Customer Choice and the Power Industry of the Future

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Summary

In the United States, the modern electric utility industry began to emerge about 100 years ago, guided by a philosophy which came to be called the "regulatory compact." Under the compact, state and local governments generally granted the right to provide electric power in a designated service territory, in exchange for an obligation to serve all electric power customers. Much of the nation's power generation and delivery infrastructure was built under this arrangement, with customers ultimately paying for the costs of electricity services. However, the electric utility model nowadays is under pressure as the industry deals with issues such as the aging of power generation assets, the implementation of new environmental regulations favoring cleaner, low carbon emission power generation choices, and the development of technologies providing options for customers to self-generate electric power.

Some observers argue that new technologies are leading to a distributed generation (DG) future for customers, supported by utility base load generation and infrastructure. Various states and jurisdictions have begun initiatives to look at what a new "regulatory compact" could specifically encompass, with cleaner electric power and new services as the driving force behind utility investments.

While the electric utility industry seems to be fully aware of the potential for change, the question is whether and how much the industry will embrace it. Some companies may see DG as appealing to only a segment of the market, but in times of shrinking revenues, any market share loss can be significant. The Edison Electric Institute contemplates that the potential rise in DG, and requirements for net metering payments (without "appropriate" compensation by net metering customers for use of the grid), could be a threat to the regulatory paradigm that allows costs of providing service to be recovered from the consumers who benefit from grid services.

A key to the evolution of the current electric utility model is likely to be cost control for many utilities, so that prices will be competitive with other choices. Electric utilities may also have to offer enhanced service to consumers to entice them to stay utility customers, especially as it is becoming easier to go off-grid. Utilities may even offer support services for customer self-generation beyond merely providing backup power. A convergence of electric power and natural gas utilities may possibly result in the future in a new, customer focused energy industry focused on providing consumer services. However, a formal transition requiring federal policy guidance for the electric utility industry may be required if, for example, the energy markets fail to transition smoothly to a clean power future, should that continue to be a policy goal. Market failures of this sort have been discussed in the past, with stranded assets and company bankruptcies posited as potential disruptions.

Congress began to address the move of the electricity utility industry away from the regulatory compact concept by introducing competitive providers to the electric utility industry with the Public Utility Regulatory Policies Act of 1978, and reinforced competition as federal policy with the Energy Policy Act of 1992. Several laws enacted since then have contained provisions to further a range of technologies and paradigms in various "states-must-consider" standards. Congress may yet consider if a formal legislative initiative would be required to move the electric power industry to a clean energy power system should that be a goal. Congress may also consider legislation if a market failure is perceived or if consumer choice is seen to be unduly constrained.

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Introduction

In the United States, the modern electric utility industry began to emerge about 100 years ago and would be guided by a philosophy which came to be called the "regulatory compact." Under the compact, state and local governments generally granted utilities the monopoly right to provide electric power in a designated service territory, in exchange for an obligation to serve all electric power customers. Much of the nation's power generation and delivery infrastructure was built and maintained under this arrangement, with customers ultimately paying for the costs of electricity services. State public utility commissions (PUCs) or similar organizations provided oversight of the rates charged for electricity services. PUCs also approved the construction of new power plants and electric power lines, allowing utilities to recover costs of providing service in rates charged to customers.

The modern electric utility industry thus emerged and grew in most states as a virtual monopoly, with vertically integrated companies generating electric power, and delivering electricity directly to customers. Large, central station power plants were built employing economies of scale across much of the United States, most often fueled by coal, which was generally an inexpensive, local resource. Large-scale hydropower was developed where it was available as a resource. In areas without access to cheap coal or hydropower, nuclear power later developed as an option for base load power to meet the growing demand for electricity. Natural gas-fired power plants were generally built to meet intermediate and peak load needs. Petroleum saw a brief period of increasing use in the 1970s and 1980s, mostly in dual fuel combustion turbines, but has declined ever since.

The vertically integrated, regulated model for the electric power industry remained essentially unchanged across the United States until the latter years of the last century. The Public Utility Regulatory Policies Act of 1978 (PURPA) (P.L. 95-617) was arguably the law that ended the near utility monopoly on electric power. Among other goals, PURPA was designed to conserve supplies of natural gas (considered threatened at the time), encouraging fuel efficient cogeneration and alternative fuels and methods to generate electricity. PURPA required electric utilities to purchase power from these new power generators, essentially allowing a competitive provider into a utility's formerly exclusive service territory. The efficiency of combustion turbines used for generating electricity accelerated as their use in PURPA-qualified cogeneration projects expanded, and this in turn aided in the growth of the nonutility power sector.

The power generation sector has a variety of structures and ownership arrangements. Electric utilities have diversified ownership, including publicly owned utilities,[1] investor-owned utilities,[2] electric cooperatives,[3] federal power agencies,[4] and nonutility generators.[5] Competition in the

[1] An enterprise providing essential public services, such as electric, gas, telephone, water, and sewer under legally established monopoly conditions. See http://www.eia.gov/tools/glossary/index.cfm.

[2] A privately owned electric utility whose stock is publicly traded. It is rate regulated and authorized to achieve an allowed rate of return. See EIA http://www.eia.gov/tools/glossary/index.cfm?id=i.

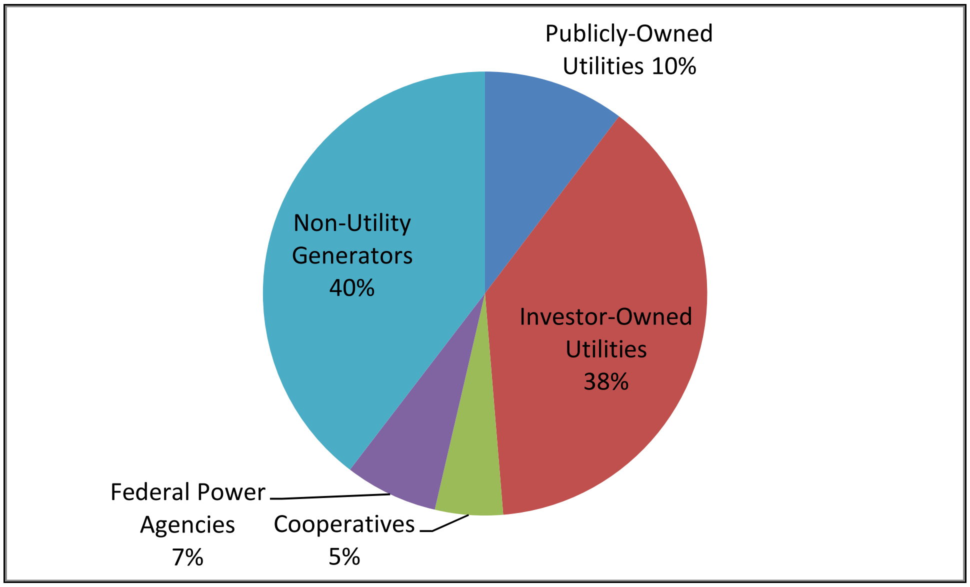
[3] An electric utility legally established to be owned by and operated for the benefit of those using its service. The utility company will generate, transmit, and/or distribute supplies of electric energy to a specified area not being serviced by another utility. Such ventures are generally exempt from federal income tax laws. Most electric cooperatives have been initially financed by the Rural Utilities Service (prior Rural Electrification Administration), U.S. Department of Agriculture. http://www.eia.gov/tools/glossary/index.cfm

[4] The federal power marketing agencies include the semi-autonomous Tennessee Valley Authority, and the four (continued...)

electricity industry was strengthened as federal policy with the passage of the Energy Policy Act of 1992 (EPACT92; P.L. 102-486), allowing a new class of nonutility producers to emerge. As is shown in **Figure 1**, the nonutility power generation sector is the largest in the United States.

Figure 1. U.S. Electric Power Generation by Company Type

As of 2011



Source: Energy Information Administration Forms EIA-861 and EIA-923.

Notes: Data compiled by American Public Power Association at http://www.publicpower.org/files/PDFs/USElectricUtilityIndustryStatistics.pdf.

In the early years of the last century, electric utility companies quickly realized that they could reduce costs and enhance reliability by interconnecting with one another, thus sharing generation resources. The development of "power pools" allowed member electric utilities to exchange power, or transfer (i.e., "wheel") power to another utility in either wholesale or retail (to an end-use customer) transactions. Power pools can be "loose" or "tight," with the level of independence being the primary differentiator.[6]

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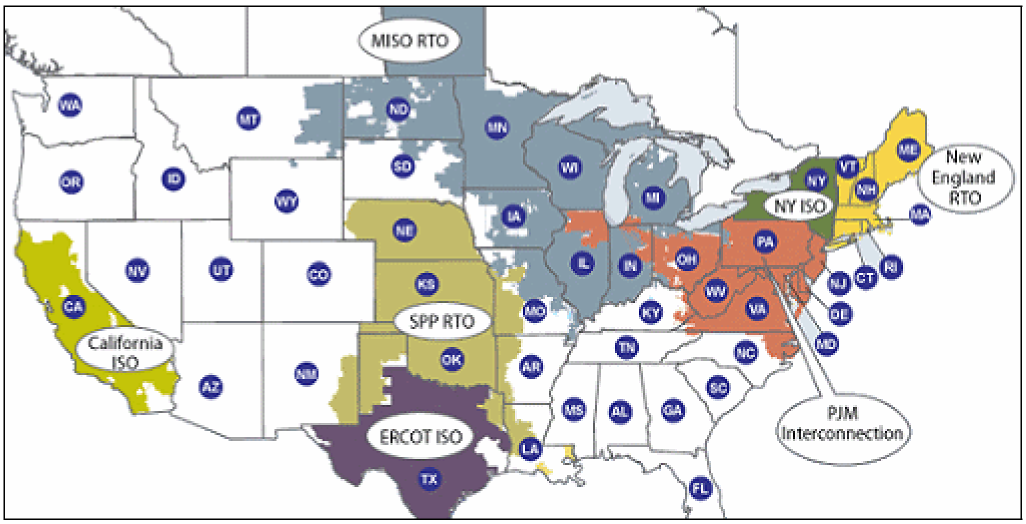
Department of Energy power marketing administrations: Western Area Power Administration, Bonneville Power Administration, Southeastern Power Administration, and the Southwestern Power Administration.

