (assuming natural gas prices around $5) are generally natural gas combined cycle (NGCC), wind (where there is a lot of wind), and nuclear. With lower natural gas prices (around $3), natural gas takes some territory from wind and nuclear. In this analysis, coal is only the cheapest option in some locations if one ignores environmental impacts, whereas a high price on carbon dioxide would benefit wind and sometimes nuclear. Utility-scale solar starts to dominate only once solar gets down to $1/watt (which it is getting closer to); solar and wind also do better if subsidies are considered.

This analysis, though, does not account for transmission and distribution (which are 40% of the cost), which means the potential role for the increasing proliferation of distributed generation (DG) technologies is not considered. It also does not account for the fact that avoiding peak demand (with energy efficiency and demand response, where technology has also been improving) is always cheaper than building new plants. In addition, the analysis looks only at what is cheapest and not at firming, hedging, resilience, reliability, or other factors that would matter.

There are also other technologies that are beginning to come into their own. For instance, companies are at the beginning of trying to get smart devices to communicate and use data in richer (but still secure and reliable) ways. This "internet of things" can provide a range of services, from advancing home automation to enabling greater diagnostics that can provide warnings on a predictive basis of when equipment needs to be serviced.

Status of Policy

The energy and electricity sectors are moving so fast in the United States (and globally) that Congress is lagging. Congress does not move at a pace commensurate with the rate of technological change and is poorly equipped to provide regulatory instruction or guidance. Politicians respond to the short-term and are not nimble. This reality is amplified by the fact that Washington, DC, is gridlocked on energy due to serious disagreements. While the Senate is working on a bipartisan energy bill, there is nothing close to consensus on some topics in Congress as a whole, such as how to grapple with the technological and regulatory issues around moving from a single-direction grid to a bi-directional grid. The long tail of Solyndra also persists in Congress; that one bad story lives on and has had huge impact.

The main locus of policy action on clean energy in the United States is almost certainly at the state level.

Policy action is still occurring on issues related to clean energy – just mostly not in Congress. Climate change and clean energy innovation are both priorities for the Obama Administration, and the EPA's Clean Power Plan has the potential to be a transformative force in the power sector. Progress on renewable energy is unlikely to cease even if a Republican takes office following the Obama Administration; the business cases are becoming so powerful that people in Congress, state legislatures, and Governors' offices are increasingly recognizing the value of clean energy.

The main locus of policy action on clean energy in the United States is almost certainly at the state level. In several states, government policies have been quite successful in advancing energy efficiency and renewable energy. At a more sweeping scale, New York, with its Reforming the Energy Vision (REV) effort, is seeking to create space for utility business model experimentation, drive clean energy deployment, and devise a new distribution platform that will allow plug-and-play of distributed energy resources. New York is not alone. There is starting to be a critical mass of conversations around distributed energy resources in the United States, with discussions underway in California, Illinois, Texas, Massachusetts, Minnesota, Georgia, and elsewhere. They may not all be as comprehensive as REV, but they are important pieces.

Governments have been key players in the clean energy scene in ways beyond policy as well. The federal government, for instance, has been making baseline investments in enabling technologies (e.g., basic R&D). The research the government has been doing focuses on a range of timescales, from immediate application to 20-25 years out. Governments are customers and partners too; they are often the largest energy users, and in many places they are project developers.

Status of Finance

In almost all fields, the market lifecycle and the adoption curve start with technology, then economics, then permissions, then capital markets. The technology has to happen first, and early technologies are always too expensive and not scalable. That is when the economics part comes in, as early actors make the technologies better and cheaper. Once the technologies are cheap and working, then productive conversations start about permissions (i.e., regulatory, policy, tax, and business environments), after which the capital markets come in. In several aspects of clean energy, the technology and economics phases have been passed, permissions are in place (or are being pursued), and capital markets are starting to become a driving force.

The last decade of the clean energy transformation has been all about finance innovation, following waves of innovation in environmental and climate policy (e.g., the Clean Air Act of 1970), technology, market structure (e.g., PURPA, which let clean energy break into the system), and renewable energy policy (e.g., renewable portfolio standards, tax credits). While there has been financial innovation with regard to the equipment, including project financing and solar installation financing, the most important innovations have involved the capital markets and have revolutionized the industry over the past couple of years. These innovations have taken clean energy to the door of the end game – reaching the mature capital markets and the low-cost capital that incumbents have enjoyed for decades.

The energy business has three primary costs: technological, operational, and financial (i.e., cost of capital). Cost of capital is highly correlated to operational costs; analysts and investors assign a high cost of capital until they see excellence in operational execution. The cost of capital also tends to be high in the face of regulatory uncertainty, which clean energy has suffered from for years. Cost of capital is a vital issue for clean energy, and particularly for distributed energy resources; when deploying energy efficiency or distributed generation in the commercial and industrial world or at utility-scale, someone has to be convinced to spend millions of dollars upfront to get a return over decades. Technologies have to be provable, scalable, replicable, and resilient, or capital will not invest.

Utilities generally enjoy the lowest cost of capital and the longest duration in capital markets. All independent power producers, distributed generation companies, and others that are not utilities get financing outside of that fairly privileged capital stack. For instance, utilities' costs are typically around 7%, whereas Solar City (which is on the lower end of the spectrum for solar PV) is around 9-10%. Renewable energy also has not enjoyed access to tax advantaged securities like master limited partnerships (MLPs) that fossil fuels have enjoyed for years, and it is harder to have lower costs of capital without access to tax advantaged structures.

Still, a transformation in clean energy finance has happened recently to bring down the costs of capital. In 2013, clean energy did its first yieldco, and about $25 billion of yieldco equity capital has been raised in about two years. The debt markets have been tapped with green bonds, furthered by the Green Bond Principles released in 2013, and more than $60 billion has been invested in green bonds since the start of 2014. The rise of yieldcos and securitization in the clean energy space have begun to allow for lower costs of capital.

Capital markets basically got fed up waiting for policy and found ways to create mechanisms that are bringing billions of dollars in investment into clean energy, lowering the cost of capital. If the policy part could start working too, clean energy finance could go even faster and bigger, including MLPs (which are federal tax policy) and the launch of green banks (which are state policy).

Even without some of the supportive policies, though, things have really changed very quickly in terms of accessing the major pools of capital. Money will be moving out of old pieces of infrastructure and into cleaner infrastructure. Real smart money – and a lot of it – is coming to the clean energy space.

