Hawaiʻi Natural Energy Institute Research Highlights

Future Energy Systems

Greenhouse Gas Reduction from Electrified Transportation

OBJECTIVE AND SIGNIFICANCE: Decarbonizing the energy sector in Hawaiʻi is a key part of the state's energy and environmental objectives. While significant progress has been achieved in the power sector, meaningful reduction in the state's overall emissions, can only be achieved with significant greenhouse gas (GHG) emissions reduction from the transportation sector, which currently accounts for nearly 60% of the state's emissions. Electrification of transportation (EoT), particularly light duty vehicles has been identified as a key component to meeting these goals.

The objective of this work was to quantify the net GHG benefits of EVs compared to the current fleet and other vehicle options. The analysis, conducted for the island of Oʻahu, included the impacts of increasing penetration of renewable energy generation in the power sector and time-of-day charging of light duty vehicles.

KEY RESULTS: The analysis showed that, while the transition to EVs for the light duty vehicle fleet does have the potential to reduce GHG emissions – the reductions will be quite limited until the renewable generation on Oʻahu reaches a level requiring substantial amounts of curtailment. Until then the increased demand for electricity to charge vehicles will require increased oil usage to meet the combined EV and power sector demand. In other words, increased percentages of EVs will require additional oil-fired generation. Based on analysis conducted by HNEI, significant curtailment on Oʻahu will not occur until renewable generation is far higher than it is today. In the short term, greater reductions of GHG can be affected by the replacement of low-mileage ICE vehicles with high-mileage energy-efficient hybrid vehicles.

BACKGROUND: As of 2018, there were over 8,400 electric vehicles registered in Hawaiʻi. While this represents only about one percent of the total passenger vehicle fleet, their share is growing rapidly increasing by 27% annually between 2015 and 2018[1]. If these trends were to continue, there would be over 156,000 EVs by 2030, approximately 20% of today's total vehicle fleet.

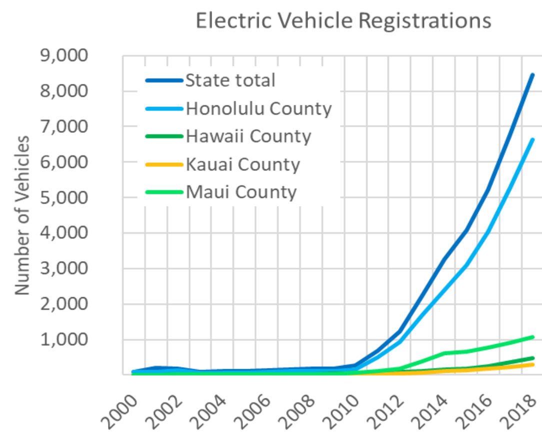

Figure 1. EV registrations across Hawaiʻi by counties.

In light of these trends, the Hawaiʻi Public Utilities Commission opened Docket #2018-0135: "Instituting a Proceeding Related to the Hawaiian Electric Companies' Electrification of Transportation Strategic Roadmap and associated pilot projects." In 2018, the Hawaiʻi legislature also passed House Bill 2182, which set a statewide zero emissions clean economy target, stating that "considering both atmospheric carbon and greenhouse gas emissions as well as offsets from the local sequestration of atmospheric carbon and greenhouse gases through long-term sinks and reservoirs, a statewide target is hereby established to sequester more atmospheric carbon and greenhouse gases than emitted within the State as quickly as practicable, but no later than 2045."

PROJECT STATUS/RESULTS: According to the U.S. Energy Information Agency, Hawaiʻi's statewide CO_2 emissions were 17.7 MMT in 2017, with transportation accounting for 58%, electricity generation accounting for 32%, and the remainder coming from residential, industrial, and commercial uses.[2]

The electric power sector has reduced emissions by approximately 30% since 2008 (Figure 2), consistent with the increase in low-emissions renewable generation. However, transportation and other sector

[1] DBEDT State of Hawaiʻi Data Book, "Table 18.09-- Vehicle Registration, By Taxation Status"

[2] U.S. Energy Information Agency, Energy-Related CO_2 Emission Data Tables, "Table 4, 2017 State energy-related carbon dioxide emissions by sector," https://www.eia.gov/environment/emissions/state/.

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emissions have increased slightly during that time. It is important to note that even if all light duty vehicles are electrified, approximately 50% of the transportation emissions result from heavy duty vehicles (7%), marine transportation (12%), and aviation (28%) remain.