[5] A corporation, person, agency, authority, or other legal entity or instrumentality that owns or operates facilities for electric generation and is not an electric utility. Nonutility power producers include qualifying cogenerators, qualifying small power producers, and other nonutility generators (including independent power producers). Nonutility power producers are without a designated franchised service area and do not file forms listed in the Code of Federal Regulations, Title 18, Part 14. See http://www.eia.gov/tools/glossary/index.cfm.

[6] A loose power pool is a voluntary association of utilities that negotiates generation sales primarily on a bilateral (two-party) basis. Bilateral transactions are private, thus other participants are unaware of the terms of the exchange, including price and transmission access. In contrast, tight power pools require true pooling of generating and transmission assets. The cost of each resource in the pool is known and each is operated on the basis of those costs, with the lowest cost resources being used more than higher cost ones. Operation of pooled generation also requires cooperative operation of transmission in the pool. As a result, tight power pools have some form of centralized transmission dispatch. Usually, there is a control center for the pool as a whole that issues dispatch instructions to the (continued...)

With FERC Order 2000,[7] the transformation of existing tight power pools was completed with the formal establishment of the Regional Transmission Organizations (RTOs) in several regions of the United States (see **Figure 2**). This led to the rise of wholesale power markets, and enabled industry restructuring in various U.S. states and regions, requiring utilities in some states to move power plants into a competitive function, while retail distribution utilities remained under state regulation. Under this arrangement, utility transmission systems are run by the RTO and are regulated largely under FERC jurisdiction. In some states, retail competition was introduced to give end-use electricity consumers a choice between their incumbent utility supplier and competitive electricity suppliers. Power plants under this new regime were therefore required to compete with each other to sell power to retail distribution companies in markets administered by the RTO.

Figure 2. Map of Regional Transmission Organizations (RTO)/Independent System Operators (ISO) Areas



Source: http://www.ferc.gov/industries/electric/indus-act/rto.asp.

Notes: Alaska and Hawaii are not members of an RTO.

Nowadays, the electric utility model is under further pressure as the sector deals with issues such as the aging of power generation assets, the implementation of new environmental regulations leading to different choices in power generation fuels, and the development of technologies providing more and newer options for customers to self-generate electric power. These factors have the potential to cause dramatic changes in how the United States acquires, generates, and uses electricity.

Given that the United States seems to be at a turning point in the history of the electric power sector, some have advocated for the electric utility industry model to be reinvented under a "Utility 2.0" paradigm, wherein the modern needs of society for electric power and services

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control centers of the larger utilities in the pool. See W.M. Warwick, *A Primer on Electric Utilities, Deregulation, and Restructuring of U.S. Electricity Markets*, U.S. Department of Energy, PNNL-13906, May 2002, http://www1.eere.energy.gov/femp/pdfs/primer.pdf. http://www1.eere.energy.gov/femp/pdfs/primer.pdf.

[7] See http://www.ferc.gov/legal/maj-ord-reg/land-docs/RM99-2A.pdf.

become the driving force behind utility investments. Various states and jurisdictions have begun initiatives to look at what this new "regulatory compact" could specifically encompass. The State of Maryland, for example, has issued a report detailing its "vision of an energy future that is more reliable, cost effective, green, energy efficient, consumer-directed, and technology advanced. *Utility 2.0* can make this service quality transformation a reality with major economic, environmental and security benefits to Maryland and all its citizens."[8] Another proposed model for *Utility 2.0* in the State of New York would see development of a system capable of accommodating more renewable electricity from smaller solar and wind generation, and depend less on power from larger, central station power plants.[9]

The question some stakeholders are asking is whether a formal transition from today's grid to the grid of the future is needed. This report will begin to explore the issues, discussing what forms a transition could take, and suggest questions that Congress may want to address.

Evolving Fundamentals

Electricity is fundamental to the commerce and daily functioning of the U.S. economy. The modern, technological underpinning of manufacturing and services relies on digital devices which have increased U.S. productivity and global sales. The way electricity is produced has changed in the last 40 years, along with the regulatory structures and laws governing its production in most of the United States. The following sections will discuss some of the primary factors affecting the U.S. power sector.

Decoupling of Electricity Demand Growth from Economic Growth

For many years, the growth in sales of electric power could be directly related to growth in the economy. However, with energy efficiency in homes and appliances increasing, a decoupling of growth in electricity demand from growth in Gross Domestic Product[10] is occurring. According to the U.S. Energy Information Administration (EIA), the linkage has been declining over the last 60 years, as U.S. economic growth is outpacing electricity use.[11] The trend is illustrated by **Figure 3**, which shows growth in electricity use and growth in GDP over the period.

EIA's projections point to a continued decline in electricity use relative to economic growth. While there may be years of relative growth in the future, EIA does not expect a "sustained return to the situation between 1975 and 1995, when the two growth measures were nearly equal in value, or the earlier period in which the growth rate in electricity use far exceeded the rate of

[8] Office of Governor Martin O'Malley, *Weathering the Storm: Report of the Grid Resiliency Task Force*, Executive Order 01.01.2012.15, September 24, 2012, http://www.governor.maryland.gov/documents/GridResiliencyTaskForceReport.pdf.

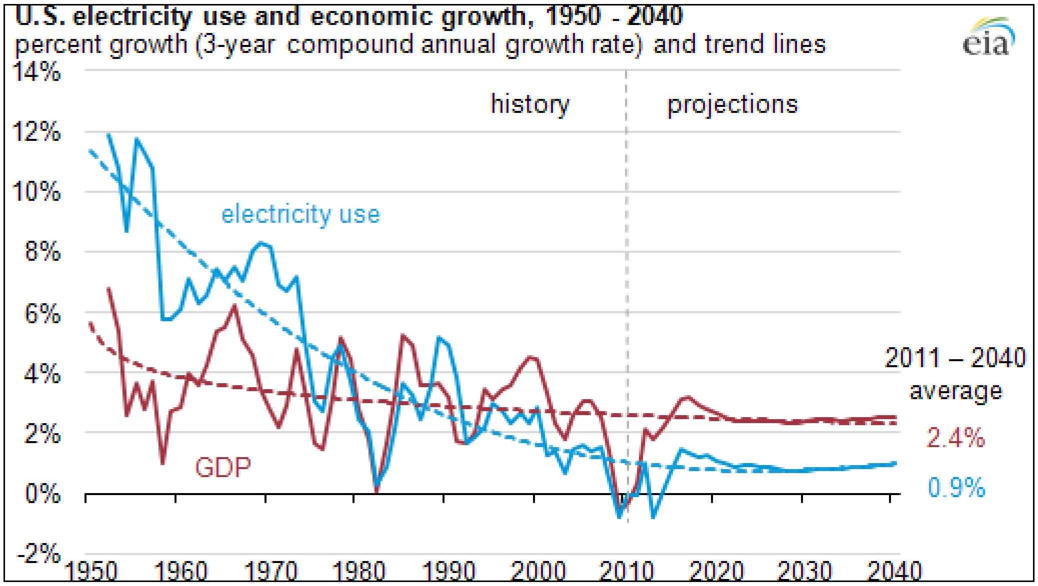
[9] New York State Public Service Commission, *Reforming the Energy Vision*, 14-M-0101, August 28, 2014, http://www3.dps.ny.gov/W/PSCWeb.nsf/All/26BE8A93967E604785257CC40066B91A?OpenDocument.

[10] Gross Domestic Product can be defined as the total value of the goods and services produced by the people of a nation during a year not including the value of income earned in foreign countries. See http://www.merriam-webster.com/dictionary/gross%20domestic%20product.

[11] Energy Information Administration, *U.S. Economy and Electricity Demand Growth Are Linked, but Relationship Is Changing*, March 22, 2013, http://www.eia.gov/todayinenergy/detail.cfm?id=10491.

economic growth."[12] EIA attributes several factors as drivers to this trend, including "slowing population growth, market saturation of major electricity-using appliances, improving efficiency of several equipment and appliance types in response to standards and technological change, and a shift in the economy toward less energy intensive industry."[13]

Figure 3. Growth in U.S. Electricity Use and Gross Domestic Product



Source: Energy Information Administration, Annual Energy Outlook 2014.

Notes: Projections of Energy Use and Gross Domestic Product growth shown after 2012.

With growth in demand for electricity having been essentially flat for many years, the need for new power plants has been delayed in many parts of the country. The projections for future demand growth in most regions of the United States are even declining. However, even an annual growth rate of 0.9% can mean an increase in electricity demand of 27% over the next 30 years, and may result in a need for new power plant capacity.

Environmental Regulations

With the passage of the Clean Air Act (CAA) amendments in 1970, Congress required the Environmental Protection Agency (EPA) to establish standards to reduce the potential health and environmental impacts of fossil fuel use by limiting emissions by-products or other consequences of combustion processes.[14] These environmental regulatory requirements have been evolving in

[12] Ibid.

[13] Ibid.

[14] "The Clean Air Act, codified as 42 U.S.C. 7401 et seq., seeks to protect human health and the environment from emissions that pollute ambient, or outdoor, air. It requires the Environmental Protection Agency [EPA] to establish minimum national standards for air quality, and assigns primary responsibility to the states to assure compliance with the standards. Areas not meeting the standards, referred to as 'nonattainment areas,' are required to implement specified air pollution control measures. The act establishes federal standards for stationary and mobile sources of air pollution and their fuels and for sources of 187 hazardous air pollutants, and it establishes a cap-and-trade program for the emissions that cause acid rain. It establishes a comprehensive permit system for all major sources of air pollution. It (continued...)

the last decade due to various legal challenges to the regulatory implementation of federal laws. Much industry attention has focused recently on the pending finalization of some of these regulations, and their potential to contribute to retirement decisions for some coal-burning power plants.

