Always On: Reliable Electricity in an Age of Coal Plant Retirement

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ABSTRACT

The notion that we rely on large coal and nuclear power plants to continually provide the minimum amount of electricity we need (also known as "baseload power") is becoming increasingly obsolete. Our electricity generation infrastructure is changing from the centralized baseload power plants of the last half of the 20th century, to the flexible system now emerging as more diverse and agile generation sources come online and as grid operators manage electricity flow more effectively on a regional scale. In light of changing market forces affecting large coal and nuclear plants - such as rising fuel prices due to global demand, increasing construction costs for new power plants, internalized environmental and health costs from heightened government regulations, and slowing growth in electricity demand - utilities, industries, policymakers and government agencies must move past the outdated idea that we need baseload power plants to keep the lights on. In addition, technological innovations are reducing the costs of generating electricity from a variety of sources and expanding grid operators' abilities to maintain a reliable and flexible grid, for example by pairing variable wind resources with agile natural gas plants. This paper provides a useful and effective narrative for key decision makers to ensure that our policies governing electricity generation reflect the changing face of our 21st century electricity grid. The author organizations for this paper are based in Minnesota, where this narrative is particularly needed, and so the paper focuses on some examples specific to that state.

Baseload Power: Maintaining Reliability as We Reduce Reliance on Traditional Baseload Power Plants

Minnesota's electricity system will undergo tremendous changes in the years ahead. Many critical components of the electricity system are transforming, forcing system planners to think differently about how to provide electricity service to the state. These changing factors include:

- The natural turnover of an aging fleet of power plants
- Shifting fuel costs and availability
- Increasing availability of clean electricity technologies
- Increasingly regional system operation that integrates diverse technologies seamlessly
- The economic development potential for Minnesota to make more electricity from its own resources
- The opportunity to diversify electricity generation sources to provide greater stability and reliability of the system
- New or expected environmental standards to reduce the dangers aging power plants pose to our air, water, health, and climate

The electricity system that was built in the 20th century relied on what have become known as baseload power plants—very large, centralized plants designed to operate nearly all the time. Usually coal, nuclear, or large hydropower plants, these baseload plants were chosen by utilities and regulators as the optimal way to provide electricity service. These power plants were not perfect, as discussed in this report, but they became the anchors of the electricity grid.

In the 21st century, the electricity system is becoming much more diverse and dynamic. As a result of this evolution, the individual baseload plant is becoming increasingly obsolete. Electricity is now managed through regulated regional energy markets that cover broad geographic regions of the country. Today's power grid serves millions of individual loads by combining electricity from many power plants—of which, at any given moment, some are operating and others are not. New technologies and forecasting methods are enabling planners to create new ways of providing reliable, affordable electricity without the drawbacks of the traditional baseload power plant technologies. The felt need to meet baseload demand with a power source that is "always on" is raised as a premise to retain these large, centralized power sources. However, these same energy demands can be met easily by our integrated and nimble grid and its diverse energy generation. Minnesota policymakers will face questions about the need for baseload power plants again and again in the years ahead—particularly given the large number of coal plants facing retirement—making it important to understand what baseload power is and what it is not.

Providing Power: What We Need

Electricity is a commodity, but one with special characteristics that pose unique challenges. Demand for electricity is immediate; it must be available at the flip of a switch. Demand is variable, always changing as we turn on our appliances or turn off heavy manufacturing machinery. Supply is also variable—a power plant's output is never entirely uniform, requiring regional grid operators to constantly manage generation resources across multiple states. Until utility-scale electricity storage becomes an economic reality, grid operators have to instantaneously match generation supply with consumer demand.

There are three metrics that planners keep in mind when balancing supply and demand. It must be done reliably. It must be done affordably. And increasingly, it must be done in a way that reduces impacts on human health and the environment. In this report, we will mostly focus on reliability and affordability. We will not discuss the effects on human and environmental health of using coal or nuclear power, except to note here that there are many negative effects.

