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Energy Policy Research Foundation

Power Vision 2050

Creating a Sustainable Pathway to Secure the American Economy

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Project Overview

The next quarter century presents an enormous challenge for the United States. A substantial and unexpected increase in electricity demand from data centers, new manufacturing, and growing electrification for EVs and other applications is bearing down on grid operators. This surge in power demand is taking place at the same time utilities are facing an array of complex and costly new regulations aimed at accelerating the retirement of fossil fuel generation. Despite the rapid growth in capacity, non-hydro renewable energy has added only a small fraction of the power needed and comes with its own costs and penalties due to the variable nature of the power produced. Nuclear energy, the largest source of carbon-free baseload electricity, faces its own set of challenges: an aging fleet whose oldest units will reach end-of-life well before 2050 without subsequent license renewals, delayed licensing timelines, and supply-chain bottlenecks that limit the pace of new deployment even as interest in advanced reactor designs continues. These challenges, if not properly addressed, will constrain the U.S. economy and damage national security should we fail to deploy sufficient reliable power to satisfy rising power requirements.

The Energy Policy Research Foundation has recently kicked off the Power Vision 2050, a multi-year initiative to help policymakers address the above challenges to ensure reliable, affordable, and sustainable power systems across the country. The initial stage of the project will include:

- Identification of regional centers where power demand is surging and an assessment of the adequacy of the existing grid structure/generation to meet these growing power requirements.
- Analysis of demand requirements by region and source, especially requirements to meet power demand for AI, manufacturing, and EVs.
- Identification of regulations impeding the expansion of additional electricity generation, incl. the construction of new power plants, the licensing and deployment of advanced nuclear reactors, and the continued operation of existing power plants.
- An assessment of the potential contribution of rapid deployment of natural gas infrastructure and construction of new gas-fired power plants to meet rising power demand in the near term (either as backup for intermittent production sources or as new baseload power production).
- An assessment of the role of nuclear energy in meeting long-term baseload power requirements, including the potential for advanced reactor technologies, small modular reactors, and innovative applications such as maritime nuclear propulsion to strengthen energy security and support economic growth.
- Sustained education and outreach to stakeholders and the public to communicate the importance of meeting the challenge for new power generation, a major condition for sustaining economic growth and national security.

Research Questions

Throughout the initiative, industry experts and academics will be invited to address important questions, such as:

- If current initiatives promulgated by EPA to regulate the electric power sector are fully implemented, what are the likely implications for the cost of electricity and reliability for the U.S. electric grid by region through 2050?
- Are some utility systems constraining electric power distribution to new industrial facilities, data centers, and manufacturing facilities? What is the cost of such constraints to economic growth and productivity improvements in the national economy?
- What plans or programs are electric power producers and RTOs undertaking to limit the risks of blackouts and contain cost escalation?
- What specific facilities should be targeted with delayed retirement to reduce blackout risks and cost escalation? How many dispatchable power facilities (coal, natural gas, and nuclear) can be extended and where?
- Are there efficiencies in the transmission of electric power that could limit rising power costs and improve reliability of national power systems?
- The U.S. has vast resources of natural gas. What are the implications of a national initiative to permit substantially higher levels of natural gas distribution (i.e., pipelines) and resource development for the cost and reliability of electric power? Is the Florida model workable and transferrable to other regions of the country?
- What measures are needed to ensure the U.S. can produce sufficient domestic natural gas at affordable prices for rising electric power requirements, domestic feedstock, and exports of both LNG and pipeline natural gas?
- What regulatory changes are most important to ensure the U.S. can continue to produce resilient and low-cost electricity to meet rising demand?
- What role can nuclear energy play in providing dispatchable baseload power at scale, and what policy, regulatory, and financing reforms are needed to accelerate the deployment of both conventional and advanced nuclear technologies?
- How can the US maintain and expand its competitive position in global nuclear technology markets, where China and Russia are aggressively exporting reactor designs and securing long-term fuel supply arrangements with partner nations?
- What is the potential for innovative nuclear applications, including maritime nuclear propulsion and off-grid industrial power, to open new markets and reinforce U.S. energy security?

Challenges of Intermittent Power

In an attempt to address environmental objectives, federal and state policies and directives subsidize and mandate the construction and dispatch of variable renewable energy (VRE) resources, notably wind and solar. However, electric power generated from wind and solar resources is both intermittent and unpredictable. These intermittent power sources present genuine challenges to maintaining adequate voltage across the electric power grid and can be costly to distribute as solar and wind resources often cannot be constructed along existing power transmission corridors. Some distributed power sources such as home-based solar power systems can remove customers entirely from the grid or place power into the grid, but only for short periods of time. These intermittent supplies can be "backed up" through the use of oscillating generation such as combined cycle natural gas power plants or, in some instances, hydroelectric power when available through pumped storage. Nuclear baseload generation offers another form of system stability, providing continuous output that complements both natural gas peaking plants and variable renewables. Utility networks can also "price-in" a higher number of intermittent consumers to help stabilize grid operations. All of the potential solutions to rising VRE resources require expenditures to properly operate the power system. The cost of integrating higher volume of VREs into power operations is often not well understood and the cost to consumers are not easily discovered.