In addition to being the largest source of electric power, coal-fired power plants are among the largest sources of air pollution in the United States. Under the CAA, however, they have not necessarily been subject to stringent requirements: Emissions and the required control equipment can vary depending on the location of the plant, when it was constructed, whether it has undergone major modifications, and the specific type of fuel it burns, among other factors. More than half a dozen separate CAA programs could potentially be used to control emissions, which makes compliance strategy potentially complicated for utilities and difficult for regulators.

While the new rules have been developed at the federal level, by EPA, they will generally be implemented by state agencies. They include the Cross-State Air Pollution Rule (which replaced the Clean Air Interstate Rule); the Mercury and Air Toxics Standard, or MATS rule; the rule for coal combustion residues; and the Clean Water Act Section 316(b) guidelines for once-through cooling water systems.

The MATS rule requires coal-fired power plants larger than 25 megawatts (MW) in capacity to incorporate the maximum achievable control technologies (MACT) by April 2015 needed to reduce the airborne emissions of mercury, acid gases, and toxic metals. However, state environmental permitting agencies are allowed to grant a one-year compliance extension.[15] At the end of 2012, according to EIA, there were 1,308 coal-fired generating units in the United States, totaling 310 gigawatts (GW)[16] of capacity, and approximately 71% of U.S. coal-fired generating capacity has installed (or plans to install) environmental control equipment to comply with MATS.[17] With low natural gas prices depressing electricity market prices and slow growth in electricity demand, the MATS rule adds to the economic pressure on coal plants. EIA currently expects that a total of 60 GW of coal capacity will retire by 2020, with 90% of these retirements taking place by 2016 "coinciding with the first year of enforcement for the Mercury and Air Toxics Standards."[18]

Regulations under development at EPA would impose new requirements on power plants to control greenhouse gas (GHG) emissions. In September 2013, EPA proposed standards for the control of carbon dioxide (CO_2) emissions from new electric generating units burning fossil fuels. EPA suggested that utilization of carbon capture and storage (CCS) is a viable means for new

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also addresses the prevention of pollution in areas with clean air and protection of the stratospheric ozone layer.... The 1970 amendments established the procedures under which EPA sets national standards for ambient air quality, required a 90% reduction in emissions from new automobiles by 1975, established a program to require the best available control technology at major new sources of air pollution, established a program to regulate air toxics, and greatly strengthened federal enforcement authority." CRS Report RL30853, *Clean Air Act: A Summary of the Act and Its Major Requirements*, by James E. McCarthy and Claudia Copeland.

[15] CRS Report R41563, *Clean Air Issues in the 112th Congress*, by James E. McCarthy.

[16] A gigawatt is one billion (10^9) watts.

[17] EIA estimates that 69% of coal-fired capacity complies with MATS using flue gas desulfurization, and another 1% has installed dry sorbent injection. See http://www.eia.gov/todayinenergy/detail.cfm?id=15611.

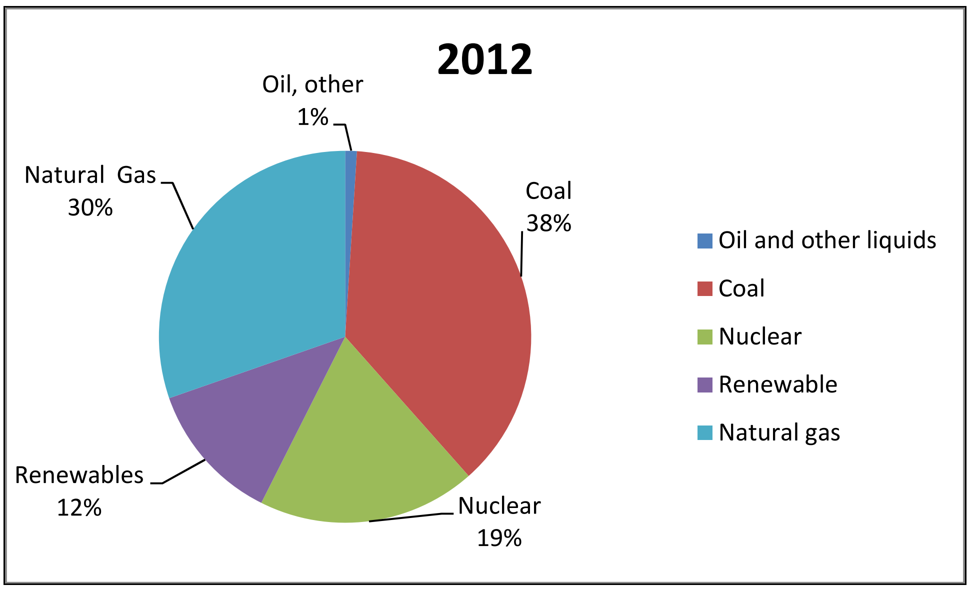
[18] Energy Information Administration, *AEO2014 Projects More Coal-Fired Power Plant Retirements by 2016 Than Have Been Scheduled*, February 14, 2014, http://www.eia.gov/todayinenergy/detail.cfm?id=15031.

coal-fired power plants to comply with the proposed standards.[19] As requirements for new sources (i.e., new power plants), EPA's proposed standards do not directly apply to existing power plants currently producing electricity.

EPA's proposal for control of GHG emissions from existing power plants was released in June 2014.[20] EPA's proposed plan seeks to lower the carbon dioxide intensity of U.S. power generation by approximately 30% in 2030 from levels in 2005. To achieve this goal, EPA would give each state a numerical carbon reduction target, based on the state's existing power generation portfolio (as of 2012). It is likely that only the newest, most efficient coal-fired power plants would remain in operation in 2030 under such a plan. As of 2012, coal-fired power plants are the single largest source of U.S. electricity generation (see **Figure 4**).

Figure 4. U.S. Electricity Generation by fuel

Trillion kiloWatt-hours per Year



Source: Annual Energy Outlook, 2014 Early Release.

Notes: See http://www.eia.gov/forecasts/aeo/er/early_elecgen.cfm.

EPA is also proposing to regulate the management of coal combustion residuals (CCR) in landfills and surface impoundments, under its authorities in the Solid Waste Disposal Act (42 U.S.C. § 6901 et seq.);[21] and to revise effluent limitations guidelines (ELG) for power plant wastewater, under its authorities in the Clean Water Act (33 U.S.C. § 1251 et seq.).[22] Each

[19] EPA's proposed standard for new power plants would require new coal units to achieve the emissions of a natural gas combined-cycle unit, which would likely require coal units to employ CCS. Environmental Protection Agency, 2013 Proposed Carbon Pollution Standard for New Power Plants, September 23, 2013, http://www2.epa.gov/carbon-pollution-standards/2013-proposed-carbon-pollution-standard-new-power-plants.

[20] CRS Report R43621, *EPA's Proposed Greenhouse Gas Regulations: Implications for the Electric Power Sector*, by Richard J. Campbell.

[21] See CRS Report R40544, *Managing Coal Combustion Waste (CCW): Issues with Disposal and Use*, by Linda Luther.

[22] See CRS Report R43169, *Regulation of Power Plant Wastewater Discharges: Summary of EPA's Proposed Rule*, by Claudia Copeland.

proposal is intended to reduce the amount of metals and other pollutants released to the environment from coal-fired power plants. Since each proposal would regulate surface impoundment ponds, EPA has stated that its final decision on the CCR rule may be aligned with any final requirements adopted under the final ELGs. A final CCR rule is expected to be issued in December 2014; the final ELG is expected to be issued in September 2015.

Aging of Power Plants and Electricity Infrastructure

All power plants are subject to retirement when they reach the end of their useful service life (i.e., how long the property will be useful to the enterprise). The average age of U.S. power plants is now over 30 years, and the life expectancy of most power plants is about 40 years.[23] As with electric power plants, electric transmission and distribution system components are also aging, with power transformers averaging over 40 years of age,[24] and 70% of transmission lines being 25 years or older.[25]

In areas of the country with traditional ratemaking (as opposed to areas with competitive markets), electric utilities recover the cost of building and operating a power plant (and other related infrastructure) from ratepayers as depreciation expense under the "cost of service"[26] model. Electric utility power plant costs are typically collected from ratepayers over a period of about 40 years, which is considered the average service life for a power plant. Thus, the original cost of many older plants has already been recovered in rates, while the cost of younger power plants is still being recovered. While older power plants are usually well-maintained, they are generally not as efficient as newer power plants. The costs of modernizing older coal-fired power plants to meet new regulatory requirements can be relatively high. When the cost of upgrades to meet new environmental requirements is considered along with perhaps increasing operations and maintenance (O&M) expenses, many older coal power plants are likely to face outright retirement decisions.

[23] "About 540 gigawatts, nearly 51% of all generating capacity, were at least 30 years old at the end of 2012. Most gas-fired capacity is less than 20 years old, and most wind generation capacity is less than 10 years old. Most coal-fired and hydropower capacity is 30 years or older. Nearly all nuclear reactors are over 20 years old and about half are over 30." Energy Information Administration, *How Old Are U.S. Power Plants?*, March 5, 2013, http://www.eia.gov/energy_in_brief/article/age_of_elec_gen.cfm?_ga=1.166295294.1197839146.1401292538.

[24] "Power equipment manufacturers estimated that the average age of [large power transformers (LPTs)] installed in the United States is approximately 40 years, with 70 percent of LPTs being 25 years or older. According to an industry source, there are some units well over 40 years old and some as old as over 70 years old that are still operating in the grid. The same source also noted that these transformers are typically warranted by the manufacturers for approximately 30 to 35 years." U.S. Department of Energy, Office of Electricity Delivery and Energy Reliability, *Large Power Transformers and the U.S. Electric Grid*, June 2012, http://energy.gov/sites/prod/files/Large%20Power%20Transformer%20Study%20-%20June%202012_0.pdf.

