2017 ASPEN INSTITUTE ENERGY FORUMS SUMMARY

THE ASPEN INSTITUTE
ENERGY & ENVIRONMENT
PROGRAM

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*

The Aspen Institute Energy and Environment Program is an active and prominent convener of non-partisan policy dialogue and neutral forums focused on key energy and environmental topics and how to advance environmental sustainability in a technological world. The Program's mission is to take-up the enduring questions about nature and society, and to prompt new thinking among diverse participants by deliberately testing assumptions and policies about sustainable water use, clean energy, climate change, and wildlife conservation. The Program promotes values-based dialogue between thought leaders from business, government, NGOs, and academia to address complex energy and environmental policy challenges in a collegial atmosphere that allows deliberation, creativity, collaboration, and compromise to flourish. Like the Aspen Institute as a whole, the Energy and Environment program seeks to inspire and explore new ideas and provoke action in the real world.

For all inquiries, please contact:

Energy & Environment Program
The Aspen Institute
One Dupont Circle, NW | Suite 700
Washington, DC 20036
Phone: 202.736.2933
Fax: 202.467.0790

The Aspen Institute
One Dupont Circle, NW | Suite 700
Washington, DC 20036

Published in the United States of America in 2017 by The Aspen Institute

PREFACE

For more than 40 years, the Aspen Institute has hosted forums about energy in the mountains of Aspen, Colorado. Whether the topics were the oil embargo of the mid-1970's, the electricity crises of the early 2000's, the shale boom of the mid-2000's, or the clean energy revolution of the past decade, the Aspen Institute has been the place to go for top policy makers, corporate leaders, researchers, and non-profit leaders to discuss the future of energy. Today, more than ever before, this non-partisan and non-ideological dialogue is important in the US, and around the world.

This year we are grateful to have had such an excellent suite of chairs for the four Aspen energy forums:

- Ernest Moniz and Anne Pramaggiore – Energy Policy Forum
- Mary Landrieu and Marvin Odum – Forum on Global Energy, Economy, and Security
- Roger Ballentine and Jim Connaughton – Clean Energy Innovation Forum
- Daniel Poneman and Joseph Dominguez – Future of Nuclear Energy Forum

INTRODUCTION

Harnessing energy for a productive human use has revolutionized our species over the last few centuries. Today, the global economy is heavily reliant on energy in many forms. The transition in our energy system now underway that started in the last decade might be the largest transformation of the energy system since the discovery of oil in Western Pennsylvania on the eve of the US Civil War. The growth of renewable energy sources, such as solar, wind, and geothermal is revolutionizing the electricity industry. At the same time, in the US, the development and deployment of technology to unlock previously hard to reach oil and gas from shale resources has revolutionized the energy security of the United States. Meanwhile, development and deployment of alternative fuel vehicles, including electric vehicles, hydrogen fuel cell cars and trucks, LNG trains, and the advent of software that makes vehicles more efficient and more autonomous are on the verge of changing the transportation system around the world.

Within this context, the Aspen Institute set out on its most ambitious set of energy gatherings since it endeavored to find solutions at the very first energy policy forum in 1977.

ELECTRICITY

BASELOAD

In the United Sates, the bulk power system and the continuing relevance of the "baseload, intermediate, peaker" paradigm is unclear. Although the concept of "baseload" remains a focal point of federal, state, and public debates about electricity, there are many types of resources that could be considered "baseload" under various definitions, and it just may not be a helpful term anymore. The historical understanding of "baseload" (*i.e.*, coal and nuclear) is being challenged by greater competition from new supply resources, with "zero"-marginal-cost renewable energy resources and low spot prices for natural gas now driving the market. The bulk power market is also being challenged by some of the same forces affecting the distribution grid, including increased penetration of DERs, little or no growth in electricity demand, and other developments behind the meter that affect the shape of the demand curve.