Types of Generation: Past to Present

In the past, an electricity generation portfolio was created using three types of power plants: baseload, intermediate, and peaker plants.

Baseload plants are those designed to meet the "base load" of electrical demand, which is the minimum power demand that can be expected to persist from day to day. These plants are rarely offline and take days to weeks to start up or shut down. This inflexibility has not been a severe detriment in the past because the plants are meant to supply only the minimum power demand on the system (e.g., weekend nights with moderate temperatures). Baseload plants are typically very large coal and nuclear plants, although hydroelectric, geothermal, biomass, and certain types of natural gas plants can also provide baseload power. In the past, baseload plants operated with relatively high reliability and relatively low operating costs compared with other sources of power (EIA, 2010b).

Intermediate (or "load following") plants are used daily. In contrast to traditional baseload power plants, intermediate plants are flexible enough to vary operations and output. They are used to provide power throughout the most demand-heavy portions of the day. They greatly curtail their operations during low-demand hours like nighttime. Natural gas plants have mainly played this load following role in recent years, particularly natural gas combined cycle (NGCC) plants.

Peaker plants are smaller plants that must be able to ramp up and down quickly during peak electricity demand times to ensure reliability in the grid. Peaker plants are typically combustion turbines that burn natural gas or even petroleum (fuel oil). They are not usually used every day at all times of the year. Typically, Minnesota's gas peaker plants are used at about 2–3 percent of their potential yearly output.

The recent addition of large-scale wind and solar power to the electricity planner's portfolio means we now have another type of generation resource: variable power. As we'll discuss later, this is contributing to a change in the optimal mix of resource types.

The Past: Why Baseload Power Used to be the Most Often Chosen Technology

The first power plant, a coal-fired facility created by Thomas Edison in 1882, served 85 local customers in New York City. Early power plants were small, local power producers, but over the ensuing decades they grew into very large, centralized power plants. This happened for many reasons. Economies of scale reduced the cost per unit of electricity produced. Coal plants required a constant influx of fuel that arrived on trains. The fewer destinations, the lower the transportation costs for a utility. Coal and nuclear plants also need huge sources of cooling water, requiring large infrastructure investments that encourage fewer, larger plants.

The historic trend toward ever larger baseload plants is reflected in Minnesota's coal and nuclear plants. In Minnesota, the oldest coal units (those built in the 1950s and 1960s) are typically small, between 50 and 100 megawatts in size. The newest coal units, built in the 1970s and 1980s, range between 350 and 900 megawatts in size. The Sherburne County coal plant, Minnesota's largest and newest coal plant, has three units with a combined capacity of over 2,100 megawatts. Minnesota also has three nuclear units—one at the Monticello Nuclear Generating Plant (631 megawatts) and two reactors at Prairie Island Nuclear Power Plant (each 593 megawatts).

Coal and nuclear plants have always been relatively costly to construct compared with peaker plants on a per megawatt basis, partly because of their size and the inherent dangers and pollution associated with these technologies. That high upfront cost posed less of a financial risk when demand for power was predictably rising. The upfront capital costs could be recouped from ratepayers over many years so that rate shock from these huge investments could be avoided in favor of gradual rate increases over time. Indeed, in earlier decades, power demand grew so fast that planning for supply was fairly straightforward—build large baseload power plants, with huge economies of scale, and let the predictable demand growth catch up to the supply over time.