[25] K. Anderson, D. Furey, and K. Omar, "Frayed Wires: U.S. Transmission System Shows Its Age," Fitch Ratings, October 25, 2006.

[26] A ratemaking concept used for the design and development of rate schedules to ensure that the filed rate schedules recover only the cost of providing the electric service at issue. This concept attempts to correlate the utility's costs and revenue with the service provided to each of the various customer classes. See http://www.eia.gov/tools/glossary/index.cfm.

Cost Structure Increasing

Electric utilities are looking at increasing costs to replace aging power plants and other infrastructure. The electric utility industry has always been capital intensive, requiring significant construction investment to produce and distribute power. Today's increased costs of construction are being driven by higher materials costs, as the prices of raw materials have been climbing, and the cost of manufactured components has also risen. Costs of maintaining and modernizing coal-fired plants (in particular) are also increasing due to environmental requirements, and altogether new concerns such as cybersecurity. With limited new generation construction and difficult prospects at state public service commissions for increased electricity rates, the opportunities for utilities to earn higher returns on investment have come in recent years from unregulated markets or in new transmission with approved higher return-on-equity incentives. However, with current low natural gas prices, revenues from electricity markets have been declining. With falling or static electricity demand and sales, control of costs is becoming a key focus in maintaining levels of returns on investment, and dividends to shareholders for investor-owned utilities. Utilities are increasingly looking at minimizing operations and maintenance costs, and downsizing workforces even as they face impending retirements of a whole generation of workers.

Defining the Impetus for Change

The U.S. electric utility industry as it exists today largely reflects the underlying fuel resources, economics, and physical limitations which exist in various regions of the country. These characteristics led to the specific technologies and infrastructure used to produce electricity. The regulatory regime has changed in some parts of the United States from a cost-of-service approach to a competitive environment for power generating plants. With the increasing availability of new technologies and paradigms for satisfying electricity demand, the traditional ways of doing things in the electric utility business are being challenged. How some of these factors have and are expected to drive change is discussed in the following paragraphs.

Public Policy Requirements

While the formative role of the regulatory compact has diminished in some parts of the country, federal and state public policy goals and requirements still have a substantial effect on the operations and investment decisions of electric utilities. Many regard PURPA as the first instance of federal legislation bringing change to the traditional model of electric utility industry. By essentially allowing nonutility entities to generate and sell power for resale to end-users, PURPA brought competition to the industry. This new paradigm was expanded upon by EPACT92, which formally created a class of competitive power producers designated as "electric wholesale generators." Congress recognized in these legislative actions that entities other than electric utilities were capable of generating electric power efficiently and cost-effectively.

State governments have been very active over the last two decades enacting policies mandating various levels of renewable electricity generation in various Renewable Portfolio Standard (RPS) requirements or goals for renewable electricity development.[27] When combined with such

[27] Renewable energy technologies include wind and solar power, biomass, geothermal, and hydropower. A main attraction of renewable technologies is that, with the exception of biomass, they do not require the combustion of a fuel (continued...)

state programs, the availability of federal tax incentives has led to a proliferation of utility-scale projects using wind power and solar photovoltaic (PV), spurring growth especially for solar PV in the commercial and residential sectors.

EPA's regulations under the CAA are further examples of public policy mandates. The requirements of compliance and potential impacts of EPA regulations on power plant operations are discussed earlier in this report.

Distributed Generation and the Natural Gas Revolution

Distributed Generation (DG) is the term used to describe electric power generated at or near the point of consumption (i.e., the customer or load). DG thus differs from base load power plants (mostly coal and nuclear power units) which were designed for economies of scale, and located usually at some distance from where the electricity is consumed. DG includes traditional backup power sources (such as the large gas-powered generators used by institutions and companies), combined heat and power facilities (used for industrial, district, and community power generation), and renewable electricity power systems used by some businesses and residences. Many manufacturers and institutional users have traditionally generated on-site some or all of the electricity they consume, while others maintain diesel or oil generation for emergency backup purposes when power outages occur. DG technologies are also referred to as distributed energy resources (DER).

Residential scale applications of renewable electricity technologies have seen growth in the last few years with the drop in the prices of solar PV panels,[28] and the growth in "solar roofs" aided by state and federal tax incentives, grants, and net metering[29] provisions. New designs for wind power units optimized for "urban" environments are being developed,[30] and may find increased opportunities for deployment. The end-use application would dictate the specific DG technology choice, as technologies suitable for base load would not be necessarily suitable for power quality or combined heat and power[31] (CHP) or even trigeneration[32] uses.

Nevertheless, most residential applications of DG in the United States are rooftop solar PV. As of 2011, 4 GW of distributed solar PV capacity had been installed in the United States.[33] Estimates

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(...continued)

to produce electricity, and thus offer the potential for cheaper energy without environmental pollutants. The source of most biomass is wood wastes or residues.

[28] Ian Glover, "US Solar Power Costs Fall 60% in Just 18 Months," *PV Magazine*, September 19, 2013, http://www.pv-magazine.com/news/details/beitrag/us-solar-power-costs-fall-60-in-just-18-months_100012797/#axzz3DOdCkeuQ.

[29] "Net metering enables customers to use their own generation from on-site renewable energy systems to offset their consumption over a billing period by allowing their electric meters to turn backwards when they generate electricity in excess of their demand, enabling customers to receive retail prices for the excess electricity they generate." See U.S. DOE, Office of Energy Efficiency and Renewable Energy, "Green Power Markets—Net Metering," May 25, 2011, http://apps3.eere.energy.gov/greenpower/markets/netmetering.shtml.

[30] Tina Casey, *Micro Wind Turbines Get $1.3 Million From Energy Department*, CleanTechnica, July 25, 2014, http://cleantechnica.com/2014/07/25/micro-wind-turbines-get-1-3-million-funding/.

[31] A CHP plant is designed to produce both heat (or thermal energy) and electricity from a single fuel or heat source.

[32] Trigeneration is the simultaneous production of electricity, heat, and cooling. This usually involves a gas-fired power generator producing electricity with the exhaust heat going to an absorption chiller (which produces chilled water for air conditioning or hot water).

[33] Tom Stanton, State and Utility Solar Energy Programs: Recommended Approaches for Growing Markets, National (continued...)

are that distributed solar PV capacity could reach 20 GW by 2017,[34] with total solar PV penetration increasing to perhaps 50 GW by 2020.[35] However, this would still represent only a small part of overall U.S. electricity generation. The U.S. grid had a generation capacity of 966 GW in 2013.[36]

With the relatively new abundance of natural gas produced from unconventional resources[37] has come an expectation of continued lower prices for natural gas, at least over the near term. Decreased natural gas prices are lowering wholesale electricity prices, stimulating a major switch from coal to gas-burning facilities. However, overall electricity costs are still increasing in many regions of the country, and prices for electricity are expected to rise.[38] This may open a window of opportunity for increased development of residentially-sized combined heat and power units, assuming fuel cell and microturbine applications become more cost-competitive and thus attractive to consumers. Large fuel cell installations are already being used to provide power to data center owners who value a greater level of power quality and reliability than they believe they can get from traditional utility service.

The advent of new, smaller scale but higher efficiency power generation technologies could possibly change how consumers obtain the majority or all of their electricity and energy needs, and may have the greatest potential for impact on the utility model. A growing amount of electric power is being generated by natural gas,[39] and a convergence of electric power and natural gas utilities may eventually result in a new, customer-focused energy industry focused on providing consumer services.

Microgrids

A microgrid may be defined as "any collection of interconnected loads and distributed energy resources (i.e., distributed generation) within clearly defined electrical boundaries that can be controlled as a single entity and that can operate in both grid-connected or island mode (i.e., non-

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(...continued)

Regulatory Research Institute, 2013, p. 5.

[34] Rick Thompson, *Can Utility Revenue Climb Despite the Growth of Distributed Generation?*, GreentechGrid, June 4, 2014, http://www.greentechmedia.com/articles/read/Can-Utility-Revenue-Climb-Despite-Growth-in-Distributed-Generation.

[35] Andy Colthorpe, "US Solar Capacity to Total 50GW by End of 2016, Says Deutsche Bank," *PVTech*, September 4, 2017, http://www.pv-tech.org/news/us_installed_capacity_to_total_50gw_by_the_end_of_2016_including_20gw_to_30.

[36] U.S. Energy Information Administration, "How Much Electric Supply Capacity Is Needed To Keep U.S. Electricity Grids Reliable?" January 23, 2013, http://www.eia.gov/todayinenergy/detail.cfm?id=9671.

[37] Much of the current natural gas supply is being produced by the use of horizontal drilling and hydraulic fracturing (i.e., fracking) of shale gas formations.

[38] "... the relationship between retail electricity prices and natural gas prices is complex, and many factors influence the degree to which, and the timeframe over which, they are linked.... In the long term, both natural gas prices and electricity prices rise. Electricity prices, which in 2030 are 10.4 cents/kWh (2012 dollars) in the AEO2014 Reference case, compared with 9.9 cents/kWh in the AEO2013 Reference case, continue rising to 11.1 cents/kWh in 2040 in AEO2014, compared with 11.0 cents/kWh in the AEO2013 Reference case." EIA, *AEO2014 Early Release Overview*, 2014, p. 8, http://www.eia.gov/forecasts/aeo/er/pdf/0383er%282014%29.pdf.

[39] Federal Energy Regulatory Commission, *Natural Gas—Electric Coordination*, September 18, p. 2014, http://www.ferc.gov/industries/electric/indus-act/electric-coord.asp.

grid connected)."[40] Thus, power is generated and consumed in a localized distribution system. Many colleges and universities use microgrids because they can choose the power generation technology (for example, natural gas-fueled or renewable), manage energy costs, and have control over how the system is operated (i.e., as combined heat and power, or as power generation sources only).

