Carnegie Mellon University
Block Center for Technology and Society

Maximizing Decarbonization Benefits of Transportation Electrification

Context and Summary

Transportation electrification is critical to the Administration's plans to achieve an over 50 percent reduction in U.S. greenhouse gas (GHG) emissions from 2005 levels by 2030. The research supporting this policy memorandum compares the CO_2 emission costs for charging electric vehicles (EVs) based on different levels of federal grid investment and accounting for regional differences in power generation. Our work demonstrates that transportation-driven emissions could be greatly reduced by EV policies tailored to regional power generation and the specific needs of local power grids.

Key Findings

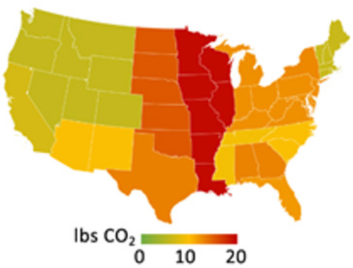
- The average emission costs (in lbs CO_2) of charging EVs will vary significantly from region to region, driven by differences in power generation.
- Targeting federal grid infrastructure investments in areas with high emission costs for EV charging—particularly the U.S. heartland—can mitigate the regional emission disparity and reduce the average daily cost by 55 percent from 9.8 to 4.4 lbs CO_2 by 2030.
- Generating clean power at scale (MWs and GWs) and enabling smart coordination of end users (clean kWs) are both important to realizing the decarbonization objectives stemming from transportation electrification.

Although increased vehicle electrification will reduce the climate footprint of our transportation sector, growth in demand risks overburdening the power grid and increasing the transportation system's dependency on pollutant energy sources. These unintended consequences may limit the expected decarbonization gains of transportation electrification investments.

Visualizing Regional Variation

The following figures compare the daily emission cost (in lbs CO_2) of charging one EV in 2020 *(Figure 1)*, in 2030 without new federal grid investment *(Figure 2)*, and in 2030 with new federal grid investment *(Figure 3)*. Regional differences in cost, depicted by map color, account for differences in electricity production and seasonal variability, daily driving patterns, and the daily charging needs of EVs in each state:

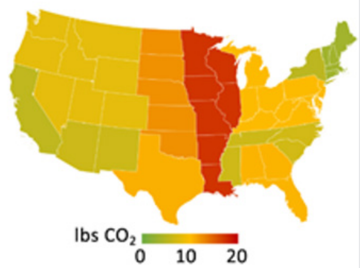
Figure 1.



Emission cost per day of charging one EV based on **2020** power generation profiles.

Average emission cost: 12.2 lbs of CO_2

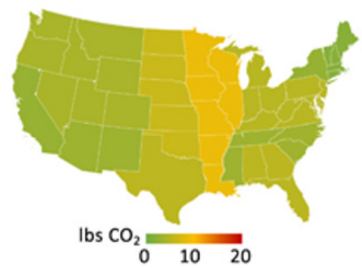
Figure 2.



Emission cost per day based on EIA projections for **2030** power generation profiles **without new federal grid investment.**

Average emission cost: 9.8 lbs of CO_2

Figure 3.



Emission cost per day in **2030** based on decarbonizing by 50 percent more than EIA projections **with new federal grid investment.**

Average emission cost: 4.4 lbs of CO_2

Figure 1 depicts emission costs from the daily charging needs of an EV in 2020, when only 20 percent of electricity generation was produced by renewable energy sources and a total of 40 percent came from carbon-free sources (renewables and nuclear combined).

Figure 2 uses Energy Information Administration (EIA) data to extend our analysis to 2030. Barring any new major federal grid investments, EIA expects that renewable energy sources and carbon-free generation will constitute 32 percent and 67 percent of the generation mix by 2030, respectively. Based on EIA's projection, by 2030 there will be considerable variation between the energy generation mix of different U.S. regions. For example, carbon-free generation will reach 37 percent in Texas, while carbon-free generation in New England will account for 83 percent of its mix.