DISRUPTION

People in the energy world have to be prepared to be surprised; energy predictions are continually wrong, missing key developments such as the shale revolution and flat U.S. electricity demand. People also have to be prepared to be amazed; technologies that one might think of as being 'the future' are happening now in pockets and places, driven from the bottom up in ways that are eroding traditional actors' influence and domination. And people in the sector have to be prepared to adapt, act, and lead – or to lag and be left behind.

Acceleration & Escape Velocity

We may be 40 years into a 100-year transition to clean energy. It did not start yesterday, and it will not be over tomorrow, but it is a phenomenal transition that has been happening steadily. It will not happen linearly, though; there are about 40 slow years, then 20 fast, then more slow. We appear to be in the early stages of the fast ramp, and what happens then is critical to the future course. (It could be useful to create an annual report – an annual statement of thought leadership that becomes famous and that key industry people and decision-makers look forward to reading – that lays out achievements to date, the current state of affairs, and next steps. There is a big audience for such a report, and it is urgently needed at the early stages of the fast ramp to get everyone on board with the direction things are heading.)

As the fast ramp phase begins, it is worth recalling that disruption can be brutally quick, as the horse-and-buggy learned with the advent of the car. Capital markets tend to be keenly aware of disruption, and investors flee before customers do.

The data is clear that clean energy has begun penetrating markets in ways that were unfathomable a few years ago. Clean energy is no longer sitting at the kids table (though it may not be taken entirely seriously at the adult table yet). The technologies are taking on lives of their own, proliferating beyond the ability to be directed top-down. U.S. energy intensity, for instance, has been improving rapidly just with the innovation that is already occurring. Future innovation will shift the acceleration into fast forward.

It is possible the world could be powered by 100% renewable energy sooner than many think.

It is possible the world could be powered by 100% renewable energy sooner than many think. Technology innovation is accelerating, with better turbines, more efficient PV, and the like. Since variable renewables (e.g., wind output) can be forecasted at least as accurately as electricity demand, grids can balance forecastable variations of wind and solar generation with other kinds of renewables or the same kind of renewables in other places, creating a highly reliable portfolio of diversified, integrated, wholly renewable sources. Clean energy is still challenged by scale, though; if the transition is to happen widely and relatively quickly, an awful lot of clean energy is needed in a rather short amount of time. For instance, with regard to electrical storage – which could help balance a grid heavy with renewables, provide backup power, and electrify transportation – backing up all U.S. power for 12 hours would require 1000 times the current production of lithium-ion batteries; it is unclear whether achieving that scale is feasible.

Still, a renewables-dominated grid is reality today. Germany was 27% renewables-powered in 2014, while Italy was 33% and four other European countries got about 50%, all without bulk storage and with great reliability. In fact, the issues and challenges surrounding destructive and disruptive innovation through technology are being discussed and grappled with, in different political environments, in Germany, China, the UK, the United States, and elsewhere, but there is little effort to understand these trends from a global perspective or to try to understand, compare, and adapt the different answers in different markets. It would be good to learn how European grid operators gained the skill and comfort to juggle half renewables and to see what could be replicated and accelerated in the United States.

Despite the potential, the progress, and the accelerating disruption, the general view is that clean energy has not yet achieved escape velocity. Technology, policy, and financing will all be essential to clean energy achieving escape velocity. Technology will have to continue to bring down the price of renewables, efficiency, the smart grid, storage, and the like, becoming ever more affordable and better integrated. Policy will need to ensure that escape velocity is achieved with reliability (as there are consumers on these rockets) and will need to move beyond the tax credits and smaller items that have served as rocket motors thus far but have fallen far short of warp drives. It is possible that the clean energy industry will not reach escape velocity without the fundamentally changed market incentive of a high and rising carbon price (and if not necessary, it may at least be economically preferable). With regard to finance, low-cost equity capital will define the clean energy sector's ability to reach escape velocity.

> ***Technology, policy, and financing will all be essential to clean energy achieving escape velocity.***

A lot still needs to be done to make the case for the energy future that advocates envision – including getting costs to the point that everyday citizens say it makes sense, improving policy predictability, using a range of tools to address the soft costs of energy efficiency and renewable energy projects, and ensuring access for a range of consumers. The clean energy community also has to figure out how to draw a box around some units of society and, through collaborations and partnerships, create all the features that the community is talking about in different parts of the world. The community needs to create its ideal in places where there is grand collaboration between incumbents, insurgents, and governments. Those places could help prove that reliable, affordable, and clean are inseparable from each other and that the clean energy economy is not only possible but also achievable at a pace and scale that matter.

Insurgents Versus Incumbents

Disruptors are converging on the electricity industry from all sides, multiplying faster than most regulators and utilities can cope. This dynamic could be thought of in a frame of "insurgents" versus "incumbents"; though those labels are not perfect, they highlight essential temporal and directional aspects of companies. Incumbents are the ones running the system and/or benefitting from the system as it is currently constructed, and they are not monolithic. Insurgents tend to focus on specific tasks and are pursuing innovation and disruption. "Incumbent" and "insurgent" are not two static states; some players can be both at the same time. Nothing limits an active incumbent player from becoming disruptive and innovative itself, though incumbents that cannot adopt the attributes of innovation and disruption are likely to become dinosaurs. The core attribute may be change versus fear of change. Innovation and risk-taking are essential ingredients to the clean energy transformation; some companies are propelling it, while others are getting in the way.

There are active incumbent forces trying to be obstacles to or subversive of the goal of accelerating clean energy to escape velocity. Since they generally cannot win on the economics or the technology, they are turning to politics and communication. Solyndra was not just a bad story; it was a bad story with multiple millions of dollars of the best communications and PR firms behind it to beat it to death. Some incumbents are also organizing new coalitions to obstruct the process of advancing renewables and efficiency, including organizations such as AARP that are concerned about costs being shifted onto consumers. In addition, there are organized attempts in numerous states to roll back existing regulations advancing clean energy, furthered by the efforts of the American Legislative Exchange Council (ALEC). (It may be beneficial for more companies to attend ALEC meetings so state legislators can hear more than one side and can have a real discussion about important issues.) Utilities' efforts to stop disruptors, such as anti-solar tariffs, could end up being boomerangs that annoy customers and accelerate adoption.

Nothing limits an active incumbent player from becoming disruptive and innovative itself, though incumbents that cannot adopt the attributes of innovation and disruption are likely to become dinosaurs.