The ability of microgrids to continue operations as a "power island" appeals to the U.S. Department of Defense. The agency has installed a few pilot microgrid projects with renewable electricity and energy storage to test the economics, resilience, and operational independence in the event of a large scale power outage. Most microgrids are expected to continue to be grid-connected and only operate in "island" mode when the costs or circumstances necessitate.[41] While the decision to adopt microgrids may be based on the desire to reduce energy costs, microgrids are not necessarily cheap to build or operate,[42] especially for the colleges or small communities seen as projected civilian customers. For example, in 2012, the San Diego Gas and Electric Company (an electric utility) started building a microgrid in Borrego Springs, CA, with a grant of $7.5 million from the U.S. Department of Energy and $2.8 million from the California Energy Commission. The project was estimated to cost at least $12 million, and sought to integrate multiple DG technologies using advanced distribution and control technologies.[43]

Some recent catastrophic events have indicated to observers the vulnerabilities of the greater grid. For example, with the prolonged power outages resulting from Hurricane Sandy in 2012, much attention was focused on electric system resiliency and the potential for microgrids to aid in storm recovery efforts. Those who were served by microgrids were able generally to ride out the storm with virtually no loss of power[44] as they were not dependent on the grid for electricity. In the wake of the Sandy power outages, some states were considering microgrids to provide support for police, fire, hospital, and operations centers for emergency workers in a widespread power outage as they restore damaged distribution and transmission systems.

Energy Efficiency, Smart Appliances, and Zero Net Energy Homes

The great promise of energy efficiency is a reduced need for electricity, which can mean a decreased need for power plants to generate electricity and thus less fuel consumption. Since

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[40] Gail Reitenbach, "Interest Growing in Commercial and Community Microgrids," *Power Magazine*, June 26, 2014, http://www.powermag.com/interest-growing-in-commercial-and-community-microgrids/.

[41] Eleanor Nelsen, "Microgrids: Electricity Goes Local," KQED Quest, July 23, 2014, http://science.kqed.org/quest/2014/07/23/microgrids-electricity-goes-local/.

[42] Microgrid electricity based on renewable sources and battery storage costs are about 37 cents per kWh in 2013, as opposed to grid supplied electricity with prices in the range of 7.2-9.2 cents per kWh. See Ben Kaldunski, *Experts Forecast Robust Microgrid Development Through 2020*, December 17, 2013, http://microgrid-news.com/mn12-17-13-1.htm .

[43] The project scope described establishing "... a microgrid demonstration to prove the effectiveness of integrating multiple [distributed energy resource] technologies, energy storage, feeder automation system technologies, and outage management systems with advanced controls and communication systems, for the purposes of improving stability and effecting feeder/substation capacity in normal and outage/event conditions." See Thomas Bialek, *SDG&E Borrego Springs Microgrid Demonstration Project*, U.S. Department of Energy, June 8, 2012, http://energy.gov/sites/prod/files/30_SDGE_Borrego_Springs_Microgrid.pdf.

[44] "Islands in the Storm: Distributed Energy and a Microgrid Survive Sandy," *BusinessEnergy*, July 19, 2013, http://www.businessenergy.net/DE/Articles/Backup_Technology_Progress_22292.aspx?pageid=87278920-696d-4193-a41f-9bb35dfbcd15.

most of the power we use comes from the combustion of fossil fuels, reduced electric generation translates into fewer emissions into the air, and less water consumed in the process of steam production. Many people are looking to cleaner energy sources as a solution. However, even "clean" energy sources can have their drawbacks. Wind and solar farms can impact birds or other animal habitats, and conventional nuclear power requires the mining and processing of uranium, with disposal of spent nuclear fuel requiring secure, long-term storage due to radioactivity and nonproliferation concerns.

According to EIA, the average U.S. household consumed 11,320 kiloWatt-hours (kWh) of electricity in 2009.[45] Historically, the greatest consumption of electricity in U.S. residences has been for heating and cooling purposes, but standards for energy efficiency have considerably reduced the amount of power used by these systems. However, a new trend has emerged recently with the energy savings achieved by these appliances being almost offset by a growing number of consumer devices in the home which are using more electricity. As a result, EIA is now reporting that the largest portion of power consumption in homes is for appliances, electronics, lighting, and other miscellaneous uses.[46]

Research aimed at increasing energy efficiency continues, funded by a mix of federal and state programs. Approximately 27 states have established mandates for utility companies with energy efficiency resource standards or goals.[47] These efforts are expected to result in energy savings between now and 2025 which may offset any demand growth in the period.[48] These new energy efficiency programs are likely to focus on the appliances themselves as a new wave of appliances with built-in intelligence becomes available. These "Smart Appliances" may be controlled by a home-based system which will automatically cycle or run appliances at the best times to reduce energy usage and costs. Such systems may be initiated or augmented by smartphone applications and other devices which will automatically adapt household energy use according to residents' usage patterns.

Residential energy management will likely take a major step forward with the design and construction of Zero Net Energy Homes, which the U.S. Department of Energy describes as "high performance homes which are so energy efficient, that a renewable energy system can offset all or most of its annual energy consumption."[49] Thus, a zero net cost for energy can result as sales of electricity generated on-site from renewable energy balance costs of energy purchased. Such

[45] U.S. Energy Information Administration, "Heating and Cooling No Longer Majority of U.S. Home Energy Use," March 7, 2013, http://www.eia.gov/todayinenergy/detail.cfm?id=10271&src=%E2%80%B9%20Consumption%20%20%20%20%20%20Residential%20Energy%20Consumption%20Survey%20%28RECS%29-b1.

[46] Ibid.

[47] See http://www.dsireusa.org/documents/summarymaps/EERS_map.pdf.

[48] "Under our medium case scenario, annual incremental savings from customer-funded electric energy efficiency programs increase from 18.4 TeraWatt-hours (TWh) in 2010 in the U.S. (which is about 0.5% of electric utility retail sales) to 28.8 TWh in 2025 (0.8% of retail sales).... These savings would offset the majority of load growth in the Energy Information Administration's most recent reference case forecast of retail electricity sales through 2025, given specific assumptions about the extent to which future energy efficiency program savings are captured in that forecast." See Galen L. Barbose, Charles A. Goldman, and Ian M. Hoffman, et al., *The Future of Utility Customer-Funded Energy Efficiency Programs in the United States: Projected Spending and Savings to 2025*, Lawrence Berkeley National Laboratory, LBNL-5803E, January 2013, http://emp.lbl.gov/sites/all/files/lbnl-5803e.pdf.

[49] DOE already has a program to certify these residences as "DOE Zero Energy Ready Homes." See http://energy.gov/eere/buildings/zero-energy-ready-home.

systems may also be applicable to new commercial buildings, perhaps further decreasing demand for utility-generated electricity.

Electric Vehicles

One area with the potential for increased electricity consumption is transportation. A growing number of automobile manufacturers are introducing plug-in electric vehicles (EVs) as new products for U.S. consumers. Some utilities are considering whether EVs will be a longer term means for addressing increasing electricity demand, and provide opportunities for vehicle-to-grid energy storage and related services.[50]

> When parked, vehicles could potentially provide various grid services. Charging of EVs can potentially be controlled and can provide a source of dispatchable demand and demand response. Controlled charging can be timed to periods of greatest [variable renewable generation] output, while charging rates can be controlled to provide contingency reserves or frequency regulation reserves. Vehicle-to-grid (V2G) (where EVs can partially discharge stored energy to the grid) may provide additional value by acting as a distributed source of energy storage. Most proposals for V2G focus on short-term response services such as frequency regulation and contingency. Their ability to provide energy services is more limited by both the storage capacity of the battery and the high cost of battery cycling. This could restrict their ability to provide time shifting (energy arbitrage) beyond their ability to perform controlled charging. The role of V2G is an active area of research. Because electric vehicles in any form have yet to achieve significant market penetration, assessing their potential as a source of grid flexibility is difficult. However, analysis has demonstrated potential system benefits of both controlled charging and V2G.[51]

However, obstacles exist to the wider adoption of EVs. Along with high cost, the limited range for EV travel is also described as one of the current barriers for large scale EV penetration in the U.S. market. Building out a national infrastructure for EV charging might address this concern. While this would seem to represent an opportunity for electric utilities, it is possible that some other entity would build this EV charging network. Regulatory issues have also been raised as regards the sale of electricity from private owners of EV charging stations (including the question of whether a sale of electricity from an EV charging station is a "sale for resale," and as such, subject to laws governing electric utilities). Some state jurisdictions have moved to prevent classification of EV charging stations as electric utilities.

A recent United Nations study predicted the possibility for an almost complete transition of U.S. automobiles from internal combustion engines to EVs by 2050, should that be a policy goal.[52] The potential of such a scenario for large scale GHG reduction would depend on how electricity is generated, i.e., assuming that U.S. policy is focused on almost exclusive use of low or zero-carbon fuels and sources. Fuel cell vehicles could present a competitive or alternative pathway to a potential transportation future dominated by EVs. However, EIA projects that EVs and plug-in

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[50] Under this concept, EV batteries could eventually be used as storage of off-peak energy for the grid, and help provide demand response when the vehicles are not in use.

[51] CRS Report R42455, *Energy Storage for Power Grids and Electric Transportation: A Technology Assessment*, by Paul W. Parfomak.