Rising levels of VRE resources arguably create new challenges for capacity market designs because VRE resources suppress wholesale energy prices while providing relatively little capacity. This effect becomes more pronounced the higher the VRE penetration in a market. In any instant of time, system operators generally choose the lowest cost power available on the grid. System operators argue that existing power auction systems, especially for future capacity requirements, represents an efficient system because power is distributed from the lowest cost supplier and that separate markets or arrangements are made to assure the grid remains stable and reliable. Such grid stability measures are often implemented through arrangements that require the system network grid to have a fixed capacity of on-demand power.

Capacity Management

One of the consequences of rapid growth of VRE generation is that "net load" on the grid (electricity demand minus VRE generation) has effectively shifted down requirements from base load power, but also increased the peak to trough ranges, requiring growth in oscillating power and in some cases construction of additional grid connections. In some cases VREs can distort power prices to the point where they are creating negative prices for power producers. The low cost of dispatched power by VREs is the result of a combination the technology used and government policy. VREs are intermittent and unpredictable, have low operating costs, and operate under incentives to dispatch power even when its value to the power system may be negative. In many instances, rapid deployment of VREs substantially raise system costs.

To meet federal and state electric power reliability requirements, grid operators must ensure that load-serving entities have enough resources to meet expected demand plus a "reserve margin." This reserve margin provides a cushion during unexpected spikes in demand or potential loss of supply or transmission resources. Reserve margins help operators maintain the reliability of the system. Capacity markets in RTO/ISO regions are typically set up to ensure that there are sufficient resources available to serve load plus reserves at some point in the future, typically from one month to several years out in time. They may use auctions to lock in prices for electric capacity from generation resources well before they are actually needed (3 years in some markets). Capacity markets can also be marketplaces for demand response in which customers reduce their demand when called upon to do so in exchange for capacity payments similar to what generators receive. Prices vary by location and timing of capacity commitments and typically not by size or fuel type. ISO New England, PJM, MISO and NYISO operate capacity markets, while other ISOs do not currently have capacity markets.

RTOs and ISOs, with their capability to move power across a wide geographic area and draw upon different kinds of capacity resources, can in theory use a diversified pool of power generators to meet both cost and reliability objectives. However, studies undertaken by the Foundation for Resilient Societies, the Center of the American Experiment, and the North American Electric Reliability Corporation (NERC), among others, all have documented growing threats to the resilience of power delivery systems in both PJM and MISO regions. The premature retirement of dispatchable generation, including nuclear plants that provide reliable baseload capacity, compounds these resilience concerns. Capacity market reforms that properly value the firm, on demand characteristics of nuclear and natural gas generation will be essential to maintaining grid reliability as VRE penetration continues to rise. Without such reforms, the generation portfolio the nation inherits at mid-century may be structurally incapable of delivering the reliability that a larger, more electrified economy will demand.

What's Ahead: Power Demand is on the Rise

Population, economic growth, advanced manufacturing, and growing power requirements for EVs and new devices are all driving increases in U.S. power consumption. According to the U.S. Energy Information Administration, U.S. power consumption will rise to record highs in 2024 and 2025. EIA projected power demand will rise to 4,096 billion kilowatt-hours (kWh) in 2024 and 4,125 billion kWh in 2025. That compares with 4,000 billion kWh in 2023 and a record 4,067 billion kWh in 2022. These near-term figures only hint at the scale of the challenge ahead; most long-range forecasts project U.S. electricity consumption growing by 30 to 50 percent or more by 2050, driven by the electrification of transportation, buildings, and industrial processes alongside continued expansion of data-intensive industries. Rising power requirements present a host of challenges to reduce the risks of supply interruptions (blackouts) and escalating costs. Unrelated research by he Foundation for Resilient Societies, the American Experiment, and the National Electric Reliability Corporation allo find catastrophic risks to blackouts, especially in the MISO and PJM regions.

Meeting this surge in demand will require a pragmatic strategy that pairs near-term natural gas expansion with accelerated nuclear deployment. The decisions made in the next five to ten years on permitting reform, fuel supply chain investment, workforce development, and advanced reactor commercialization will largely determine whether the United States arrives at 2050 with a power system capable of sustaining its economy and defending its interests, or one that has fallen behind competitors who made those commitments sooner.

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