Apart from active opposition, there may also be parameters that constrain corporate action, such as how boards and corporate executives perceive their fiduciary responsibilities to uphold profitability for shareholders. While these constraints are real, they do not excuse a lack of leadership, and an argument could be made that board members of incumbents who are blocking change instead of welcoming it may be violating fiduciary duties.

Insurgents, though, may only be able to get so far on their own. A lot of insurgent companies have people from the technology sector, who came into the electric utility industry thinking it was like any other industry – and it is not. The electric utility industry is a strange business governed in strange ways, and it is difficult to change something one does not understand. Waves of technology companies have died on the vine because they did not understand the industry and its laws and regulations. Incumbents may be useful or even necessary to clean energy scaling.

While the pace of transformation is set by the insurgents, the incumbents are incredibly important parts of the equation. With a transition this rapid, the incumbents will have a say in what the pathway for clean energy looks like, how the distribution system will evolve, and other key issues. Incumbents could also serve as strategic partners, invest in early-stage companies, and buy insurgents and offer their products as their own. Partnerships between insurgents and incumbents are key and can be significant and productive, though incumbent-insurgent collaboration can at times be a challenging path; there are many people wandering in the desert talking to the wrong people for a long time. Where those partnerships are not happening, more thought is needed on how to create the space and incentives to push incumbent-insurgent partnerships. The "incumbent" and "insurgent" labels themselves may need to be discarded to further partnerships; those labels do not further dialogue and do not neatly fit many players in the field.

Some incumbents are actively working to morph themselves into disruptors, or at least to explore the space. While many utilities are hanging on to their core product and business model, some are also beginning to look at the possibilities of where they could go; there is generally more going on in individual utilities' back-office R&D teams than utilities let on in public. The revised utility business model is a big opportunity; it is not so much that utilities are against innovation as that they are not currently rewarded for being innovative by those who govern them. Some utilities will remake themselves, and some will not, and policy frameworks can facilitate that.

There will be winners and losers among both the insurgents and the incumbents, and that is fine. Broader trends can be predicted more accurately than which companies will lead the way or dominate the market; trends have pathways of their own, and business obsolescence will outpace technology obsolescence. With the technologies coming in, the winner should be the customers and the world, and everyone else should fight it out for themselves. Not every virtuous device and company can thrive just because they are virtuous, just as not every publicly traded utility has to last forever.

DISTRIBUTED GENERATION INNOVATION

There may not be a bigger driver of change and spirited engagement in the electricity sector right now than distributed generation (DG), about which there are several consequential policy debates underway at the federal and state levels. DG generally refers to electric power generation at the point of consumption – i.e., the generation of power on-site, rather than centrally. DG and other on-site energy tools, collectively referred to as distributed energy resources (DER), represent a paradigm shift in the electricity sector.

Rooftop Solar & Net Metering

In 2014, 6.2 GW of solar were installed in the United States – one-third of all the solar ever installed in the country – and half of that was DG. While solar still makes up less than one percent of energy today, it scares some utilities even at those low levels, though other utilities see enormous opportunities from both utility-scale and distributed solar. While utility-scale solar is cheaper, rooftop solar is more customer-centric.

Rooftop solar has also been heavily driven by rate structures that pay homeowners for the electricity they generate – policies known as net metering. Net metering has been a financial convenience to homeowners and has spurred a lot of investment, however there is a lot of drama about ensuring that rooftop solar consumers still pay for their use of the grid. Some view net metering as using grid costs to subsidize solar, while others argue that if net metering truly had utilities and customers paying each other fair values for the services both are providing, the non-energy values of rooftop solar are worth more than the system costs (i.e., net metering customers may be subsidizing the grid). Net metering rates and policies also tend to be designed to incentivize, not to optimize. Utilities managing the grid would rather have energy production later in the day, which would suggest having solar panels on the west side of the house. Net metering policies incentivize maximizing production, which would suggest having panels on the south side but which does not help the system with capacity. In addition, traditional rate designs, such as block rates and other kinds of volumetric rates, become more complicated when the end user is also a generator, and time-of-use rates can get similarly complicated if the times in those rates do not adjust to a shifting peak. Getting the residential retail rate design structure for rooftop solar right could unlock an advanced energy economy for millions of residential customers.

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A Distributed Future

The DG horse is out of the barn, and it will not be put back in. Incumbents ought to view DG, and DER more broadly, as an opportunity. While there are certainly challenges, they are solvable, and the opportunities (especially 5-10 years out) are tremendous. The opportunities go beyond rooftop solar, which is just the bellwether in many ways. Incumbents will be looking at a range of other technologies, such as demand response, energy efficiency, and energy storage, as they try to operate a more complex system. Managing, reducing, and shifting demand can bring real value to incumbents' systems. Distinctions are sometimes made between energy efficiency and renewable energy, but those distinctions are artificial from the end user's perspective. Both rooftop solar and smart thermostats have the same effect on the system in terms of reducing demand and allowing demand to be shifted.

DG and other DER are becoming consumer products, and people will increasingly have the choice to use them if they want to and to opt out of the grid if they want to. The transition, however, has to embrace a variety of solutions. Some consumers will want to take control of their energy, and some will want others to do it for them. Some will want the security and low rates of a grid tie, and others will want to augment it or cut the tie with self-generation. It is foolish for policy and planning discussions to lock into any single paradigm or platform. Instead, it makes sense to try to optimize both centralized and distributed systems. There are situations in which DG and energy efficiency are the least-cost method to maintain service and reliability, and there are situations where centralized power is the least-cost method. (It should be noted that there are grid integration costs involved in both.) Having both centralized and distributed systems also provides benefits in terms of resilience; since the grid already exists, adding distributed energy resources provides tremendous optionality, allowing centralized and distributed resources to back each other up. There is a role for utilities to be the ones to act as intermediaries to pull the various centralized and distributed resources together.

The distribution level is the purview of state governments, which means this will largely get figured out state by state. It is possible, though, that the proliferation of DG will call state authority in this area into question, spurring calls for increased regional and national authority and diminished state authority. Decisions will be made shortly about whether demand response, distributed generation, storage, and other aspects fall under state or federal regulatory control. One way or another, the new technologies and increased competition create new needs for generation and distribution markets and changes in how those markets are regulated. Utilities will want more flexibility and a way to incentivize DG in places where it benefits the grid. Resolving the regulatory picture around DER will help determine not only who has to pay for the transition but also who gets to make money from it.

