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The Cost of Electricity and Capital Expenditures in the U.S. Eastern Interconnection Under Electrification Scenarios

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Our interest is to better understand the benefits, costs and impacts of transportation electrification on the electric power grid and its generation components: wind and solar, gas intermediate and peak load technologies, and units designed for baseload operation (nuclear power and existing and new coal-fired power plants (CFPPs) some with CO_2 capture and storage.) The electrification of the U.S. economy will be a challenge for the electric grid, but could be helpful if the load shape were more uniform over hours of the day and over weekdays vs weekends.

Battery operated electric vehicles (EVs) could substantially flatten the load duration curve (LDC) over time making advanced nuclear and efficient fossil fuel fired plants able to run primarily at full capacity. An example of an efficient gas- or coal-fired technology design currently in demonstration stages are ones with supercritical working fluids which automatically separate CO_2 for capture and sequestration.

In the intermediate term there could also be some benefits of battery storage for reducing cycling damage from existing electric power plants, thereby reducing gas "lock-in" associated with NGCC capacity additions while advanced baseload technologies are being developed and thereby lowering the cost of electricity compared with the alternative case. We will present these results in our presentation.

Here we simulate scenarios from the NREL report: Electrification Futures Study: Scenarios of Electric Technology Adoption and Power Consumption for the United States (see summary below*).

Our modeling tools are the PNNL GCAM Integrated Assessment Model and the Argonne Electricity Supply and Investment Model (ESIM). ESIM contains a unit inventory of existing CFPPs including their characteristics and operating conditions such as capacity factors and exposure to load following and weekday/weekend cycling.

*Mai, Trieu, Paige Jadun, Jeffrey Logan, Colin McMillan, Matteo Muratori, Daniel Steinberg, Laura Vimmerstedt, Ryan Jones, Benjamin Haley, and Brent Nelson. 2018. *Electrification Futures Study: Scenarios of Electric Technology Adoption and Power Consumption for the United States*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-71500.

https://www.nrel.gov/docs/fy18osti/71500.pdf

From the Study: "A better understanding of the potential impacts of electrification on load shapes and opportunities to influence them is critical to minimizing overall costs."

"The transportation sector experiences the greatest technology transition toward electric vehicles in the scenarios from this study. …scenario results for one segment of the transportation

sector includes the sales share, vehicle stock, and miles traveled for the light-duty fleet (cars and trucks) in three scenarios. These estimates foresee ranges of stock penetrations of plug-in electric vehicles in the 2050 light-duty fleet from roughly 11% in the Reference scenario to nearly 84% in the High scenario. More broadly, plug-in hybrid and battery electric vehicles are estimated to grow in all on-road transportation segments in the Medium and High scenarios. In the Medium scenario, growth in plug-in electric vehicles occurs most prevalently for transit buses, throughout the light-duty fleet, and primarily for short-haul applications for medium- and heavy-duty trucks. This expansion is most pervasive in the High scenario, which is designed to include plug-in electric vehicle sales shares beyond many existing studies and where over 240 million light-duty electric cars and trucks, 7 million medium- and heavy-duty electric trucks, and 80,000 electric transit buses are estimated to be on U.S. roads by 2050. For comparison, there were about 560,000 plug-in electric vehicles on U.S. roads by the end of 2016. Together, these electric vehicles would account for up to 76% of vehicle miles traveled in 2050."

Caveat:

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