However, these large, high-cost, long-lived plants can be very risky investments, as the nation learned in the 1970s and 1980s. During that era, utilities around the nation launched massive baseload power plant building projects, assuming that electricity demand would continue rising uninterrupted and that construction costs would stay manageable. Utilities were surprised by (and in many cases ignored) the reduced demand growth associated with the 1973 and 1979 oil crises and the subsequent recessions, dramatically rising construction costs (especially for nuclear plants), and new safety concerns following the Three Mile Island accident in 1979. As a result, more than 100 nuclear plants and 80 coal plants were cancelled nationwide, sometimes after hundreds of millions of dollars had already been spent. In other cases, plants were completed but represented costly excess capacity for years while waiting for demand to catch up, often as long as 20 years after plants came online. This resulted in lower revenues to pay off the interest on capital, which meant higher price tags for the plants. Legal battles erupted around the nation to determine whether utility stockholders or ratepayers should bear the billions of dollars in losses (Clemmer et al. 2011).[1]

Today, utilities are faced with similar challenges. A recession and an increasingly energy-efficient society are resulting in forecasts of relatively low growth in electricity consumption. While electricity demand increased at a rate of 9.8 percent in the 1950s, demand growth was a mere 0.7 percent in the first decade of the 21st century and is expected to continue growing at a rate below 1.0 percent over the next few decades (EIA 2013). The public is increasingly concerned about the health and environmental impacts of fossil fuel use and nuclear power. In addition, new supply and demand-side technologies have become viable alternatives. With so many old coal-fired baseload plants up for refurbishment, this is a critical time to reevaluate the risks and benefits of traditional baseload power plants and to compare them with emerging alternatives.

Baseload Plants Today: Benefits are Less Relevant, Drawbacks More Costly

In the past, baseload power plants' benefits of high reliability and low operating cost largely outweighed other concerns about health and environmental impacts. Large upfront investment risk was lessened (with exceptions mentioned earlier) by relatively reliable demand growth and the willingness of state regulatory commissions to assess ratepayers for the costs of excess capacity. Fuel costs stayed relatively low compared with other generation alternatives powered by oil or natural gas. The inability of traditional baseload power plants to ramp up and power down quickly was mitigated with intermediate and peaker power plants. As a result, the electricity service model became centered on baseload power plants. Today's world is very different.

Major trends are combining to make traditional baseload power plants less valuable. These trends are exacerbating baseload power plants' innate drawbacks and are causing their benefits over the "next best option" to dwindle:

[1] It should be noted that rate-regulated utilities have a built-in incentive to construct high-capital-cost baseload plants, because the more capital they invest, the higher the "rate base" on which their rates are calculated. This is another reason—beyond the inherent financial risk associated with such large and long-term projects—why regulatory scrutiny of power plant projects is particularly important. After the financial disasters associated with a national wave of ill-fated power plant construction in the 1970s and 1980s, many states, including Minnesota, put in place new laws requiring utilities to engage in transparent long-term resource planning so regulators and the public could better oversee their choices and assumptions.

- Renewable electricity generation is becoming more widespread and predictable, and it will be deployed widely in a growing number of states. As a result, the electricity grid of the 21st century will need to pair this variable renewable resource with flexible, agile resources instead of large, slow-moving plants unable to ramp up or down quickly.
- Fossil and nuclear fuel costs are increasing, and power plants are being held accountable for their health and environmental costs. As a result, coal-fired and nuclear power plants are not as economically attractive as they once were.
- Growth in electricity demand has slowed. Whereas in the past, a utility could afford the risk of an enormous capital investment because it could be assured that growth would be consistently high, this is no longer the case. Utility customers are now exposed to more cost risk than before.

Increased Renewables and Better Ways to Integrate Them

Increasingly, there will be a significant amount of renewable electricity on our electricity grids. Twenty-four states have enacted Renewable Energy Standards (RES) requiring utilities to obtain a gradually increasing percentage of the power they sell from renewable sources. Another five states have enacted renewable energy goals. Minnesota's Renewable Electricity Standard is one of the strongest in the nation, requiring utilities to obtain 25 percent of their electricity from renewable sources by 2025, except for Xcel Energy, which must obtain 30 percent from renewables by 2020. Collectively, these renewable energy policies in the Midwest region will result in 24,000 megawatts of wind energy generation added by 2026. Utilities and grid operators are using new methods of planning and innovative technologies to integrate these more variable resources into the grid.