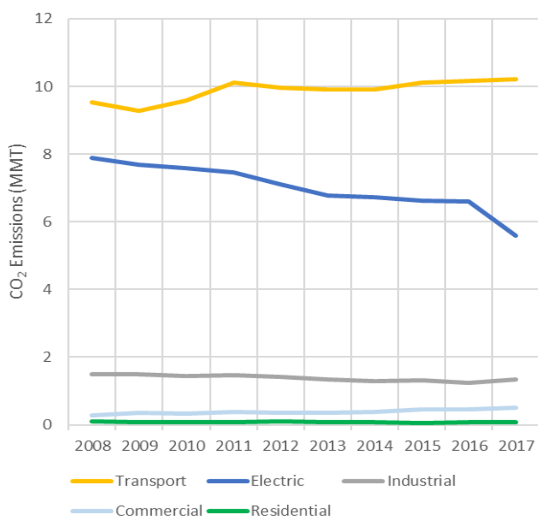

Figure 2. CO_2 emissions by sector type in Hawai‘i.

While electric vehicles have zero tailpipe emissions, that does not mean they are emissions-free. Instead, the indirect emissions associated with an EV depends on the emissions rate of the electricity produced to charge the vehicle. To understand these results, one has to examine the Hawai‘i grid compared to that on the U.S. mainland. Without curtailment of the renewable generation resources, additional EV charging loads require increased oil-fired generation to meet the combined EV-grid demand. This is highly unique to Hawai‘i relative to other North American grids where charging will be incrementally served by lower carbon resources, such as natural gas-fired generation. While individual homeowners can reduce their carbon footprint when they have both rooftop PV and EV, it does little to change the overall island balance. Without the EV, their solar energy generation could have otherwise gone directly to the grid and to offset oil generation.

To understand the role of electrification of transportation in reducing GHG emissions, grid models used to evaluate strategies for integration of renewable generation were modified to include different levels of electric vehicle adoption, up to 40% of the current light-duty vehicle fleet. This analysis was conducted for O‘ahu, which accounts for approximately 70% of the statewide transportation emissions.

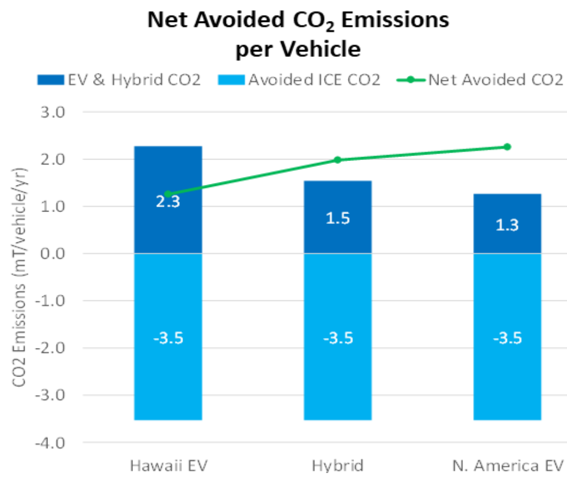

Figure 3. Comparison of CO_2 emissions by vehicle type in Hawai‘i vs. the U.S. mainland.

The analysis examined the combined EV-power grid GHG emissions at both near-term and longer-term renewable adoption levels. Specifically, the GHG emissions assumed additional solar + storage installations ranging from 500 GWh to 3500 GWh beyond what is currently deployed on O‘ahu, representing up to 50% of the total O‘ahu generation mix.

Time-of-day charging is often considered as a means to manage the use of solar for eV charging. To explore this issue, HNEI analyzed grid models four different charge regimens (Figure 4). While there were modest dependencies on when the vehicles were charged, the ability of the utility scale PV + storage to shift energy to when its needed, results in minimal impact.

The system-level results of this analysis, summarized in Figure 5, show the combined emissions on O‘ahu from the electric power sector and light-duty vehicle fleet at different penetrations of solar + storage energy. It assumes 20% of the current light duty vehicles are replaced by EV. While electrification of transportation does decrease the vehicle emissions, it is mostly offset by an increase in electricity sector emissions. It is not until O‘ahu reaches very high levels of PV penetration on the grid that the net emissions savings start to substantively increase. For reference, previous findings indicate that with an additional 2000 GWh of solar + storage, curtailment is only 1-2% reaching approximately 6% with 3500 GWH of additional solar + storage energy generation.

