How the U.S. power system could evolve with widespread electrification

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The fifth report in NREL's Electrification Futures Study (EFS) series is now available, presenting analysis on the potential impacts of widespread electrification on the U.S. electricity system—specifically generation and transmission infrastructure investments, fuel use, system costs, and emissions.

The EFS is a multiyear collaborative study designed to assess the potential impacts of widespread electrification in the United States. The study examines how future electrification could affect different parts of the energy system, including demand sectors (buildings, industrial, and transportation) and the electricity sector.

In the latest phase of the study, NREL analysts and research partners used a scenario framework to model U.S. electricity and energy systems through the year 2050 to identify key trends with increased electrification. The results are published in "Electrification Futures Study: Scenarios of Power System Evolution and Infrastructure Development for the United States."

Modeling Supply-Side Scenarios

Building upon a recent related analysis published in *Electricity Journal*, this report focuses on supply-side scenarios encompassing a wide range of future conditions under electrification levels that were developed for the second report in the series. Scenarios with the highest electrification levels reflect transformational electrification in multiple demand sectors.

Using NREL's flagship capacity expansion and dispatch tool for the contiguous United States—the Regional Energy Deployment System (ReEDS) model—analysts assessed how electrification-driven changes in electricity demand could impact the future buildout and operation of the bulk power system. Several modifications were previously made to the ReEDS model to better represent interactions between supply and demand with widespread electrification, which is documented in detail in a methodology report from July 2020.

Scenario results include projected changes to the physical infrastructure of the U.S. power system, utilization of that infrastructure, and impacts related to the broader energy system, like emissions. The scenarios will be further evaluated with more-detailed grid simulations in a forthcoming EFS report, and a scenario data viewer is available for those who want to take a deeper dive. From the scenarios modeled, five key findings emerged.

Five Key Findings

- Electrification drives the sustained deployment of renewable energy and natural gas generators in all regions of the United States. To meet electricity demand in high-electrification scenarios, installed capacity grows to more than double 2018 levels by 2050. Generation from low-cost renewable energy increases in all scenarios and, in the absence of new policies, new natural-gas-fired generation is also built to meet electrified loads. Which source supplies more electricity will largely hinge on the future prices of renewable technologies, energy storage technologies, and natural gas, among other drivers.

- Local resources are increasingly relied upon to meet electrification-driven load growth, which mitigates the influence of electrification on the need for additional long-distance, inter-regional transmission expansion. However, the magnitude of short transmission segments to interconnect new renewable energy generators scales with electrification, and total transmission capacity expansion similarly scales with renewable energy deployment levels.
- Electrification increases the reliance of demand sectors (buildings, transportation, and industry) on electricity, which could expand opportunities for flexible loads. Flexibility in the timing of demands from electric vehicle charging, space heating, and other end-use services can help meet peak demands and planning reserves without additional power sector infrastructure. Without this demand-side flexibility, electrification-driven shifts in the magnitude and timing of demand peaks could require infrastructure development and the need for greater supply-side flexibility (e.g., batteries).
- There are abundant resources in the United States with similar costs to meet potential electrification-driven growth in electricity demand. Low-cost renewable energy resources and natural gas are available in all regions of the United States in the absence of new policies, and they are increasingly developed under growing levels of electrifications. However, this analysis finds that electrification has only a modest effect on the cost per unit of electricity consumed ($40–$46 per megawatt-hour) and bulk electricity prices across all scenarios considered.
- The system cost impact of electrification on the entire energy sector depends strongly on future advancements in the cost and efficiency of electric end-use technologies. Electric-sector system costs increase with the additional generation and transmission capacity that is needed to serve the growing load under widespread electrification. However, these costs are partially or entirely offset by fuel and operational savings in the buildings, transportation, and industry demand sectors. Higher levels of electrification with rapid advancements in the cost and performance of end-use electric technologies can result in net energy system savings—up to $800 billion in the high-electrification scenario.
- Widespread electrification leads to reductions in direct energy consumption and emissions from the energy system, due to the improved efficiency of electric end-use technologies and declining emissions intensities associated with electricity generation. Energy savings and emissions reductions are largely driven by electrification in the transportation sector. The level of emissions reductions that could be achieved depend strongly on the future generation mix, but emissions of carbon dioxide and criteria pollutants decline in all scenarios examined.

More information: Caitlin Murphy et al. High electrification futures: Impacts to the U.S. bulk power system, *The Electricity Journal* (2020). DOI: 10.1016/j.tej.2020.106878

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