ACCELERATING DEEP DECARBONIZATION IN THE U.S. POWER SECTOR

EXECUTIVE SUMMARY

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The Challenge

Deep decarbonization for the economy as a whole hinges on the electricity sector, which is responsible for 27 percent of total U.S. greenhouse gas (GHG) emissions.[1] It is relatively easy to imagine how a decarbonized electric supply system could help achieve multiple social and environmental goals. More complicated is envisioning the diverse political and organizational factors aligning at the needed scale and pace. Thus, much of this chapter looks not simply at technologies and long-term aspirations, but also practicalities. Those practicalities arise in at least three dimensions:

- Design and implementation of policy in the highly fragmented federalized U.S. system
- Building and sustaining political and community support for decarbonization of a sector that must meet other political goals
- How to craft and implement a policy process that addresses seriously the high uncertainties about which technology and investment strategies will be best

This chapter looks at these three challenges from four different perspectives: (1) supply of electricity; (2) demand for electricity; (3) the topology of the evolving grid; and (4) policy incentives and implementation.

The Solution

Over the last century the U.S. economy, like all modern economies, has become increasingly electrified. In a world of deep decarbonization that process of electrification must accelerate further. The modeling in chapter 2 of the Zero Carbon Action Plan suggests that the share of final energy from electricity—starting from 25 percent today—may increase to 50 percent or more by 2050. It could be higher if loads—like heavy freight shipping and high heat industrial application such as making steel—prove easier to electrify than currently thought and if we invest more in innovation. On the other hand, if other energy carriers, like hydrogen, prove less costly then more of the nation's primary energy could move to users in that form rather than electricity. For now, the best planning tools suggest electrification will be the foundation of cost-effective decarbonization. A critical lever is accelerated investment in innovation and in technological and system-level experiments and pilot projects to make a fully decarbonized electric system as cost-effective and reliable as practical.

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Decarbonization of the U.S. economy will require that many applications that currently rely on direct combustion of fossil fuels—for example, vehicle transportation, heating in buildings and many industrial applications—be electrified. A large and growing number of energy uses are ripe for electrification and are often called “easy to electrify.” These include low grade heating systems—already, resistance heating is used in water heaters and some space heating—and with more efficient heat pumps there could be more widespread utilization of electricity for these services.

This need and opportunity to electrify more of the economy is one of the most consistent results from large-scale energy models. While new technologies are appearing in other sectors, such as transportation and industry, emissions continue to rise. In the power sector, however, emissions have been going down since 2005—about a 33 percent decline in emissions from the sector by the end of 2019. That trend might be described as shallow decarbonization, but may be auspicious. So far, decarbonization of the power sector has come from factors only partly related to climate policy. Other drivers include the surge in inexpensive natural gas, and rising supply of renewables and energy efficiency. As a result, for the first time since 1885 the share of renewables in the U.S. power supply—hydro, wind, solar, and geothermal—now exceeds that of coal.

Policy Recommendations

Looking to the future, the rate of decarbonization of the U.S. power sector must accelerate. Laws in at least eight U.S. states require, either by goal or mandate, the installation of zero-carbon electricity systems by mid-century. Most of these mandates are written in terms of emission characteristics, although nearly all also require a very large fraction of the zero emission supplies to come from renewables—principally solar and wind. Thirteen other states are actively considering similar measures.

Federal policy has not been reliably supportive of the speed and extent of change required. Even existing statutory authority (the Clean Air Act) is not being used to its fullest potential. New legislation is needed, and the single most important action at the federal level would likely be some form of a “clean energy standard” that transitions to nearly zero emissions by 2050 (or sooner). Opportunities for synergistic actions among agencies—for example, the Federal Energy Regulatory Commission (FERC), the Environmental Protection Agency (EPA) and the Department of Energy (DOE)—could also accelerate the process of electrification and decarbonization, with significant cost, health, and justice benefits for the country. Whether “zero” is the right goal depends on the evolution of technology that is unknowable at present, and that popular goal should not be allowed to distract from the fact that routes to near zero can be envisioned now.

In terms of technology, most attention is focused on two clusters: (1) variable renewable energy (VRE) and the integration with diverse forms of energy storage, and (2) firm low-carbon options, such as generators that might utilize carbon capture utilization and storage (CCUS).