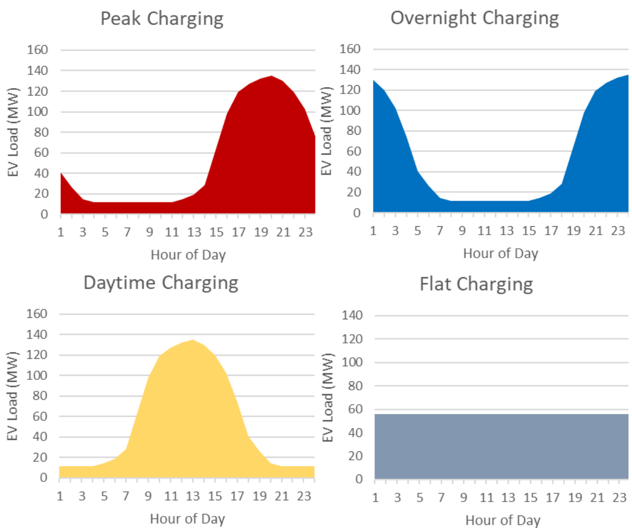

Figure 4. Grid models for four different charge regimes based on time-of-day charging.

When viewed in the larger context of statewide emissions, EoT has a marginal effect on total emissions. Figure 6 shows that with substantial adoption of renewable energy, concurrent drop in GHG emissions will occur within the state. However, the electrification of light-duty electric vehicles – even as high as 40% of the total vehicle fleet, has minimal additional impact on the reduction of CO_2 emissions. For reference, the impact of replacing the AES coal plant with solar + storage has a significant impact.

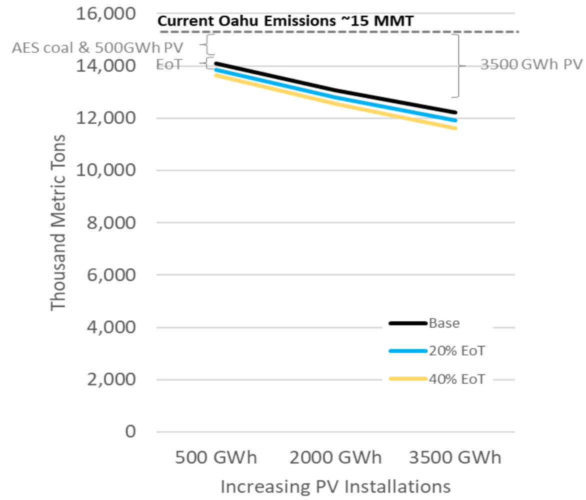

Figure 6. Oʻahu CO_2 emissions based on amount of installed PV.

It is not until the grid is more fully decarbonized that the emissions savings from an EV are higher. However, as solar generation increases, so does the underlying emissions benefits. In a high solar grid, EV charging can be utilized as an effective load management approach and provide valuable grid services. This would allow for further PV adoption and improved emissions benefits.

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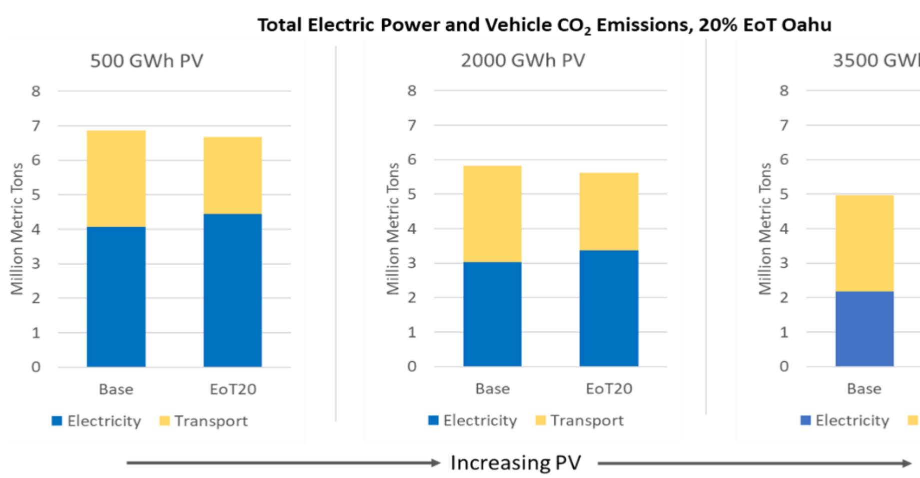

Figure 5. Oʻahu CO_2 emissions from the electric and transportation sectors at varying inputs from solar + storage energy.