Whether or not energy resources are "baseload" matters less than the attributes those resources provide. Markets generally pay only for power and, with less uniformity, for capacity, but there is increasing interest in figuring out how to pay resources for their capabilities, which could include ramping ability, frequency response, and other essential reliability services. There are also other important attributes less directly related to grid functionality, such as being zero-carbon, that are not currently valued in markets, and some attributes, such as the national security and rural employment implications of a domestic nuclear power industry, are virtually impossible to price methodologically (though not politically). Within the federal government, there is broad recognition of the importance of commercial nuclear energy and growing recognition of the role nuclear energy plays from a national security and global non-proliferation perspective – but the importance of nuclear is not matched by its federal funding level. Listing attributes is thus much easier than figuring out how to actually price and create markets for the values and services provided by electricity system assets.

> **Defining 'Baseload'**
>
> - Baseload = lowest demand over course of year
> - Baseload = paid-off capacity
> - Baseload = power plants that ramp slowly
> - Baseload = coal, nuclear
>
> Conclusion: the word "baseload" is now obsolete, and possibly even damaging
>
> *Source: Michael Webber, UT Austin*

Because these largely market dynamics negatively impact some assets, there appears to be a growing crisis of faith in competition. That said, market design is rarely meant to be static, and there are several ways markets could be reformed to value additional important attributes (*e.g.*, capacity availability, zero-carbon generation). At some point, the Federal Energy Regulatory Commission will have to weigh in on how state policies are affecting interstate wholesale markets, and the presence of new commissioners represents an opportunity for engagement and education on ways of improving competitive markets.

MARKETS AND CLEAN ENERGY

"Clean energy" is difficult to define, but certainly includes renewable and other low or zero carbon generation; devices, software, and systems that reduce energy use; and, lower carbon transportation technologies. But by any definition, clean energy deployment around the world continues to grow. The cost of renewable energy has been plummeting and is competing and winning contracts as the lowest-cost source of generation in many instances. Virtually throughout the entire world, renewable energy is the fastest growing source of new generation. Along with natural gas, renewables have dominated the new generation marketplace in the United States. In most advanced economies, power demand is flattening in a way that does not necessarily fully reflect economic productivity. The decoupling of energy use from economic growth can be attributed in significant part to the increased use of more efficient devices, processes, and energy systems.

Distributed energy resources (DERs) – which encompass a broad and transformational set of technologies that are gaining momentum and that excel at enabling flexible loads – are upending retail markets and the distribution system. DERs and DERMs (i.e., DER management) can provide significant benefits not just to the customers who use them, but also to utilities and the grid. However, in the face of persistent legacy regulatory structures and utility business models, they also pose the potential to erode revenue for utilities, and require changing approaches to how the grid is managed for economic optimization and reliability. Still, DERs offer the opportunity for a more distributed and dynamic grid architecture, although that is not yet a reality. Big customers – who have the economic heft and whose need for electricity, resilience, and security is the highest from a business point of view – are among the main drivers of DER deployment. Demand has been quite strong from corporate buyers looking both to directly purchase renewables (mostly in deregulated markets) and to leave retail rates (given the widening gap between retail and wholesale prices). Community choice aggregation programs, which could be thought of as the average consumer's opportunity for choice, are also growing. State and federal policies will be a key ingredient in further broadening DER adoption, including policies on rates, interconnection, financing, procurement, billing, taxes, and trade.

The US power system is in a period of disruption and transition. Renewables and DERs have experienced astonishing technological innovation and cost reductions, leading to wider customer-driven and utility-driven adoption. The Internet of Things (IoT) and big data applications are also proliferating, and the "smart" devices already installed in some American homes are just beginning to be used to deploy energy services at increasing scale. These trends open up multiple potential sources of value, depending on what particular DERs are designed to do and how they interact with the system. Measuring the value of DERs, however, is nascent, and there is no consensus on how to correctly measure DER value; setting up compensation for DER value can also create tensions between cost-of-service models and value-of-service pricing. While DERs provide the potential for great value and new markets, they also have the potential to inject new volatility into the grid; distribution utilities will have to make sizable investments in grid observability to maximize the benefits of the new suites of distributed energy technologies.

The disruption caused by increased penetration of DERs will require new business models, markets, financing, and regulations. As the grid becomes more decentralized and bi-directional, value in the industry is shifting from generation to distribution and behind-the-meter retail. Utility CEOs are rapidly making investments in DERs, pursuing DER integration pilot projects, and buying or partnering with technology, data, and device companies. Possible utility business models include "energy as a service" (in which utilities provide customers with supply, demand, and energy optimization services) and network orchestration (in which utilities bring together the ecosystem of players and manage the platforms on which sets of technologies operate). At the same time, the rate base and regulatory jurisdiction are starting to push beyond the meter as well, and regulators – though constrained politically by constituencies, governors, and statutes – are beginning to wade into the issues surrounding transformation of the distribution grid.

Disruption is not just happening at the retail electricity market level through the onset of DER integration. The changing nature of the US generation mix and state efforts to favor certain generation resources are also creating disruptions in wholesale markets. Some older plants (e.g., coal, nuclear) are at the stage of making decisions about retiring or retrofitting, whereas almost everything new being built in the United States is wind, solar, and natural gas. The changes in generation have led to debates about the effect of renewables on baseload resources and on the reliability of the grid, though it seems clear that the influx of renewable energy is not causing problems for grid reliability and management. Nevertheless, where organized wholesale markets exist, wholesale prices continue to plummet because of low natural gas prices, zero-marginal-cost renewables, and stagnant demand. Gas tends to set the marginal price while zero-fuel-cost renewables pull wholesale prices down – a combination that can undermine market support for other types of generation and leading to political backlash and out-of-market solutions.

SUPPLY AND DEMAND

While transitions in the energy sector typically take decades, energy production in the United States has transformed in a very short period of time, not least because of the shale resource revolution. Hydraulic fracturing has taken off in North America in recent years due to a confluence of developments, including horizontal drilling and improved understanding of frack propagation. The cost structure has also come down, giving companies greater license to innovate and experiment and enabling them to be more profitable in lower-price oil environments. The shale resource revolution has made supplies of US natural gas abundant and reliable, which will enable US liquefied natural gas (LNG) to be one of the lowest-cost exported gas in the world – changing the global energy balance of power and making natural gas more commoditized on a worldwide basis. Similarly, growing production of natural gas liquids (NGLs) and liquefied petroleum gas (LPG) will be more than the US market can consume and will have to be exported.

The shale resource revolution has also upended the scarcity model that underpinned global strategies on oil and gas reserves. The entire industry has long been structured around the idea that oil and gas reserves would be depleted, meaning reserves underground were more valuable in the future than in the present, but the ability to produce tiny particles of oil and gas from source rock now means that supplies might as well be infinite, which means it no longer makes economic sense to wait to produce. At the same time, however, the risk of supply shocks seems to be growing, with geopolitical instability in many spots around the world. Energy markets could continue to experience volatility – raising questions about the role of the Strategic Petroleum Reserve and about how fast US shale can respond to a major disruption.

Several factors beyond geopolitics could affect levels of production as well. Investors, for instance, are sending conflicting messages to companies about strategies to pursue (*i.e.*, growth versus returns). In addition, the Trump Administration's deregulatory push might affect the levels of US energy production and export at the margins, though prices and market conditions will be far more important. Data analytics, machine learning, and other emerging technologies, however, could have big impacts on improving production, such as by helping companies understand and optimize the downhole physics of their systems.

Energy supplies cannot meet energy demand without midstream infrastructure to move energy resources from where they are to where they need to go. New infrastructure development in the United States is mostly concentrated in the Northeast and West Texas; other basins have been in a deep freeze for a couple of years and already had too much pipeline capacity. Most Northeastern and Permian production is headed for the Gulf Coast, but billions of dollars of additional investment is needed in infrastructure to move gas there. Beyond pipelines, vital energy infrastructure includes rail, trucks, ships, ports, and storage capacity. Human infrastructure is also essential; finding, training, and retaining the right people is a constant struggle for the energy sector, and the recruitment challenge has been made more difficult by the Trump Administration's actions on immigration. The limiting factor for industry, though, may be that people are increasingly resistant to construction of necessary infrastructure – from pipelines to coal export terminals to intermodal infrastructure – whether because the infrastructure will negatively affect them personally or because of opposition to using fossil energy generally (*i.e.*, the keep-it-in-the-ground movement). It is getting more difficult to get permits for anything now, and opposition to hydrocarbon infrastructure will only grow more intense, especially in the absence of serious climate policy.

Given the abundance of energy supplies, it is likely that energy markets in the coming years will be driven more by demand than by supply. Demand for energy is expected to rise over the next couple of decades, with most of the growth occurring in developing countries. Global gas demand appears to be rather bullish and may even be under-forecasted, whereas some forecasters (but not all) are projecting the potential for global peak oil demand. There are clearly potential drivers of demand destruction out there, particularly in the transportation sector (*e.g*., electrification, shared mobility, automation, vehicle-free urban centers, efficiency gains). Still, demand for US LNG appears to be strong in Europe (as an alternative to Russian gas supply) and potentially elsewhere, and demand for gas is also rising steeply in the US power sector at coal's expense. US defense, meanwhile, is a source of large, relatively consistent energy demand, both for installations and operations, and the Department of Defense's focus on mission has driven its initiatives on energy efficiency, renewable energy, and alternative fuels.

DECARBONIZATION AND CLIMATE CHANGE

The evolution of the US grid is occurring in the context of a global push to address climate change. The scale of decarbonization needed to reach the climate targets set out in the Paris Agreement is much greater and much harder to achieve than many people might recognize. The initial commitments made by countries under the Paris Agreement are only a first step. In the United States, deep decarbonization of the economy will require a portfolio of innovative technologies, markets, financing, a carbon price, and sector-specific policies at the federal, state, and local levels. Anticipated building blocks of deep decarbonization in the United States include energy efficiency (in transportation, buildings, and industry), decarbonization of electricity (including renewables, carbon capture and storage, and nuclear energy), fuel switching (*e.g*., electrifying transport and heat), and enhancing efforts to remove carbon dioxide from the atmosphere through both biological and engineered systems.

Despite all the progress made in clean energy, deep decarbonization is rapidly becoming an organizing principle that guides the evolution of energy systems. Climate impacts are being experienced today, and a lot of warming is already locked in, so serious efforts are needed to reduce greenhouse gas emissions in order to meet the globally accepted target of 80 percent reductions in emissions by 2050 in every developed nation and 50 percent in every major developing nation. The power sector will be responsible for a sizable portion of those reductions, but care must be taken to avoid siren song pathways that dead end or that delay achievement of deep decarbonization. A portfolio of technologies will be needed across all sectors, including in the areas of energy efficiency, end-use electrification, zero-carbon energy supply, enabling infrastructure, and negative emissions. It is in our best interests to keep all solution options on the table, including both existing technologies and new advanced technologies.

Decarbonizing transportation is more of a challenge, as it remains the sector most reliant on fossil fuels. Electrification of light-duty vehicles is gaining momentum, as the precipitous drop in lithium-ion battery prices has resulted in greater cost-competitiveness for these vehicles. The number, quality, and variety of electric vehicles (EVs) that will be available over the next few years will help drive the transition, as will a range of other factors, including pledges by automakers and countries to start selling only electric vehicles, interest by utilities in advancing a potential new source of load, and new battery chemistries and designs. Hydrogen fuel cell vehicles, only recently seen as falling out of favor, may be poised to contribute to the transformation of mobility as several major automakers have reasserted their commitment to bringing these vehicles to market. Driven by the efforts of large fleet owners and OEMs, heavy-duty vehicles have become significantly more efficient in recent years. Beyond efficiency, other options for heavy duty vehicles include electrification, hybridization, and low-carbon fuels, though constraints related to cost, scalability, and vehicle duty cycles remain.

Without question, achieving deep emission reductions across all sectors will require policy action. There is already a scattershot suite of policies and supports for carbon abatement in the United States, but prospects for an increasing, transparent price on carbon – or other big ideas on climate – are hindered by dogma and ideology at the federal level. There is likely no path to deep decarbonization that does not involve some agreement from both sides of the aisle, so progress may need to be tied to bipartisan goals such as resilience or innovation. While the Administration has no plans to address climate change, the industry will fundamentally be stuck with the energy policies currently in place, which were developed with an eye towards energy scarcity instead of energy abundance, until a way is found to address the climate issue. It is conceivable – though a very long shot – that there may be a narrow path forward for a carbon tax, particularly as part of broader tax reform efforts, as some Republicans in Congress begin to look for a more constructive approach to dealing with climate change.

Depending on the direction of the Trump Administration, achieving deep decarbonization in the United States (and globally) may become even more challenging, so sub-national actors such as states, communities, and private sector actions may have to become even bigger sources of decarbonization progress. Advocates of climate action have to do a better job of reaching out to affected stakeholders to bring them on board the decarbonization transition.

While US decarbonization actions are critical, it is the developing world that will truly determine the fate of climate change. The United States cannot and is not acting alone, though, and a key question regarding deep decarbonization is whether scaled-up clean technologies will find a major role in Asia, Africa, and the Middle East. China has become, in some ways, a new global leader on decarbonization, though there are reasons to be concerned about how real that leadership is. China's development pathway could shape the future of climate change, and there are reasons to be both pessimistic and optimistic about China's ability to achieve deep decarbonization. What is happening in China provides all the more reason for the United States to do its part on the climate issue, focus on its innovation advantages, and become the leading exporter of clean technologies to the world.

SECURITY

Energy security is a major priority for the current Administration. The President's support, as well as public concerns regarding clean air, climate change, US technological leadership, and national security, have led to varying opinions about nuclear energy. Nuclear plants around the country are shutting down, and the loss or serious diminishment of the existing fleet is likely to have a range of implications, such as impacts on reliability and resilience. There are economic and security implications as well. Among the lower 48 states, 44 have companies in the nuclear supply chain, providing nuclear products and services. A shutdown of a plant in one state sends ripple effects through others. The same companies also supply the nuclear Navy; as the supply chain gets weakened from civilian plant closures, there could be risk factors for the Navy, potentially reflected in price or availability. Nuclear power impacts a number of ecosystems surrounding the US energy portfolio including the zero-carbon economy, climate, geopolitics and security (including non-proliferation), international competitiveness, and resilience, as well as fuel diversity and grid reliability.

As the US energy portfolio and electric grid continue to evolve, cybersecurity has also become a growing concern. Utilities are getting hacked thousands of times a day, and new networked IoT devices can create cyber vulnerabilities. Even measures taken to enhance grid reliability, such as increased automation and improved sensing and monitoring, can simultaneously create additional cyber vulnerabilities. In response, the industry and the federal government have initiated a range of efforts to boost cybersecurity. Investor-owned utilities are working closely with each other and with municipal utilities and co-ops to analyze information, prevent cyberattacks, and respond if an attack is successful.

Developments in the US grid over the past few years have also occurred during a period of increased energy integration among the three North American countries, both bilaterally and trilaterally. Canada and the United States have a long history of energy integration and a symbiotic network, building on each country's respective strengths and attributes, though the relationship is not without its points of contention. Mexico has a much smaller energy relationship with the United States than Canada does, with energy integration focused on natural gas moving south, although electricity connections are increasing. The North American countries have collaborated on grid security and resilience, as well as on promotion of clean energy and climate initiatives. It is unclear, though, what will happen to trilateral commitments that do not fit with the Trump Administration's policies, such as the continental clean energy target. There are enforceable federal cybersecurity standards on the bulk power system, and the Department of Energy (DOE) has provided cybersecurity support to distribution utilities, public power, and co-ops. Still, clearer legislative authority and increased budgetary resources are needed to support the Department of Energy and the Federal Energy Regulatory Commission (FERC) in their efforts to promote cybersecurity and grid reliability.