Figure 3 depicts the scenario where new federal grid investments lead to a 50 percent increase in the replacement of fossil-fuel power plants in regions with the highest GHG emissions. In this setting, the average emissions of EV charging nationwide would be reduced to 4.4 lbs of CO_2 per day, from 9.8 lbs of CO_2 per day, as depicted in Figure 3. The share of renewable energy sources would increase to 55 percent, while total carbon-free options will contribute up to 75 percent of the generation mix. In this scenario, the inequity of GHG emissions between different regions is reduced (ranging from 68 percent in Texas to 92 percent in New England).

Policy Considerations

Federal grid investments should be regionally tailored to maximize decarbonization benefits of transportation electrification nationwide. Targeting federal investments in areas with high emission costs for EV charging—particularly the U.S. heartland—can mitigate regional emission disparities and reduce the average daily cost of EV charging from 9.8 to 4.4 lbs CO_2 by 2030.

- **Modernizing the grid is key to achieving U.S. decarbonization goals.** Planning efforts need to strike a balance between creating clean kWs associated with bottom-up infrastructure investments and top-down investments that enable MW/GW-level power generation *(see Figure 4)*. Prioritizing investments depends on many factors—such as the overall energy generation mix and grid resilience—and there is no one-size-fits-all approach for all states. In order to meet the Administration's climate targets, both bottom-up and top-down strategies must be pursued.

- **Bottom-up grid investments will be faster to implement than top-down strategies to achieve the same GHG emissions reduction goal of 50 percent by 2030.** Clean kWs, which can be created by adjusting energy consumption or production levels of end-use technologies using responsive demand and energy storage, can be integrated on shorter time scales and face fewer cost barriers than large-scale infrastructure projects to achieve a comparable impact in reducing GHG emissions. However, integrating clean kWs with local power grids requires close coordination at the local level and active end-user engagement. Utilizing kWs towards grid operation also depends on their effective aggregation. The aggregate impact of distributed kW improvements will accumulate to savings on the MW scale.

- **Regulatory and approval processes should be reviewed to accelerate the implementation of new top-down renewable energy projects.** Top-down investments are equally critical to the Administration's longer-term goal of reaching a carbon pollution-free power sector by 2035, but new large-scale projects will have limited near-term impact in reducing GHG emissions if they continue to face long planning and regulatory cycles. Establishing an accelerating effort similar to Operation Warp Speed could help institutionalize the urgency of approving new major renewable energy projects.

Figure 4.

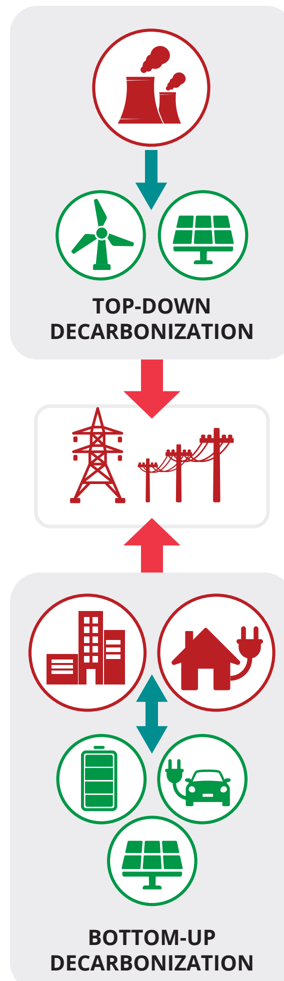


Figure 4. Top-down decarbonization will involve the creation of MW/GW-scale nuclear and other renewable installations, while bottom-up decarbonization centers on creating efficiencies in kW-scale end-user generation and consumption.

The Block Center for Technology and Society at Carnegie Mellon University features leading academic faculty translating research insights into policy impact. The underlying academic analysis supplementing this policy memorandum is available upon request. Please send inquiries to blockcenter@andrew.cmu.edu.