One way to enhance the ability of some players in the DER space to make money from the transition is by getting the cost of capital for DG down even further. To do that, there is a need for a secondary market that sits underneath everything; secondary markets in asset classes drive investment. For money to come from the secondary markets, the primary market has to structure things in a way that addresses the risk stack to make it simple for the capital markets. Distributed generation today, however, is complex; DG needs to move from bespoke projects to structured finance. The rules, laws, tools, and structures to get DG to the more efficient secondary markets are still lacking.

Systems

DG and DER technologies have become a force in recent years, but it is rare for any given DER technology to operate in isolation. A key issue now is integrating the various distributed technologies together – such as solar panels, batteries, inverters, and control systems – and thinking more deeply about what benefits are being offered to end users. (Energy systems can also involve more than just electrons; much electricity generation produces heat, which can replace natural gas.) Integration into a system can unlock significant value. For instance, new office buildings in 2015 are far more energy efficient than those built in 2010, not because the technologies have changed but because they are better integrated. For buildings such as hospitals that require secure and resilient power, on-site generators can now be replaced by a system of renewables and batteries. Similarly, the combination of PV and load control (e.g., smart appliances) could end up shifting 80-90% of a household's load to the times when rooftop solar panels are running. There is power in taking a systems perspective.

Greater focus is therefore needed not just on the devices but also on the connective tissue that ties the devices together – the instruments in the orchestra and the orchestra itself. Connective infrastructure is needed that determines when to take rooftop solar power to charge a vehicle battery versus for some other value – and in a way that is fairly transparent to consumers. All the little local controls, from synchrophasors to thermostats, have to work in harmony and communicate in a way that is resilient enough to allow for malfunctioning pieces to be isolated and the rest of the orchestra to keep playing. That resilience has to be available at the level of individual consumers, homes, vehicles, and buildings, at the same time it is available at the macro level for the whole grid. There is a need to create multi-scale levels of control, from the local to the systems level.

> ***Well-intentioned regulations promoting efficiency can sometimes pose an additional obstacle to efforts to create an integrated, connected energy system.***

There are challenges in creating such an integrated, highly connected system. A key one is data communications, as integration currently involves different pieces of software from different developers and manufacturers. Interconnection can also be a huge challenge; even within a single building, there are times the different pieces have to be done and financed separately. Getting everything to work together in a quality-controlled way is a further challenge – but a surmountable one. The security issues around DER are real too; it is generally rather easy to hack into these systems. In addition, it can be very hard to enable iterative dynamic policymaking that can respond to changing conditions in a way that facilitates the range of technologies working together.

Well-intentioned regulations promoting efficiency can sometimes pose an additional obstacle to efforts to create an integrated, connected system. For example, regulations in numerous countries to drive down vampire loads are being applied to devices in the "internet of things", despite the fact that these technologies save five to ten times more energy through the network effect than they use. Focusing too squarely on the energy usage of each device can miss the forest for the trees; these devices need some standby power for their sensors and to ensure they are constantly awake to the network, but they save far more than they use through systemic efficiencies.

Integrating parallel systems can be even more challenging. An emerging federal agenda is systems science, figuring out how to integrate systems of systems – generation, water, transportation, infrastructure, security, etc. – to gain synergies and benefits.

SPURRING TECHNOLOGICAL ADOPTION

Technology development is generally bottom-up, focused on devices and materials instead of on systems. Even with the boom in clean energy deployment, technologies are still not getting adopted at scale fast enough. Whether in the transportation or power sectors, spurring greater deployment and adoption of technologies that already exist is a continual challenge.

Adoption of Transportation Technologies

These appear to be heady times for electric vehicles, with more than 20 models on the market in the United States. EVs, however, currently live and die on subsidies, which can be a double-edged sword; as regulators take away subsidies, sales fall. The EV adoption curve has also been flattening, even with all the cars on the market and all the incentives. Low gas prices are part of the decline, as buyers save less money and the market moves back towards bigger vehicles. The lack of public charging infrastructure is also part of it, as is the huge depreciation in value that moves people to buy used EVs rather than new ones. It is becoming increasingly difficult to get past the early adopters. Regulations are trying unsuccessfully to force a market. In California, the Air Resources Board is requiring 22% of sales by 2025 to be EVs, while current sales are below 1%.

Focus on technology adoption should not be too U.S.-centric, however. In 2014, China was the third largest market for EVs, with its market more than doubling during the year, and China's EV targets far surpass California's; if China even comes close to its targets, it will have a huge impact on the market. The focus should perhaps not be too road-centric either. While on-road electrification gets more publicity, great inroads have been made with non-road transportation, such as by electrifying cranes, conveyors, and other machines at ports, mines, and elsewhere.

There may also be a different strategic path for EVs based on light-weighting and carbon fiber. The current EV strategy for most car manufacturers is to put an electric power train into a heavy, high-drag vehicle, but making a car out of carbon fiber can get rid of half to two-thirds of the weight and drag. It can also use about two-thirds less energy to run the car, get better performance, get the same or better safety and range, and use approximately three times fewer costly batteries or fuel cells. Fewer batteries means the vehicle can be recharged in a reasonable time using ordinary house current (instead of extra charging infrastructure); if using fuel cells, it means they can be much smaller, which allows them to reach competitive prices faster. Some manufacturers are exploring this light-weighting strategy, and it turns out the expensive carbon fiber is paid for by the need for fewer batteries and the radically simpler auto-making process. It may be possible for the United States to run an expanded transport system in 2050 with no oil, running on a mix of hydrogen, electricity, and advanced biofuels (for trucks and airplanes).

EV adoption could also be spurred by other developments. For instance, it is possible that EV costs could come down dramatically, as happened with solar PV and wind. Similarly, finding ways to value the stored energy in an EV could help offset the costs of the vehicles; for instance, gathering dozens of EVs in one spot to provide auxiliary services to the grid late in the day would help cover the incremental costs of the vehicles, if the EVs could get paid for that service. Thus far, though, the goal of volumetric displacement of oil through EVs has not yet been achieved.

Spurring adoption of other clean technologies in the transportation sector has proven to be challenging as well, and some technologies seem like they are perennially 50 years away. Compressed natural gas (CNG) is expensive, faces issues with compression, and is only a partial solution from a climate perspective. Hydrogen is hard to make, store, and move, though if there could be a big, coordinated push on infrastructure up front (which is unlikely in the United States), hydrogen might be a viable option. Utilities looking at vehicle-to-grid technologies may be disappointed for a couple of decades due to the lack of volume and needed improvements in software.

As for the internal combustion engine, it will keep getting better, such as through improvements in materials. There is no consensus on whether internal combustion engines will still be the majority of the fleet in 50 years, but to the extent they still exist, biofuels are a neglected technology that could deliver near-term greenhouse gas benefits – though biofuels have had their own deployment challenges.

Clean Power Deployment

Technologies in the clean energy space have generally needed big players to get deployed at scale. Wind turbines, for instance, came down in price because some industrial giants got involved. Those types of companies can provide not only economies of scale, but also cross-sectoral experience that can help integrate technologies into a system and make them work both functionally and economically. Startups are good at solving discrete problems, but coupling innovation around a specific problem with systemic issues and scales can require the involvement of large companies with huge assets. Partnering with incumbents or large entities that have wherewithal, resources, and vision can help innovators understand the market and gain credibility.

Large companies can also play a vital role in clean energy deployment in their role as customers. A lot of corporate CFOs and finance people are starting to realize that energy efficiency really does help the bottom line and that there is real money in renewable energy. With the Corporate Renewable Energy Buyers' Principles, large commercial and industrial customers have basically spelled out what they want in energy. While many utilities are still somewhat culturally resistant to the distributed and clean energy worlds, solar and other renewable energy providers are much more eager to meet those customers' needs and desires. If utilities introduce new programs in those areas that have real value in deploying clean energy, many retail customers would be eager to join.

Big players in the energy space are not only located in the private sector. The military is another huge entity that plays in the energy space – primarily for mission effectiveness and operational efficiency – by deploying energy efficiency measures, increasing the use of renewables, and promoting microgrids that advance regional resilience. The military will generally work first with incumbents to get energy that fits its desired attributes, but if the incumbents cannot provide it, the military will work with insurgents to get it. The military can also act as a market leader and can be a way for incumbents and insurgents to come together to test technologies and models, as well as to push for the right policies.

Partnering with incumbents or large entities that have wherewithal, resources, and vision can help innovators understand the market and gain credibility.

Beyond the military, the federal government more broadly can be a pivotal player in clean energy deployment. The government cannot chase after every new gadget – that would be a terrible way to invest public dollars – but the curmudgeons in some bureaucracies are slowly starting to be educated on the value of changes in energy and are starting to open their minds to new ways of doing business that involve better sharing of risks and rewards. For the federal government to be nimble or use the full weight of its purchasing power to drive change in energy, however, there is a need for a group of smart contractors, acquisition lawyers, and others across the government to go through all the rules on the books and streamline them.

Another clear role for governments in clean energy deployment is through policy. Policies can set the direction and help bring the right players together in the beginning, at which point a functioning market can come into being and drive further progress, overtaking policy. Hawaii is a case study of that, with policies to get the state off of oil spurring robust renewable energy markets. States have a responsibility to create space in the regulatory and policy framework to allow innovation and to foster technology deployment.

Utilities, of course, can be another important avenue for clean technology deployment. The current regulatory model for utilities worked great for the past hundred years during high load growth, but that is no longer the case. As alternatives are explored for how to pay utilities, there is an opportunity to align the clean energy market path with the fiduciary duties of utility executives. Performance-based regulations that delineate clear outcomes (e.g., affordable, reliable, clean) and specific metrics for those outcomes can tie utility compensation to performance on those metrics. Many utilities are interested in pursuing that model instead of a cost-of-service, rate-of-return model.

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At the moment, though, many large utilities do not have a real underlying incentive to reduce their customers' electricity demand, so accelerating deployment may require focusing on groups that do have an incentive to reduce energy use, such as munis and co-ops. Rural co-ops could actually be terrific laboratories for distributed energy resources, as they have to replace 50+-year-old infrastructure on low-density lines that never make enough revenue to pay for themselves.

CUSTOMERS & TECHNOLOGY

For most utilities, the "customer" has historically looked like a meter. Technology companies, however, have long had a strong focus on consumers, which is not typical in the energy sector. Some utilities are starting to recognize the need to know more about their customers and so are beginning to ask customers about their needs. Leveraging technology and new business models can enable needs – both individual and societal – to be met in more sustainable ways, whether at the level of a home, an office, or a city. The customer is now a driver of action in the electricity world.

Technological Focus on Consumers

Some of the key technological breakthroughs in recent years have focused squarely on the holistic customer experience. The iPod, for example, transformed the music business by enabling customers to carry 1,000 songs in their pockets, with a business model built around people buying individual songs (instead of a whole CD) with increased download quality (e.g., no viruses) from the iTunes store. Massive transformations can happen very quickly and in any sector. Transformative technologies have proven skeptics wrong time and time again, overcoming adversarial market conditions by designing new business models meticulously focused around the customer experience. These technologies have also moved to market with tremendous speed, going from blueprints to market launch in a matter of months; with the advent of 3D printing, that cadence is only getting tighter. That technological cadence and customer focus stand in stark contrast to typical utility approaches to customers and to the cadences in the regulated energy business, which operates on 30-year timelines for generation, retrofits, or revamping grid architecture. Some utilities have hired people from outside the industry to help them think differently about ways they can provide services to customers, such as bundling solar with batteries and storage.

Technology enabling the servicing of customer desires and the tailoring of offerings to individual consumer preferences is disrupting business models in the energy sector. Technology is headed towards a focus on individual experience. With the critical mass of internet-connected devices, personal fitness devices, and sensor devices, there will increasingly be an ability to get a sense of individual comfort and to use that to optimize control systems in the built environment. On an even more individualized level, buildings can use customized chairs that have fans and car seat heaters controlled by a touchscreen that enable each person to be at their own desired temperature without having to heat or cool an entire building.

Giving people individualized control with cool technologies is not the same thing as helping to solve global energy or climate problems, but cool technologies are essential for addressing those problems. For instance, a decade of massive investment around climate awareness has yielded relatively minor and underwhelming outcomes, in part because customers do not have anything they have control over that can hook them from a behavioral standpoint; people have not been empowered previously to take actions in their homes and businesses that can have tangible impacts on global priorities. Technologies, whether in lighting, thermostats, generation, or something else, can put that kind of control in customers' hands. Those customer technologies, however, should also be coupled with basic energy efficiency efforts; for instance, in the residential realm, the majority of homes were built before insulation was required, and clever devices put into or on top of these homes targeting behavior change mean less if the uninsulated homes cannot hold their energy savings.

Diverse Electricity Customers

Not all electricity customers are the same. At the most obvious level, there are clear differences between commercial and industrial customers and residential customers. When customers, particularly commercial and industrial ones, deploy energy reduction technologies (e.g., DG, storage systems), utilities are starting to notice the change in load.