[52] Sustainable Development Solutions Network and Institute for Sustainable Development and International Relations, *Pathways to Deep Decarbonization*, United Nations, July 8, 2014, http://unsdsn.org/wp-content/uploads/2014/07/DDPP_interim_2014_report.pdf.

hybrid vehicles together may achieve only a 2% penetration of the light-duty vehicle market by 2040.[53] EVs currently represent almost 1% of light-duty vehicle sales.[54]

Energy Storage

Today, electricity must be generated throughout the day and night at levels needed to meet varying demand because energy storage applications are very limited. While batteries, compressed air, and pumped hydro storage schemes are currently in use, they represent a very small part of the overall power generation portfolio due mostly to cost and efficiency issues, and suitability of siting for new pumped hydro projects. Increased use of energy storage could benefit consumers because levels of power generation could be reduced, as would the real dollar and environmental costs of generation. Innovative technologies and schemes for energy storage are being tested, with the possibility that newer, more economic means of large scale energy storage may soon become available.[55] Economies of scale for advanced battery production are also possible, resulting in cheaper, more effective storage options.[56]

Increased energy storage would also benefit the deployment and efficiency of intermittent and variable renewable technologies, since surplus energy could be stored and used when needed. These resources could then potentially provide power during times of peak demand, and could help to address load and demand balancing issues raised with increasing amounts of renewable electricity generation on the grid.

California offers an example of how storage can help integrate renewable generation. The state has ambitious plans for renewable generation, with a 33% RPS requirement by 2020.[57] The California "duck curve"[58] presents a scenario for a grid whose operations may be substantially affected by renewable resource integration, since peak renewable generation from wind and solar power is unlikely to coincide with customer demand (see **Figure 5**). In the period from 2015 to 2020, the California Independent System Operator[59] (CAISO) expects increasing amounts of solar power generation due to RPS requirements. The deepening trough in the chart from 2015 to 2020 (from the early morning to the afternoon hours) represents the net load as more solar power comes on the system. Customer demand during the daytime for electricity will not match the power being generated by solar resources, and CAISO may be required to shut down traditional base load generation resources to avoid damage to the system from potential over-generation.

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[53] EIA, *AEO2014 Early Release Overview*, 2014, http://www.eia.gov/forecasts/aeo/er/pdf/0383er(2014).pdf.

[54] John Gartner, "Why Luxury EV Sales Outpace the Overall Market," *Forbes*, May 16, 2014, http://www.forbes.com/sites/pikeresearch/2014/05/16/why-luxury-ev-sales-outpace-overall-market/.

[55] While traditional lead-acid batteries are usually thought of for today's electricity bulk storage systems, new energy storage technologies are on the horizon. For example, advanced battery and fuel cell technologies may be able to efficiently use hydrogen from dissociated water, thus employing renewable electricity generation technologies like solar PV or wind power to generate hydrogen as well as power during peak hours of operation, and provide power for night-time use.

[56] Dwayne De Freitas, "How Tesla's Battery 'Gigafactory' Could Change Everything—Not Just Electric Cars," *VentureBeat*, August 1, 2014, http://venturebeat.com/2014/08/01/how-teslas-battery-gigafactory-could-change-everything-not-just-electric-cars/.

[57] See http://www.cpuc.ca.gov/PUC/energy/Renewables/hot/33RPSProcurementRules.htm.

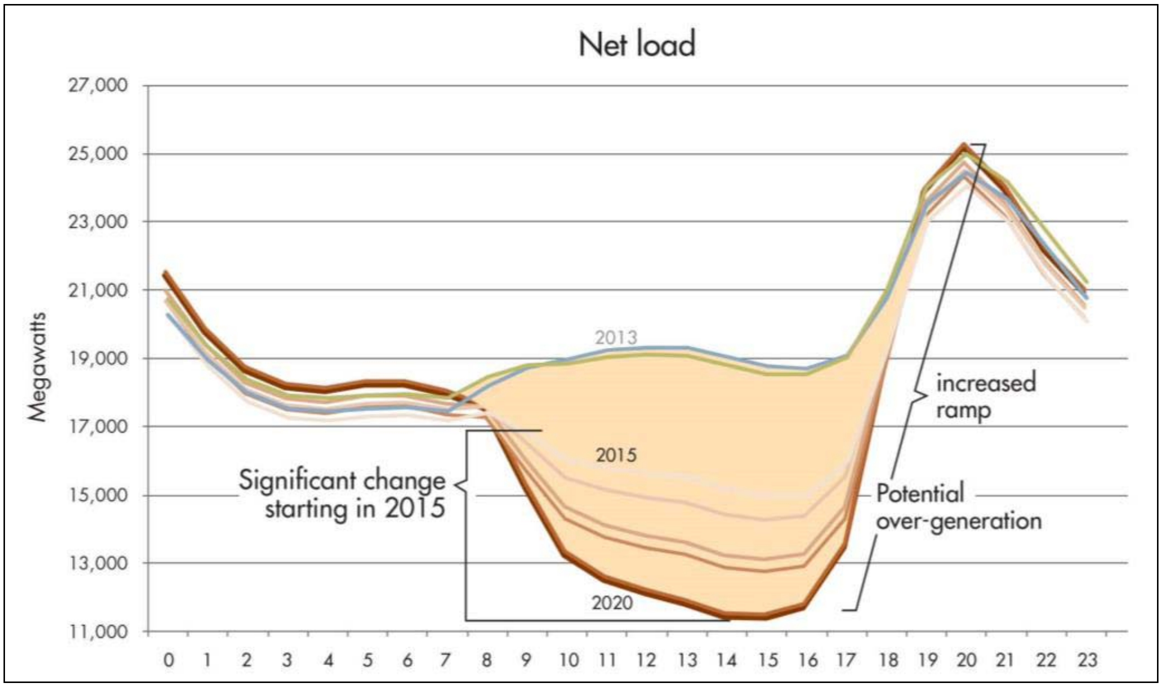
[58] California Independent System Operator, "Fast Facts: What the Duck Curve Tells Us About Managing a Green Grid, 2013, http://www.caiso.com/documents/flexibleresourceshelprenewables_fastfacts.pdf.

[59] CAISO provides open and nondiscriminatory access to the bulk of California's wholesale transmission grid, supported by a competitive energy market and comprehensive infrastructure planning efforts.

But as the sun begins to set solar generation ebbs, and traditional base load fossil must ramp up quickly to meet demand. Most existing base loads power plants are not designed to cycle up and down quickly in this manner. As a result, California may need more fast-ramping natural gas power plants to meet this new base load need (or energy storage) in order to match the variability of renewable generation.

Figure 5. The California "Duck Curve"

Net Load and Effect of Increased Solar Power Generation from 2013 to 2020



Sources: California ISO, EEI.

Large scale energy storage could help electric utilities to manage costs, especially as a dynamic source of energy or as a demand-side resource. But determining appropriate pricing strategies for energy storage will be important as a driver of stand-alone energy storage projects. Electric utilities have fought past regulations requiring avoided cost[60] payments, and the industry will likely want to ensure that it is not providing energy at a lower rate to storage developers, and purchasing energy back at higher rates.[61]

Implications for Today's Electric Utility Model

The preceding sections have discussed some of the new drivers for technology in the power sector. While the electric utility industry has also seen technological advances over the years, the

[60] Under the Public Utility Regulatory Policies Act of 1978 (P.L. 95-617), "avoided cost" is the incremental cost to an electric utility of electric energy or capacity which, but for the purchase from another entity, such utility would generate itself or purchase from another source.

[61] Anne C. Mulkern, "Calif. Plans 'Road Map' to Make More Energy Storage a Reality," *GreenWire*, August 4, 2014, http://www.eenews.net/greenwire/stories/1060004022.

economies of scale possible with large, central station power generation have discouraged any real change in the industry model. But with aging of this power generation infrastructure, new environmental regulations, the prospect of increased supplies of natural gas for years to come, and the potential development of economic alternative power technologies, electric utilities are facing questions about the near-term future. This section of the report will discuss how change may come to the electric utility industry, and the roles that government may possibly play.

Electric Utility Viewpoints

Electric utilities are the incumbent power provider today, with an investment in infrastructure and primary access to customer bases in most of the United States. The PUCs are accustomed to working with utilities on ratemaking, plant location and transmission siting, and planning for the future with integrated resource planning.[62] Given the regional nature of the grid and the different regulatory regimes and infrastructures which exist, it may be reasonable to think that the current system is too entrenched to change. Nonetheless, the electric utility industry seems to be fully aware of the potential for change.[63] The question is whether and how much the industry will embrace new technologies and market opportunities. Some companies may see DG as appealing to only a small number of customers, but in times of shrinking revenues, any real reduction of the customer base can be significant for some companies.

Nonetheless, the perceived trend towards DG technologies is forcing many utilities to look at how they are positioned in the electricity business. Some companies are opting out of the merchant power generation and electricity marketing segments, choosing to focus on traditional electricity service to customers. Other companies are looking at how they can embrace renewable generation as their customers demand more clean energy solutions.

The Edison Electric Institute (EEI) contemplates that the potential rise in DG could be a threat to the regulatory paradigm that allows costs of service to be recovered from the consumers who benefit from the investment (as discussed in the next section). EEI has cited examples from other industries (i.e., the telecommunications and the airline industries) which faced changes in their regulatory and competitive environments, and proposes changes in state regulatory policies to address the issue.[64] The evolution to some version of a future *Utility 2.0* model will not be without costs. But the electric utility industry is concerned about its ability to recover the costs of its current plant in service (i.e., *Utility 1.0*), as it looks at a new era of infrastructure building and costs looming ahead.

[62] "An integrated resource plan, or IRP, is a utility plan for meeting forecasted annual peak and energy demand, plus some established reserve margin, through a combination of supply-side and demand-side resources over a specified future period." See Rachel Wilson and Bruce Biewald, *Best Practices in Electric Utility Integrated Resource Planning*, The Regulatory Assistance Project, June 2013, http://www.raponline.org/document/download/id/6608.

[63] Peter Kind, "Disruptive Challenges: Financial Implications and Strategic Responses to a Changing Retail Electric Business," Edison Electric Institute, January 2013, http://www.eei.org/ourissues/finance/Documents/disruptivechallenges.pdf. (Herinafter DisruptEEI.)