Managing Variability

Variability requires utility planners and grid operators to complement renewable energy output with flexible, agile ways of quickly increasing supply or reducing customers' electricity demands through pre-agreed upon, voluntary demand response contracts. They are increasingly doing this by deploying fast thermal generation, such as "intermediate" and "peaker" natural gas plants that can be brought online and offline in short periods of time. For example, wind energy coupled with generation from intermediate natural gas plants is proving to be very cost effective and reliable. These fast, agile resources are much better complements to variable renewable generation than traditional baseload power plants, which are slow moving and harder to manipulate.[2]

In addition, new innovations in "demand response" allow utilities and grid operators to increasingly rely on the ability to reduce customers' demands for electricity. Demand response utilizes voluntary agreements primarily between industrial customers and utilities in which customers reduce electricity usage during periods of peak demand. Many utilities provide

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[2] Some argue that renewables will require "back-up" generation in excess of what we already have for the current baseload-centered paradigm. In a presentation to the Western Electricity Coordinating Council, researchers from the National Renewable Energy Laboratory concluded that, "The traditional focus of resource adequacy has been, 'How much installed capacity is needed?' With increasing generation from wind and solar, the additional question is, 'What type of capacity is needed?' Wind and solar do not cause need for additional capacity, but may require a different kind of capacity (more flexible capacity)" (King & Milligan 2011).

financial incentives to customers participating in demand response programs. When customers' electricity demands can be quickly reduced through load management techniques, it reduces the need for additional supplies of electricity.

Reducing Variability

As we find more effective ways to manage variable generation like wind and solar, we are also developing technologies, tools, and techniques to reduce the variability itself. Innovations in wind, solar, and storage technologies and in grid operation tools and techniques are creating solutions that will help make renewable electricity even more reliable.

Many experts consider utility-scale energy storage to be the key to unlocking the vast potential of variable renewable power. Many techniques are commercially employed in niche applications around the world as utilities and energy companies are innovating to realize the large economic benefits of cost-effective storage. "Pumped Storage Hydroelectricity" is currently the most widely used method, with over 129 gigawatts of capacity around the world. "Compressed Air Energy Storage" is also a promising technology identified as one of the cheaper potential options. There are many types of chemical energy storage technologies (i.e., batteries) that are employed by utilities or companies in special applications. The challenge for the coming decade is to continue improving large-scale storage technologies and for policymakers to identify what policies are needed to create a market and economic opportunity for storage innovators (Rastler 2010). As these markets and technologies develop, energy storage will play an expanding role in reducing the variability of the future grid.

Forecasting and Planning

Improved methods of forecasting and planning are allowing grid operators to more accurately predict variable electricity output. Studies by institutions including the Lawrence Berkeley National Laboratory show that increasing the geographic diversity of variable generation increases its reliability (Alliss 2011; Mills & Wiser 2010). While the wind may not be blowing in one isolated location, wind is generating electricity in other parts of the region. As we continue to add more renewables across the Midwest and the country, we will see increased reliability on the whole. Regional grid operators will draw power from a geographically and technologically diversified portfolio of variable resources.

Larger Regional Transmission and Electricity Market Management

Regional grids are becoming more connected and are able to transmit and optimize power across longer distances. Experts are now beginning to tackle the challenges of interconnecting the country's regional grids and increasing the reach and capacity of transmission lines, realizing enormous value as the country adds more renewables to the system (NCSL 2006).

In June 2011, the Midwest Independent System Operator (MISO), which manages the electricity transmission grid and electricity markets across 12 U.S. states (from Pennsylvania to Montana) and Manitoba, announced a new resource designation: Dispatchable Intermittent Resources. This category will allow wind resources to be "treated like any other generation resource in the market and, for the first time, participate in the region's real-time energy market. Now wind can automatically be dispatched" (MISO 2011).