As noted earlier, there are also differences between consumers that want to take control of their energy and those that want others to do it for them. Some utilities have customers asking to install smart devices and figuring out that they can buy fewer electrons, use those in a more productive and timely manner, make some of their own, and trade some. For other utilities, the "average consumer" (especially in the residential realm) has pretty low expectations in terms of a desired energy mix, does not care much whether electricity generation is centralized or distributed, and has a profound lack of interest in energy topics. Utilities and other companies in this space have to be very conscious of which consumers will actually engage in which areas.

Customers differ in their electricity usage as well. Within the residential sphere, there are five general categories of electricity usage, with different peak times and usage patterns. That kind of data can allow utilities to drive demand response programs in a more targeted way, providing personalized information and specific tips at the right time to achieve 5-7% peak reductions across utility service territories and across demographics.

There may also be differences between current consumers and future ones. Kids today are used to being able to use technology to customize everything at the same price. A new generation of homeowners will be unable to fathom not being able to turn down their thermostats with their phones. These new and future customers, with their more customized and connected mindsets, may accelerate the advent of the connected home. For the many millennials that do not want to be homeowners and instead rent and move a lot, community solar may be an option, though for the most part the current business models do not lend themselves to enabling DG for these customers.

Creating Space for Customer-Focused Partnerships

Bringing customers to the center of the conversation is still a relatively new thing for the electricity sector, but it has the potential to be truly transformative.

As consumers grow more empowered, it effectively gives permission to policymakers to act. Currently, regulations generally do not allow utilities to provide many kinds of customer-focused services, which means utilities tend to revert to the regulated business models that they know and are allowed to pursue. As technology adoption curves get quicker, discussions around regulatory structures also need to evolve and increase in speed. It can be a challenge to transpose a customer-focused technology business that is delivering new products and features every few months into the regulated energy construct. The NY REV initiative is trying to enable that transposition to occur, creating space in the utility sector for experimentation, the development of new business models, and partnerships between technologists and utilities to increase utility customer engagement and diversify utility revenues. REV exemplifies the approach of creating space and opportunity instead of plans and business models. Creating the space for innovation to occur can spur breakthrough services and technologies that help residential and commercial customers.

As technology adoption curves get quicker, discussions around regulatory structures also need to evolve and increase in speed.

Partnerships between technology companies and utilities can provide benefits to all involved. Such partnerships allow utilities to provide a range of potential new services to their customers, including both energy services (e.g., demand response programs, discounts on smart appliances that can network with other devices to shift load) and non-energy services (e.g., safety, security). The average regulated utility gets about nine minutes of customer attention per year, so these kinds of partnerships can dramatically increase customer engagement and interaction. Utilities can essentially become platforms for delivering products and services to both active and passive customers that can help them manage their energy usage, save energy, and gain other benefits.

These partnerships not only allow utilities to improve and increase customer engagement, but also provide consumers with a bundle of products that will matter and that will be sustained. The "internet of things" is currently a mishmash of different platforms, different hubs, top-down subscriptions, bottom-up single product options, and many other variations, raising the risk that consumers that are not extremely tech-savvy and that are operating outside of a utility context may hitch their wagons to a platform or technology that will be obsolete within a couple of years.

Partnerships, products, and services should put customer experience right at the heart of the value proposition, and the innovations should drive the next-generation business models instead of the other way around. As electricity and technology companies look to develop new customer-focused innovations, though, it is important that they aim to meet customers where they are going and not where they currently are. As automobile pioneer Henry Ford observed, if he had asked customers what they wanted, they would have demanded faster horses.

CLIMATE CHANGE & CLEAN ENERGY

Technology choices all have tradeoffs. Thinking holistically and systematically, there may be no more compelling organizing principle by which to evaluate choices than climate change. Climate may be at its high point of political and social recognition, with presidents, popes, governors, mayors, CEOs, and others unabashedly making it a priority issue. Climate policies will likely accelerate the clean energy sector's move to escape velocity, though it is not clear if they will be enough to get the sector all the way there or if they will just be a booster rocket.

U.S. Climate & Energy Policy

Climate action and clean energy innovation share a lot of technical elements in common, but the telos or end goal of each is not necessarily the same. The political economies, escape velocities, and near-term priorities for climate action and energy innovation are also different. For climate change, there is an imperative to deploy the clean energy technologies already on the shelf. At the same time, moving today's technologies should not forestall efforts to push clean energy innovation that can yield systems, products, and value far beyond what is in the traditional energy paradigm. Ways have to be found to think about the telos for both climate and clean energy innovation and to bring people along on both visions.

Climate change is certainly the long pole in the tent for the Obama Administration, which has made a full-throated push on the issue, framing climate change in every way that will resonate, including through public health, faith, and national security lenses. The Administration has relied on executive actions, regulatory tools, and convenings to advance climate action in light of a lack of support from Congress. The Administration's Climate Action Plan includes mitigation, resilience/preparedness, and international efforts, each of which is critical. On mitigation, it has pursued a range of regulatory and voluntary efforts to drive down greenhouse gas emissions from many sources, the centerpiece of which is the EPA's Clean Power Plan to regulate stationary sources of carbon dioxide, issued under section 111(d) of the Clean Air Act. Analyses have suggested that the Clean Power Plan is roughly equivalent to a $15/ton price on carbon dioxide, which can be good for reducing emissions and will influence the energy marketplace, though it likely will not be enough to spur bold clean energy innovation. Resilience is an important part of bolstering the political economy of climate action, and the urgency behind it can help those pushing disruptive technologies such as microgrids, DG, and systems integration.

Unlike in technology, in politics, it is not possible to meet people where they will be; the only choice is to meet them where they are today.

The Administration takes the international piece seriously, placing great importance on the international climate negotiations in Paris. The approach of the international negotiations has shifted from global negotiations driving policy and markets to policy and markets driving global action. The bottom-up Paris approach rectifies the most serious problem with the UN Framework Convention on Climate Change and the Kyoto Protocol, which was the division of countries into Annexes – countries that act and those on the sidelines. For Paris, there are numerous developing countries ready to take action, which fundamentally shifts the political dynamic globally and domestically. The climate commitments made by China and Brazil are a big deal (and those countries represent huge markets for clean energy). Even if all the Paris pledges are realized, however, that will represent less than a third of the emission reductions that need to occur. The road must extend past Paris.

The Administration has been actively championing clean energy deployment and innovation as well. A big part of what the Administration will focus on going forward is federal R&D, though there is a billion dollar gap between where the Administration wants to be and where Congress is. For example, Congressional Republicans have pushed to zero out R&D funding for onshore wind, arguing it is a mature technology, even though there is more modeling work that could be done, as well as work on taller turbines, new materials, and other early-stage research opportunities.

The political polarization that has immobilized Washington, DC, has stymied efforts to advance climate action and clean energy innovation in Congress. The politics around these issues has to change, and a convergence of factors in 2015 may create an opportunity. The Pope's climate encyclical and visit to the United States are bringing spiritual leaders behind the climate push, creating a new line of pressure. The EPA's Clean Power Plan has officials in many states, including some of the Plan's opponents, engaging in extensive conversations about how to live with it. The bottom-up approach being pursued in the Paris negotiations represents an opportunity to highlight the impacts that mayors, governors, and CEOs are having. These all present opportunities to broaden engagement.

Stories will also be essential for breaking through the polarization. Figures make politicians' eyes glaze over, but compelling narratives they notice. Stories are important for the general public as well. The clean energy and climate stories have to be told in ways that 11-year-olds can understand. With civics dropping out of the U.S. education system, the public is less informed and less educated than in the past about the theoretical and practical aspects of citizenship, making it even more important for the wonky world of energy and the promising outcomes envisioned to be translated into things that impact people and that they understand. Especially when combined with social media, story-telling can create a huge political force to change opinions.

Unlike in technology, in politics, it is not possible to meet people where they will be; the only choice is to meet them where they are today. Momentum on climate change may not be durable if it is framed solely as a climate issue, as there will not be a durable political base for climate action alone in the United States any time soon. Even though climate change and clean energy do not have identical end goals, they are inextricably connected, the overlap is relatively good, and progress should be made where it can be.

One great feature of the clean energy revolution that is underplayed is that it has the potential to be trans-ideological.

One great feature of the clean energy revolution that is underplayed is that it has the potential to be trans-ideological. Whether someone cares most about profit, jobs, national security, strong communities, creation care /environmental stewardship, climate change, public health, or something else, clean energy makes sense and money. This means that people do not need to agree about which outcome is the most important. Anyone liking any of those outcomes can get behind the clean energy transition; it does not matter why. Focusing on desirable ends, not questioning others' motives, and working together to overcome short-term impediments can help realize longer-term outcomes. The Green Tea coalition in Georgia, for instance, shows the potential for greens to ally with the Tea Party to promote clean energy. Distributed generation technologies can get political pushes from concerns about climate change, resilience to weather extremes, independence, and cyber security. Concerns about redundancy, resilience, and security could create opportunities for investments in clean energy. There are constituencies to be built of cities and others that want to be clean and secure. If some labels can be shed and some condescending tones eliminated, there is an opportunity for trans-political common ground and progress. Efforts also need to be made to structure political decision-making to allow for outcomes that are widely desired, such as through non-partisan commissions or packaging votes for some decisions. Such conversations might even be able to unlock the potential for a grand bargain – reforming the tax code and instituting a carbon tax.

Cities

Outside of Washington, DC, there has been tremendous growth in climate action in cities in a relatively short time. Cities are increasingly organized and working with each other to figure out how to scale and work more efficiently on climate issues at the city level. Cities are tracking and reporting data to figure out the trends that are occurring, setting up supportive infrastructure (e.g., better solar permitting), developing supportive local policies (e.g., zoning codes, building codes, benchmarking laws), and taking action on their own projects (e.g., clean energy, LED programs, combined heat and power, microgrids, buses with regenerative braking). Cities do not have the direct levers for spurring change that states or federal agencies have, but cities are trying to understand what levers they do have to support change in helpful ways.

Cities are getting more sophisticated and proving themselves as test beds for technologies. Cities are great laboratories, as they tend to be more nimble and willing to take risks, though some are finding it challenging to stay focused and not to get distracted by every new gadget. Mayors are also constantly searching for things that have worked elsewhere that they can adopt and adapt for their cities. In addition, cities are the ones that have to respond to extreme weather events, and that realization – driven home by Superstorm Sandy in 2012 – has been a real factor in changing cultures and mindsets. Cities are beginning to plan more with climate change in mind; climate adaptation and resilience are increasingly entering the picture. There is lots of coordination happening among cities on climate forecasting and planning too.

Cities tend to have close relationships with utilities as well – particularly with an eye towards consumer service, engagement, and protection – and there is increasing convergence between utility infrastructure and smart cities. For instance, cities are trying to manage growing concentrations of people and get real-time data on quality of life, things that need to be fixed, crime, and the like, while at the same time there are millions of high-wattage outdoor lighting fixtures in the country – many of which are owned by utilities – that will likely be changed to LEDs in the next 10-20 years. Putting sensors, wi-fi radios, some storage, and other technologies inside the LED light fixtures combines super-efficient lighting with sensors located where most human activity occurs. The sensor data can be transmitted through the internet to an application platform, where developers can develop apps to make use of the data – whether telling people in a city where open parking spots are (thereby reducing downtown pollution), monitoring buses and traffic, or analyzing video to improve security. There is no reason incumbent utilities could not get into providing infrastructure that facilitates parking or safety or other systems for cities, though there are "big brother" privacy concerns to address.

Top Chinese leaders see clean energy innovation as a way to solve a whole suite of top issues at the same time, including climate change and air quality.

China

While there are different political ecosystems for climate action and clean energy innovation in the United States, there appears to be no such division in China. Chinese policies that include climate change at their core will be massive drivers of trillions of dollars of investment in clean energy markets. Top Chinese leaders see clean energy innovation as a way to solve a whole suite of top issues at the same time, including climate change and air quality. (The air situation in China is now so bad that it is threatening social and political stability, and the government is committed to putting lots of money into cleaning up the problem.)

While China is the largest coal user in the world, using twice as much as the rest of the world combined, it is also the biggest clean energy market. China is the top country in terms of spending on clean energy, at $53 billion. It is the largest PV manufacturer and will soon be the largest market, and it is the largest wind manufacturer and market. Grid-connected solar increased 67% and wind capacity more than 20% in 2014. China will also soon be the largest EV market. All of these markets were very clearly driven by policy. China is also investing more in material science than the United States. While there are many things the United States does not like about the situation in China – such as clear problems with intellectual property – the plummeting commodity prices for clean energy that are critical to the transformation are occurring because of Chinese policies.