[64] DisruptEEI.

Net Metering and Other Transitional Concerns

In particular, the electric utility industry has raised specific concerns with state programs for net metering,[65] especially in areas with growing penetration of residential solar PV installations. Net metering is one of several "states must consider" standards added to PURPA by the Energy Policy Act of 2005 (EPACT05; P.L. 109-58). Under section 1251 of EPACT05, electric utilities were called upon to make net metering available as a service to customers wishing to generate at least a portion of their own electricity needs.

Ostensibly, state net metering programs are intended to encourage DG adoption. Net metering requirements are intended to compensate consumers for specific types of self-generation identified by states, or to promote self-generation. For electric customers who generate their own electricity, net metering allows for the flow of electricity both to and from the customer—typically through a single, bi-directional meter. In some instances, during times when a customer's generation exceeds the customer's on-site use, electricity from the customer flows back to the grid, offsetting electricity consumed by the customer at a different time. In other instances, the customer is paid for power generated at either the utility's full retail rate or at the utility's avoided cost price.[66]

Utilities have expressed concerns that their current investment in power generation infrastructure to serve today's customers may not be fully recovered if growing numbers of these customers opt for distributed generation.

> The threat to the centralized utility service model is likely to come from new technologies or customer behavioral changes that reduce load. Any recovery paradigms that force cost of service to be spread over fewer units of sales (i.e., kilowatt-hours or kWh) enhance the ongoing competitive threat of disruptive alternatives. While the cost recovery challenges of lost load can be partially addressed by revising tariff structures (such as a fixed charge or demand charge service component), there is often significant opposition to these recovery structures in order to encourage the utilization of new technologies and to promote customer behavior change.[67]

The argument is then made that under such policies, those customers who do not switch to distributed energy resources will be left to pay the unrecovered costs of existing central station

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[65] "Net metering enables customers to use their own generation from on-site renewable energy systems to offset their consumption over a billing period by allowing their electric meters to turn backwards when they generate electricity in excess of their demand, enabling customers to receive retail prices for the excess electricity they generate. Without net metering, a second meter is usually installed to measure the electricity that flows back to the provider, with the provider purchasing the power at a rate much lower than the retail rate.… Providers may also benefit from net metering because when customers are producing electricity during peak periods, the system load factor is improved." See U.S. DOE - Office of Energy Efficiency and Renewable Energy, "Green Power Markets—Net Metering," May 25, 2011, http://apps3.eere.energy.gov/greenpower/markets/netmetering.shtml.

[66] For example, in Arizona, net metering is to be accomplished using a single bi-directional meter. Any customer with net excess generation (NEG) will have that value carried over to the customer's next bill at the utility's retail rate, as a kiloWatt-hour credit. Any NEG remaining at the customer's last monthly bill in a calendar year will be paid to the customer, via check or billing credit, at the utility's "avoided cost" payment (i.e., the cost the utility would have incurred had it supplied the power itself or obtained it from another source). See http://www.dsireusa.org/library/includes/seeallincentivetype.cfm?type=Net&currentpageid=7&back=regtab&EE=0&RE=1.

[67] DisruptEEI.

infrastructure. Thus, in effect, legacy customers may make it easier for DG customers to "exit the system" with the resulting cross-customer subsidy, and "stranded cost"[68] exposure for utilities.

> While the regulatory process is expected to allow for recovery of lost revenues in future rate cases, tariff structures in most states call for non-DER customers to pay for (or absorb) lost revenues. As DER penetration increases, this is a cost-recovery structure that will lead to political pressure to undo these cross subsidies and may result in utility stranded cost exposure.[69]

These legacy customers, some argue, are likely to be less affluent residential customers, or other customers who are not able to or are less inclined to switch to DG systems. Thus, some electric utilities argue that state policies should consider utility system cost recovery in the regulatory schemes for net metering. However, the Center for American Progress (CAP) debates the viewpoint that mostly "affluent" customers are adopting DG systems, and shows adoption of rooftop solar photovoltaic (PV) systems by middle-income customers.

> The question is: Who is buying up all of those solar power systems? Through our analysis of solar installation data from Arizona, California, and New Jersey, we found that these installations are overwhelmingly occurring in middle-class neighborhoods that have median incomes ranging from $40,000 to $90,000. The areas that experienced the most growth from 2011 to 2012 had median incomes ranging from $40,000 to $50,000 in both Arizona and California and $30,000 to $40,000 in New Jersey. Additionally, the distribution of solar installations in these states aligns closely with the population distribution across income levels.... In this issue brief, we show that rooftop solar is not just being adopted by the wealthy; it is, in fact, mostly being deployed in neighborhoods where median income ranges from $40,000 to $90,000.[70]

CAP's analysis is based on solar PV installations, which are largely being installed in states with good solar resources or with favorable state incentive policies.

Is a Formal Transition Necessary?

Some observers look at the EPA's regulations for carbon emissions from new power plants and proposed reductions of GHGs from existing power plants and contend a transition of the electric power sector is already underway. EPA's existing or proposed rules do not mandate anything with regard to utility industry structure; but EPA's proposed regulations for GHG reduction between now and 2030 may lead utilities to the use of more natural gas generation, renewable electricity, and possibly nuclear power, and less coal-fired generation.

EPA's regulations are focused on larger scale, central station generation of electricity. Wider use of natural gas by central station generators and DG applications may hinder GHG reduction goals, since natural gas is a fossil fuel. Therefore, if even lower carbon emissions or a GHG emissions-free regime is the future of electricity generation, then what fuel or paradigm is this future to be based on? Separation and sequestration (or reuse) of carbon captured from fossil fuels

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[68] Stranded cost may be defined as the decline in the value of an asset as a result of regulatory change.

[69] DisruptEEI.

[70] Mari Hernandez, *Solar Power to the People: The Rise of Rooftop Solar Among the Middle Class*, Center for American Progress, October 21, 2013, http://www.americanprogress.org/issues/green/report/2013/10/21/76013/solar-power-to-the-people-the-rise-of-rooftop-solar-among-the-middle-class/.

may be economical at that time. Renewable electricity generation may be another long-term answer, but the United States is far from a grid which could depend mainly on renewable generation from solar and wind power without at least some central station generation (possibly nuclear power), and large scale energy storage. Increased use of natural gas has been described by some observers as only a "transition strategy" to a clean energy future.[71] If natural gas is a transitional fuel strategy, then could hydrogen be its replacement? Coal and natural gas could well be sources of hydrogen (assuming carbon capture and reuse or sequestration), as might nuclear power or renewable electricity (if electrolysis of water is a source). And hydrogen is also a fuel which could be used by fuel cells which may also be a significant residential energy choice for DG in the future.

It is important to note that approximately one-third of today's approximately 100 U.S. nuclear power plants in service will see their operating licenses expire by 2030.[72] A number of these plants may face retirement, as issues of competitiveness in a time of low wholesale electricity prices and the costs of keeping these aging plants running are taken into consideration. At this time, only five new nuclear reactors are under construction in the United States.[73]

To some, these and other questions may point to the need for a longer-term national or regional energy policy planning if we are to know how the U.S. energy future will be structured to promote lower GHG emissions and/or higher renewable energy use. Assuming that GHG reduction is the direction of future U.S. energy and environmental policy, a formal transition requiring federal policy guidance for the electric utility industry may be an option if, for example, the energy markets fail to transition smoothly to such a clean power future. Market failures of this sort have been discussed by industry observers in the past, with stranded assets and company bankruptcies posited as potential disruptions. While it is unlikely that such instances would result in a major disruption of the nation's power supply, the effect on financial markets of a major company failure could be a concern.

Similar transitions have been accomplished in the past by other industries without significant congressional policy intervention. The telecommunications industry dealt with competitive market issues from deregulation in the early 1990s, resulting in companies like AT&T taking a $6.7 billion write-down to modernize its plant in preparing for competition.[74] As stated earlier in this report, electric utilities are already looking at cost control strategies as growth in demand for electricity declines. Changing the remaining life of assets in book depreciation[75] rates authorized by state utility commissions is a tool that can be used to deal with stranded assets. This would

[71] Amory Lovins and Brett Williams, *A Strategy for the Hydrogen Transition*, Rocky Mountain Institute, 1999.

[72] See http://www.nei.org/Knowledge-Center/Nuclear-Statistics/US-Nuclear-Power-Plants/US-Nuclear-Plant-License-Information.

[73] World Nuclear Association, *Nuclear Power in the USA*, August 2014, http://www.world-nuclear.org/info/Country-Profiles/Countries-T-Z/USA—Nuclear-Power/.

[74] Reference for Business, *AT&T Corporation—Company Profile, Information, Business Description, History, Background Information on AT&T Corporation*, p. 2014, http://www.referenceforbusiness.com/history2/15/AT-T-Corporation.html.

[75] Book depreciation is a regulatory accounting concept which involves the allocation of the cost of an asset over its expected useful service life in a manner that systematically charges the cost of the asset over the period of time it is in service. Book depreciation may be charged at a faster or slower rate than allowed by the Internal Revenue Service, in order to provide management with a realistic view of the gradually diminishing value of the company's assets.

allow utilities to accelerate recovery of the cost of their assets if they believe cost recovery over longer service lives is threatened.[76]

> ... the Uniform System of Accounts [as per 18 C.F.R. Part 352 under the Code of Federal Regulations], defines depreciation as the loss in service value not restored by current maintenance incurred as a result of consumption or prospective retirement of (utility) plant in the course of service from causes that are known to be in operation and against which the utility is not protected by insurance. Among the causes given consideration are wear and tear, decay, obsolescence, changes in the art, changes in demand, and requirements of public authorities.[77]

Concerns over rate base erosion from net metering policies and a growth in distributed generation are issues related to the competitive environment (i.e., changes in demand, related to the requirements of public authorities). A potential switch to DER involves all customer rate classes—from residential to commercial to industrial electricity consumers. This is due to competition for the electricity customer, as technology and other changes to the business and regulatory environment present customers with choices. Recovery of costs through increased depreciation rates has been recognized by EEI as a proposed action to help electric utilities deal with potential competition from DER.[78]

However, such issues are largely under state jurisdiction. If a change in the depreciable service life is made, then making this change as early as possible is preferable since this will result in a smaller increase in overall customer rates. The shift to a new, shorter remaining service life recovery would raise the depreciation portion of customer rates but it would be potentially spread over a larger customer base.