Using some or all of the innovations and trends listed in this section, regional operators like MISO are quickly developing the ability to manage large volumes of renewable electricity on the grid, which substantially increases the value of these resources to the system. Having more renewables on the grid is spurring innovation to increase reliability and complement the variable nature of wind and solar. These innovations include flexible and fast-moving resources such as natural gas plants, technologies that manage customers' electricity loads, or other near-term technologies like electricity storage.

In this evolving 21st-century electricity grid, the optimal resources are no longer large, inflexible baseload power plants. In fact, our inability to control the traditional baseload plants' generation output in a timely manner will become an increasing liability, as noted by Jon Wellinghoff, chairman of the Federal Energy Regulatory Commission: "…[I]f you can shape your renewables, you don't need fossil fuel or nuclear plants to run all the time. And, in fact, most plants running all the time in your system are an impediment because they're very inflexible. You can't ramp up and ramp down a nuclear plant. And if you have instead the ability to ramp up and ramp down loads in ways that can shape the entire system, then the old concept of baseload becomes an anachronism" (Straub & Behr 2009).

Costs Are Rising for Baseload Power, Falling For More Flexible Options

In the past, power from traditional baseload power plants has been viewed as reliably cheap. This reputation is quickly changing.

Construction. Construction costs for traditional baseload power plants have always been painfully high. Constructing a mid-sized coal plant today would cost more than $1 billion, and costs to construct a nuclear plant are estimated to exceed $5 billion. The U.S. Energy Information Administration (EIA) estimates that 2011 construction costs for new coal and nuclear plants were 25 and 37 percent higher (respectively) than 2010 estimates, indicating the rapid increase in costs for these projects (EIA 2010c).

During the construction boom of the 1970s and 1980s, construction costs skyrocketed, leading to widespread project cancellations and rate increases for customers. This increase in construction costs was blamed on many factors, including rising commodity costs caused by global demand for building materials, especially from fast-growing China. This trend continues today. Unlike newer and more distributed technologies such as solar and wind, these plants are not in a position to benefit from expanded mass-production and technology improvements. Traditional coal and nuclear plant construction costs will continue to rise, just as solar and wind costs continue to fall due to innovation and economies of scale.

Fuel. The other large cost element in traditional baseload plants is fuel. One of the justifications for building coal-fired power plants has been the belief that fuel costs would stay low, but that is increasingly unlikely. Between 2000 and 2010, the price of coal delivered to electric utilities nearly doubled, despite the economic slowdown in the final years of that decade (Paduano et al. 2011). One major factor driving U.S. coal prices higher has been the growing influence of global coal markets. Coal imports in China, India, and Japan have been rising steeply, driving up global coal prices and U.S. coal exports (EIA 2011b). Coal producers in the Powder River Basin in Wyoming and Montana (the source of almost all of the coal burned in Minnesota) are trying to build new West Coast ports to allow them to export coal to the burgeoning Asian markets

(Whittaker 2011). This would put Minnesota coal plants in direct competition with Asian coal plants for fuel and make coal prices increasingly like oil prices—driven by global events and more volatile and hard to predict. The cost of coal as a fuel in the future looks increasingly uncertain and unreliable (Tierney 2012). By contrast, the fuel for wind and solar electricity production is permanently and reliably free.

Health and environmental protections. State and federal governments are increasingly concerned with the costs to human health and the environment caused by traditional baseload power plants. New standards to control mercury, soot, smog, and greenhouse gases and to reduce water and waste pollution from coal plants have been recently finalized or will be released in the coming decade. Coal plants in particular must internalize these health and environmental costs by installing better equipment that reduces pollution. In Minnesota, projected costs to clean up aging coal-fired power plants run into the hundreds of millions of dollars. Ottertail Power estimates that its $500 million clean up at Big Stone I will increase rates by 15 percent. The costs for new nuclear plants have become almost prohibitively high due to the increasing cost of equipment, the reduction in the number of manufacturers, the failure of the federal government to fully develop high-level radioactive waste disposal, safety concerns, siting problems, and long delays due to public opposition. These health and environmental protections, equipment costs, logistical problems, and public sentiment will force traditional baseload power plant producers relying on nuclear plants to internalize costs that they could previously transfer to citizens' medical bills and environmental clean-up costs. As this happens, the price of producing traditional baseload power from this source will more closely reflect its higher true cost, again reducing its appeal as a cost-effective source of electricity.

The emergence of natural gas as an alternative. As the price forecasts for coal are increasing, natural gas prices have dropped significantly based on new and substantially higher estimates of domestic U.S. natural gas reserves. The EIA expects natural gas-fired power plants to account for 63 percent of new capacity additions in the U.S. by 2040 (EIA 2013). One of the chief advantages of natural gas plants is the ability to go from a standstill to generating significant amounts of power quickly. This has always been a useful trait but will become even more important as we continue to move toward a dynamic power grid with greater amounts of variable renewable power.

There are many unresolved concerns about hydraulic fracturing, a method used to force natural gas out of fractured rock, which underlies present supply and price forecasts. These concerns include the impacts on water quality, the potential increased incidence of earthquakes, the use of huge amounts of water, and the risk of leakage of methane—a potent greenhouse gas—during the drilling process. These and other factors may greatly reduce the environmental benefits of lower carbon dioxide emissions from gas-fired power plants. The environmental impacts of these new drilling techniques need to be understood and then mitigated if natural gas is to serve as a widely adopted generation resource. The costs of reasonable environmental protections from hydraulic fracking are unknown but will certainly place at least moderate upward pressure on gas prices.

There is presently a substantial amount of underutilized natural-gas-fired combined cycle capacity in and around the state of Minnesota that could be used to generate needed power as old coal-fired power plants are retired and/or as large amounts of variable renewable power come into the system. A new combined cycle gas-fired power plant should be able to fully operate 60 to 70 percent of the time, which is at or beyond the average capacity factor for coal plants nationwide in 2009 (EIA 2010a, 48). "Capacity factor" is stated as a percentage and represents the amount of time a plant is actually producing power divided by the amount of time it could produce power if it ran all the time. In fact, new, efficient gas-fired combined cycle power plants in Minnesota and the neighboring states of Wisconsin and Iowa appear to be generating far less electricity than they are capable of producing, with capacity factors in the range of 10 to 20 percent. This excess capacity gives the region important flexibility as it transitions to the electricity grid of the 21st century.

More risk, less benefit. Traditional baseload power plants are experiencing rising construction, fuel, and health and environmental costs. In contrast, new sources of energy such as wind and solar are seeing downward trending costs due to economies of scale and innovation. They have no fuel risk, and their health and environmental impacts are significantly smaller and therefore less costly than coal and nuclear plants. These trends will continue—in a regulatory world where we plan 20- to 40-year capital projects, they must be incorporated into energy resource decision making.

Slower Demand Growth Exposes Cost Risk

Large, traditional baseload power plants require significant new investments. Utilities and regulators take big risks when they add huge chunks of capacity. In the past, utilities would rely on demand to grow, and until very recently, there was steady and relatively predictable demand growth. As noted previously, utilities have made bad bets that cost their ratepayers and/or taxpayers billions of dollars in wasted investment and capital expense. But the general trend in the past was that over the long haul, a large, expensive power plant would eventually recoup its construction and operation costs. This is no longer necessarily true.

Demand Growth Dropping

Demand growth has dropped dramatically over the last few decades. The EIA predicts less than one percent annual demand growth in the future (through 2040), cutting deeply into the cushion that utilities have relied on to reduce risk in planning and constructing traditional baseload power plants (EIA 2013). In late 2011, Xcel Energy revised its demand growth projections to 0.5 percent annually (Xcel Energy 2011), and Great River Energy mothballed a brand new $440 million 99 megawatt coal plant because there is not enough demand to justify its use (Shaffer 2011).

Energy Efficiency Increasing

One of the main reasons Minnesota and U.S. demand growth has slowed is that consumers are becoming more and more efficient in consuming electricity. Minnesota currently has a goal for utilities to save 1.5 percent of their retail sales on an annual basis through energy conservation programs (with a 1.0 percent annual savings requirement). Even before the 1.5 percent goal became effective in 2010, Xcel Energy alone estimated that its conservation and efficiency programs had eliminated the need for building nine new medium-sized power plants.

Statewide from 1996 to 2009, energy efficiency programs saved Minnesota utility customers $2.5 billion and did so in a highly cost-effective way: for each utility dollar spent, $2.74 was saved (MDOC 2011). Not only does energy efficiency save consumers money directly, it reduces future energy demand and thus the need for construction of new power plants. Energy efficiency programs cost far less than building new power plants, particularly traditional baseload power plants. According to a report prepared by ICF International, on average, energy efficiency costs between $.02 and $.05 per kilowatt hour, less than any other form of new energy development (EPA 2009). A study by McKinsey and Company identified energy efficiency as a "vast, low-cost resource for the U.S. economy" that could save more than $1.2 trillion through 2020. This savings equates to a reduction in consumption of 9.1 quadrillion BTUs, which is 23 percent of future demand (Granade et al. 2009). Other states across the U.S. have recognized the immense money savings and demand reduction potential that energy efficiency holds. For example, Illinois, Indiana, and Ohio have goals in place to reduce electricity use by at least two percent annually through efficiency.

As Minnesotans and Americans continue to accelerate the adoption of energy efficiency improvements, utilities will see lower demand growth than in the past. Utilities and planners are recognizing the implications of this fact: We are no longer in a world where large additions of electricity-generating capacity make financial sense. Instead, incremental additions with smaller price tags that are shaped more tightly to load growth will be the economic winners. This will favor generation options with short construction times that are modular in size so that system planners can react quickly to changes in peak demand. In this new paradigm, the large baseload power plants of the past lose relevance.

Conclusion: Baseload Power's Place in the Grid of the 21st Century

Inflexible baseload plants are outdated in the new fast-moving grid. Grid operators are using new tools to optimize resource use. Innovations in modeling and forecasting combine with a smarter, more interconnected grid to increase reliability of renewables and allows grid operators to flexibly dispatch agile resources to ensure that variable supply meets variable demand. These newer technologies and regional operational tools and techniques are crowding out large traditional baseload power plants while still providing the reliability that customers expect.

Traditional baseload power's shortcomings are no longer masked by unbeatably low costs. Construction costs of large coal-fired and nuclear power plants are constantly rising. Fuel costs for coal and nuclear plants are also rising due to increased demand around the world. States and countries are increasingly holding nuclear and coal-fired power plant operators responsible for the costs they inflict on human health and the environment. Meanwhile, wind and solar costs are decreasing, and natural gas—which is an agile complement to variable renewable resources—has become more affordable and possibly more available for electricity generation, making them more cost-effective options for ratepayers. The argument that nothing can compete with coal on cost is no longer true—in fact, barring new innovations in this mature field, dependence on coal will be a liability to ratepayers as future costs increase.

Traditional baseload plants are becoming drags on the system. The value of traditional baseload power plants is diminishing as the electricity world is innovating. Because of the plants' enormous size, grid operators require maintenance reserves of large amounts of expensive generation capacity in case these large units suddenly shut down or are taken offline for maintenance. Increasingly, "reserve margins" required by regional grid operators are mostly related to the potential for large plants to fail for one reason or another. One advantage of more modular power plants is that they can stop making electricity without posing big reliability problems to the grid.

In today's world, traditional baseload power plants are no longer the least-risk, least-cost option to provide reliable and affordable electricity service. While some traditional baseload plants will continue to operate, their value is diminishing as rapidly as the electricity world is innovating. These plants will no longer provide the benefits they once did as we move to a more agile, dynamic electricity grid that is more controllable, creates less pollution, and results in lower long-term costs.

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