As noted, China is also making strong climate commitments on the international stage. The November 2014 U.S.-China bilateral agreement, which forms the basis of China's international commitment, provides a strong foundation for the Paris negotiations and will further spur domestic policy implementation. The set of policies China put on the table is really important, including peaking emissions by 2030 and having the share of non-fossil energy be 20%. That means building a United States worth of renewables or nuclear power in the next 15 years. Add to that the fact that top leaders have said they want deep power sector reform, ambitious air quality rules, and perhaps a national carbon market, and it seems clear that Chinese policy on the synergies between air quality, the power sector, and climate change will drive markets and make China a proving ground for clean energy technologies.

APPENDICES

AGENDA

Monday, July 20

9:00 AM – 10:45 AM SESSION ONE: The Big Picture

Energy markets are undergoing near unprecedented change. Abundant oil and gas – and falling prices - are leading to consolidation, reassessments of capital investments and geopolitical impacts. What is the impact on the clean energy sector? In this session, we will level-set where the energy sector is today, how deployment of capital and changing business models are signaling where the sector is going, how innovation is driving fundamental change, and how policy is responding.

Moderator: **Roger Ballentine** and **Andy Karsner**

Discussant Topics:

The Relative Price of Energy	**Michael Webber**, UT
The Cost of Capital	**Stuart Bernstein**, Goldman Sachs
Challenges and Opportunities: A View from Capitol Hill	**Hon. Elizabeth Esty,** Member of Congress
The Present Future of Clean Energy	**Amory Lovins**, RMI

11:00 AM – 12:30 PM SESSION TWO: The Transformation of the User Experience – The Blurring of the Lines Between Energy and Information Management at Home, Work and Beyond

The trend towards a cleaner, more resilient and more interconnected energy system is being lead in large part by devices and services found all around us – in our homes, businesses and nearly everywhere in-between. What was once a kitschy Jetsons-like dream is now much more realistic. With smart fridges, wi-fi enabled light bulbs, intelligent thermostats, smart phones and the "internet of things" (IOT), the dream seems a lot less impossible. What are the opportunities and challenges of connecting the currently unconnected? Can the energy system keep pace with the new way consumers consume information and entertainment? What are the implications for aggregate energy savings from the alignment of information and technology? Will efficiency and cleaner energy necessarily be beneficiaries of a new model of energy use and consumption?

Moderator: **Andy Karsner**

Discussants Topics:

The Regulated Leapfrog	**Andy Baynes,** Nest
IOT: Secure, Scalable, Interoperable	**Geoff Sharples,** Intel
Bright Ideas in Control, Efficiency and Analytics	**Hugh Martin,** Sensity Systems
Large Scale Building/ Industrial Efficiency	**Paul Camuti,** Ingersoll Rand

2:00 – 4:00 PM SESSION THREE: Distributed Generation Innovation and the Disruption of the Electricity Services Business Model

Playing out in different ways and at different speeds across the country, the role of distributed generation (DG) is growing. Led by commercial, industrial and residential solar, perhaps no clean energy application has more promise for growth. What are the right business and regulatory models and tools for DG? How should DG be incentivized and what are the most equitable ways to meet growing demand for DG while balancing incumbent and ratepayer interests? What are the answers to controversies over net metering, third party ownership and integration with storage and IT technologies? What might a "post DG" grid look like?

Moderator: **Roger Ballentine**

Discussant Topics:

Innovation in DG	**Robyn Beavers,** NRG
Rooftop Solar – Problem or Opportunity?	**Jeff Guldner,** APS
The Emerging Retail Consumer	**Dave Ozment,** Walmart
The Changing Utility Model	**Chuck Darville,** Southern Company
Making DG Capital Costs Competitive	**Jeff Weiss,** Distributed Sun

Tuesday, July 21

9:00 – 10:30 AM **SESSION FOUR: Technology Evolution from Development to Adoption – Cracking the Nut**

To achieve the electrification and interconnectivity of almost everything we use, the timeframe to get technology to market must accelerate. Can low energy prices accelerate innovation and shorten the time for technology to reach market? What are other ways to shorten the gap? What role should regulation play? Are there market changes that need to occur to assess the potential value of technology? How do you change established behavioral patterns to encourage adoption?

Moderator: **Andy Karsner**

Discussants Topics:

Bridging the Technology Gap	**Peter Littlewood,** Argonne
Storage, Systems and Constructive Disruption	**Bryan Hannegan,** NREL
The Limits of Regulatory Push and Market Pull	**Bill Reinert,** ret. Toyota
Assessing Value and Strategic Involvement	**Colleen Calhoun,** GE Energy Ventures
Deploying New Technologies	**Dennis McGinn,** US Navy

10:45 – 12:15 PM **SESSION FIVE: The Pope, Paris and 111d – Is Climate Driving Real Market Transformation?**

Climate skeptics say that we don't know how serious climate change will be, and they're right. But isn't it still prudent to address threats even when we're unsure of them? Clean energy markets and technologies were once wholly dependent on policy and regulation largely based on the threat of climate change to gain a toehold and begin scaling. Today, the growth of clean energy markets and technologies is a global phenomenon that is outpacing useful policy promulgation and regulation, as people have radically overestimated the sacrifices and dramatically underestimated the opportunities. Inevitably, greenhouse gas regulations, climate concerns, Congress and the courts are continuing to shape markets at home and abroad with big questions looming like: What is impact of EPA's section 111d? Is it ultimately a state issue? What succeeds the solar investment tax credit? What is the prospect and impact of a global accord in Paris? Does all of this accelerate change or are emissions reductions along for ride driven more by information technology and consumer choice?

Moderator: **Roger Ballentine**

Discussant Topics:

111d – The Convergence of National Energy and Environmental Policy?	**Ali Zaidi,** OMB
The Road to Paris goes through Beijing	**Eric Heitz,** Energy Foundation
The View from Financial Markets	**Michael Eckhart,** Citi
Local Opportunities; Global Impacts?	**Katherine Gajewski,** Philadelphia Office of Sustainability

Wednesday, July 22

8:30 – 11:30 AM **SESSION SIX: The Takeaways**

Building upon discussions in the preceding sessions and looking forward strategically, what are the ongoing obstacles to the proliferation of energy innovation and market uptake? What are the priority needs that this group can identify or help clarify as the transition to a clean energy continues? Where should this discussion go next to add value?

Moderators: **Roger Ballentine** and **Andy Karsner**

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