Observations

The U.S. grid has long been considered as one of the wonders of the last century. But the grid is aging and in need of modernization in many areas. The average age of U.S. coal power plants, the mainstay of the industry, is about 43 years. New technologies and cost structures are now making inroads into U.S. electricity markets and may eventually result in dramatic changes to the industry over the next few decades.

A Modern Power System for All Users

Many consumers have real choices in how to obtain the power they use today depending on availability and cost, and will have greater choices in the future as technologies currently under development reach the market. With renewable electricity, fuel cells, and EVs seeing increasing acceptance by consumers, regulations like RPS requirements, net metering, and tax incentives are making adoption of individualized power generation solutions easier. As the grid modernizes, it

[76] R. Campbell, "Competing in a Market Environment: What Utilities Should Consider," Public Utilities Fortnightly, May 15, 1993.

[77] Ibid.

[78] "Apply more stringent capital expenditure evaluation tools to factor-in potential investment that may be subject to stranded cost risk, including the potential to recover such investment through a customer hook-up charge or over a shorter depreciable life." DisruptEEI.

will likely be expanded in ways as to be flexible enough to accommodate both new technologies and the ways customers will want to use power.

However, economic development at the national and local levels will likely continue to be tied to the availability of low cost energy for many years to come, and the electric utility model has proven that it can provide relatively low cost electricity. Therefore, it is possible that the majority of today's consumers will remain future utility customers if the grid's infrastructure can be modernized and grid electricity costs can be kept at reasonable levels. If not, then some customers who can afford to switch may switch to DG solutions.

Telephone companies recognized that change was coming and adapted to change as they became "telecommunications" companies, offering choices that ranged from "plain old telephone service" to a variety of networked and other services. The telecommunications marketplace expanded with the range of technological offerings. The analog for evolving electric utilities may begin with an offering of "plain old electricity" service in recognition of what services customers may be willing to pay for. Continuing the telecommunications comparison further, the build-out of the system from plain old telephone wires to cellular and fiber optic infrastructure was accomplished by serving the needs of consumers. The cost of the infrastructure build-out was underwritten by customers willing to pay for the perceived added value of these new services.

The Smart Grid as Enabler or a Result of Change

For the electric utility industry, the "Smart Grid"[79] may eventually be the great enabler of change. While some look upon the Smart Grid as a gradual modernization of the system to include two-way intelligence capabilities for monitoring and controlling systems, others see its potential for enabling services and even greater change.

Most electric utilities appear to view the intelligence and communications capabilities of Smart Grid systems positively, even with the added concerns for cybersecurity.[80] Cost of operations could potentially be reduced and system resiliency improved from further integration of automated switches and sensors, even considering the cost of a more cybersecure environment. But with the potentially high costs[81] of a formal transition, some see the deployment of the Smart Grid continuing much the same as it has, with a gradual modernization of the system as older components are replaced.

The potential for the Smart Grid to enable change may be exemplified in the potential to further integrate variable renewable resources at a lower cost. A wider deployment of a "fully-functional"

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[79] According to the Electric Power Research Institute, "[t]he term 'Smart Grid' refers to a modernization of the electricity delivery system so that it monitors, protects, and automatically optimizes the operation of its interconnected elements—from the central and distributed generator through the high-voltage transmission network and the distribution system, to industrial users and building automation systems, to energy storage installations, and to end-use consumers and their thermostats, electric vehicles, appliances, and other household devices." See C. Gellings, Project Manager, *Estimating the Costs and Benefits of the Smart Grid*, EPRI, Final Report 1022519, March 2011.

[80] CRS Report R41886, *The Smart Grid and Cybersecurity—Regulatory Policy and Issues*, by Richard J. Campbell.

[81] The Electric Power Research Institute (EPRI) estimated in 2011 that the "net investment needed to realize the envisioned power delivery system (PDS) of the future is between $338 and $476 billion." EPRI also estimated the benefits of a Smart Grid at "between $1,294 and $2,028 billion." Investment of "between $17 and $24 billion per year [would] be required over the next 20 years" to achieve the PDS. C. Gellings, Project Manager, *Estimating the Costs and Benefits of the Smart Grid*, EPRI, Final Report 1022519, March 2011.

Smart Grid could see the renewable generation in one state or region supporting renewable generation in another state or region, with the power flowing from where it's generated to where and when it would be needed. It is likely that all of the drivers and technologies discussed earlier—from microgrids, energy efficiency, smart appliances, and zero-net energy homes to EVs and energy storage—could all see more effective deployment at lower cost from an integrated Smart Grid approach. However, the cost of a build-out of a more fully functional Smart Grid could be compared against the cost of building a new, more flexible natural gas-based generation system to replace retiring coal (and perhaps retiring nuclear) capacity, and to augment renewable power in a load-following (i.e., backup for variable renewable generation) mode.

Modernization of the grid has been accomplished to various degrees as new digital systems replace old analog components. Attempts to introduce some components of the Smart Grid have been deemed successful (i.e., the deployment of synchrophasors providing real-time information on system power conditions,[82] and the replacement of old inverters on solar PV systems with smart inverters capable of disconnecting from the grid during times of power interruption[83]). But introduction of other components have been problematic. Smart Meters have run into cost and performance issues and resistance to the technology (generally from concerns of some customers over potential health impacts of radio wave emissions), causing some to question if the Smart Grid will really provide the expected benefits.[84]

Electricity Technology Drivers in Recent Legislation

Congress has enacted legislation several times in the last 10 years in recognizing the role of new electricity technologies and their potential to change how consumers use electricity. The vehicle for implementing legislation has often been "states-must-consider" standards added to PURPA. As such, state utility regulators "must consider" the proposed action, and decide whether or not to adopt the standard as a requirement for the electric utilities it regulates.

EPACT05 added five states-must-consider standards requiring states to consider provisions such as net metering, a consumer option for smart meters, and time-of-use pricing.[85] The Energy Independence and Security Act of 2007 (P.L. 110-140, EISA) also added several states-must-consider standards including a provision for Smart Grid investments.[86] As regards previous states-must-consider standards, responses have varied depending on state policies. Some states adopted the proposal, while other states have said that their own policies have gone beyond the requirement and have thus declined to adopt the federal initiative. Still other states have considered the initiative and declined to adopt or adapt the initiative, but in so doing appear to have satisfied the "must-consider" requirement.

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[82] See U.S. Department of Energy, *Synchrophasor Technologies and their Deployment in the Recovery Act Smart Grid Programs*, August 2013, https://www.smartgrid.gov/files/doc/files/Synchrophasor%20Report%2008%2009%202013%20DOE%20%282%29%20version_0.pdf.

[83] Smart inverters can also smooth the swings in power flow due to intermittent power generation from solar PV operation. Herman K. Trabish, *Smart Inverters: The Secret to Integrating Distributed Energy onto the Grid?*, Utility Dive, June 4, 2014, http://www.utilitydive.com/news/smart-inverters-the-secret-to-integrating-distributed-energy-onto-the-grid/269167/.

[84] Mark Chediak, "Boulder Finds 'Smart Grid' Slow, Pricey," *The Grid*, November 1, 2011, http://www.bloomberg.com/news/2011-11-01/boulder-finds-smart-grid-slow-pricey.html.

[85] EPACT05, sections 1251 and 1252.

[86] EISA, section 1307.

Most recently, the American Recovery and Reinvestment Act of 2009 (P.L. 111-5, ARRA) extended the production tax credit for qualifying renewable electricity technologies (since expired), and modified tax provisions for new plug-in vehicles (plug-in hybrids and pure electric vehicles) along with other actions and funding to advance the Smart Grid.

Conclusions

The electricity industry is unlike most industries in that the product it produces is important to the functioning of our modern commercial society. Produced using economies of scale, electricity has been a fairly inexpensive enabler of national economic activity. But the convergence of many factors—new environmental regulations, an aging electric utility infrastructure, the growing availability of cost-competitive consumer-oriented electricity technologies, and state implementation of policies to advance renewable electricity—is presenting challenges to the electric utility industry while providing consumers with increasing choices for obtaining electric power. An evolution to some version of a new *Utility 2.0* model capable of providing for customer choice in a clean energy future has been advocated by some as the next logical step for the electric utility industry.

The electric utility industry would likely argue that before the United States can shift to *Utility 2.0*, the obligations of today's *Utility 1.0* model must be considered in plans to move forward. Such obligations would include the unrecovered costs of power plants and other infrastructure, and environmental and public safety obligations related to legacy coal and nuclear power.

It may well be assumed that the current electric utility model will continue to evolve. A key to the future is likely to be cost control for many electric utilities, so that utility electricity prices will be competitive with other choices. Conversely, as utility customers seek to control their own costs or power-related decisions, the service choices offered to entice them to stay utility customers will probably increase, especially as the DG option becomes potentially more attractive. The options for electric utilities to satisfy these customers in the future may even include support services for customer self-generation beyond merely providing backup power.

Congress began to address the move of the electricity utility industry away from the regulatory compact concept by introducing competitive providers to the electric utility industry with PURPA, and reinforced competition as federal policy with EPACT92. Several congressional bills have contained provisions to further a range of technologies and paradigms, especially in the various states-must-consider standards. In the future, Congress may yet consider if a formal legislative initiative would be required to move the electric power industry to a clean energy power system should that be the goal. Congress may also consider legislation if a market failure is perceived or if consumer choice is seen to be unduly constrained.

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