As a class, VRE resources tend to have very low operating costs. Capital costs for certain VRE resources such as solar PV and onshore wind (and more recently offshore wind) have decreased rapidly in the past decade and continue to do so. It is almost certain that VRE will account for the largest share in new generating capacity. However, the role for clean, firm generation will rise in importance as these variable generators are integrated on the grid. This shift to variable power supplies will also lead to big increases in the need for storage of various durations. New short-term storage needs are likely to come from batteries. Long-duration energy storage technologies;

those that can store very large amounts of energy typically over 8-10 hours or more may come from several forms. These include but are not limited to pumped hydropower, compressed air, and hydrogen. At present, about 90 percent of the long duration storage comes from pumped hydro.

The future demand for electricity faces many uncertainties. In recent decades, demand has flattened in the US and other OECD countries, as new electric loads (e.g., computers) have been offset by huge improvements in the efficiency with which electricity is utilized. While there has been a lot of attention to the sheer volume of electric load, the attributes of that load—in particular, whether and how loads can be responsive to variable supply conditions on the grid—will be extremely important. Already much of the nation has installed the infrastructure needed for variable pricing of electricity, which will make it possible for loads to be more responsive to market conditions. However, outside of large power users, practically none of the nation actually uses that existing capability. Many parts of the country are running promising experiments and market tests that show how this can be done, such as through encouraging firms to aggregate loads and bid them into wholesale power markets—so that variable demand can complement the rapid shift to variable output of solar and wind.

A decarbonized electric power system will arise in the context of other massive changes in the electric power grid. Today's power grid was designed to connect a network of large power generators with a large number of end consumers spread over a wide geographical area, creating a linked ecosystem of public and private enterprises operating within a web of government institutions: federal, regional, state, and municipal. This grid, with a series of highly centralized control systems that are hardened against threats and highly reliable, is likely to remain the backbone of the electric power system. Making it more capable—with more long-distance power lines and, crucially, greater capacity and control capabilities on existing routes, such as with AC-DC interties that help make grids more stable—will be vitally important to assuring a reliable and cost-effective grid system in an era that depends more on renewable generators. Success requires collaboration between FERC, regional and state authorities. At the same time, however, there are enormous potentials emerging that are embedded within this grid system—microgrids, local controls, new retail power marketing authorities and such—for users to have more control over the power systems they utilize. Parts of the U.S. grid are already becoming more highly decentralized—in part with the goal of including more renewable supplies—and this decentralization along with new grid control technologies will help define the grid of the future.

Pushing technological frontiers will help transform the grid system—making it cleaner, and both more reliable and responsive to user needs. As a result, we find there is a need for a massive increase in public sector research, development, demonstration and deployment (RDD&D) focused on clean electric systems, whereas actual spending over the last decade (since a temporary boost in RDD&D after the last financial crisis) has been roughly flat. Much of this increase might be best focused on clean grids of the future. Still, technological advances are only part of the story. Attention on governance of the very fragmented US power system, as well as on policy coordination between the states and the federal government may ultimately play an even larger role.

At least three policies types should be prioritised under this framework.

- Use an expansive Clean Energy Standard or policies like (sector-specific) carbon pricing to price the negative carbon externality. Both of these would allow a degree of technological agnosticism, coupled with considerable flexibility in implementation. In the past, states have relied mainly on renewable portfolio standards and federal tax incentives to encourage renewables; those have a role to play in accelerating use of these technologies and will need to be migrated to carbon terms.

- Dramatically increase clean energy RDD&D funding, providing incentives for fundamental innovation and adoption of new technologies. Such a policy would help increase the provision of public goods in the form of new ideas and tested technologies, accelerating the commercial deployment of clean energy systems.

- Focus on learning and coordination. The states, as they push for deployment of renewables and other low-carbon power generators, will learn a lot about how to integrate these resources onto the grid, especially in the context of other shifts in the power industry such as grid decentralization. An active effort to compare experiences and learn quickly and to identify places of needed coordination—especially between states and federal authorities that have overlapping jurisdiction—will be needed.

Outcomes

In crafting electricity policy, it is crucial to keep the larger context of electric service in mind—including the “social contract” that informs how the sector is regulated. It is also important to understand the deep interconnections with other aspects of the energy sector, as well as beyond it. Focusing solely on the technical issues tends to be appealing,greenhouse gases.

References

1. "Sources Of Greenhouse Gas Emissions | US EPA". 2020. US EPA. https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions.