Attachment 3-1: Incremental demand accounting for the on-the-books EPA OTAQ GHG final rule (https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-revise-existing-national-ghg-emissions) that has not been reflected in AEO2021 demand

IPM requires an electricity demand and the default electricity demand in EPA Platform v6 is based on AEO2021, which does not include the full forecasted zero emission vehicle (ZEV) adoption in its reference case. Relative to AEO2021, the LMDV reference case has increased HD ZEV adoption and LD BEV adoption (to account for EPA's Revised 2023 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions Standards (LD GHG 2023–2026) final rule (86 FR 74434, December 30, 2021).[1] Therefore, we developed IPM input files specific to the demand of electric vehicles not captured by EPA Platform v6 defaults, which we call incremental demand input files.

We used the output of national MOVES3.R1 runs to develop the set of IPM incremental demand input files for the LMDV reference scenario.[2] Electricity demand was calculated using the MOVES national modeling domain, with output by each type of day (i.e., for an average weekday and weekend). IPM requires grid demand to be specified by day type, by each of IPM's geographic regions, and by each hour of the day.

IPM requires grid demand to be geographically allocated by IPM region. We developed regional allocation factors based on county-level CO_2 emissions in the 2016v2 emissions modeling platform.[3,4] We used CO_2 emissions as our basis for regional allocation because CO_2 scales well with VMT while capturing differing fleet characteristics in different counties. IPM includes a mapping of each county to an IPM region, which we used to aggregate county allocation factors by IPM region.

Inputs to the IPM model include not only the anticipated electricity demand from plug-in electric vehicles (PEVs), but also how that demand is distributed by time of day. This will depend on when PEVs charge. We develop and apply charging profiles to reflect the share of demand from PEV charging that we assume occurs each hour on weekdays and weekends.

We source charging profiles for light-duty PEVs from the Electric Vehicle Infrastructure Projection Tool (EVI-Pro) Lite developed by the National Renewable Energy Laboratory in collaboration with others.[5] EVI-Pro Lite allows users to generate charging profiles[6] for different scenarios based on the number[7] and mix of vehicles, daily vehicle miles traveled, ambient temperature, and availability and preference for certain charging types and charging strategies. While full customization isn't possible in the tool, we generally tried to make selections among the available options most consistent with our reference case where

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[1] Beardsley, Megan. 2023. "Updates to MOVES for the Mult-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles." Memorandum to the Docket EPA-HQ-OAR-2022-0829.
[2] US EPA, 2023. "Incremental Demand Input Files for the Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles." Memorandum to the Docket EPA-HQ-OAR-2022-0829.
[3] The emissions modeling platform is a product of the National Emissions Inventory Collaborative consistent of more than 245 employees of state and regional air agencies, EPA, and Federal Land Management agencies. It includes a full suite of base year (2016) and projection year (2023 and 2028) emission inventories modeled using EPA's full suite of emissions modeling tools, including MOVES, SMOKE, and CMAQ.
[4] U.S. EPA. "2016v2 Platform". January 23, 2023. Available online: https://www.epa.gov/air-emissions-modeling/2016v2-platform
[5] U.S. Department of Energy, Alternative Fuels Data Center. 2023. "Electric Vehicle Infrastructure Projection Tool (EVI-Pro) Lite." Available at: https://afdc.energy.gov/evi-pro-lite/load-profile.
[6] The tool asks users to select a city or urban area, which changes default selections for average ambient temperature and vehicle miles traveled. Since we use the resulting profiles nationwide, we made selections (e.g., 50°F) intended to reflect that.
[7] We selected 30,000 PEVs (the highest default option available in the tool). However, it is important to note that we do not use the charging profiles from EVI-Pro Lite to estimate the amount of PEV demand. Rather, we use the profiles only to distribute our estimate of PEV demand for the Reference and Regulatory cases by hour of day.

applicable, using default selections for other variables.[8] The resulting weekday and weekend charging profiles[9] are shown in Figure 1.

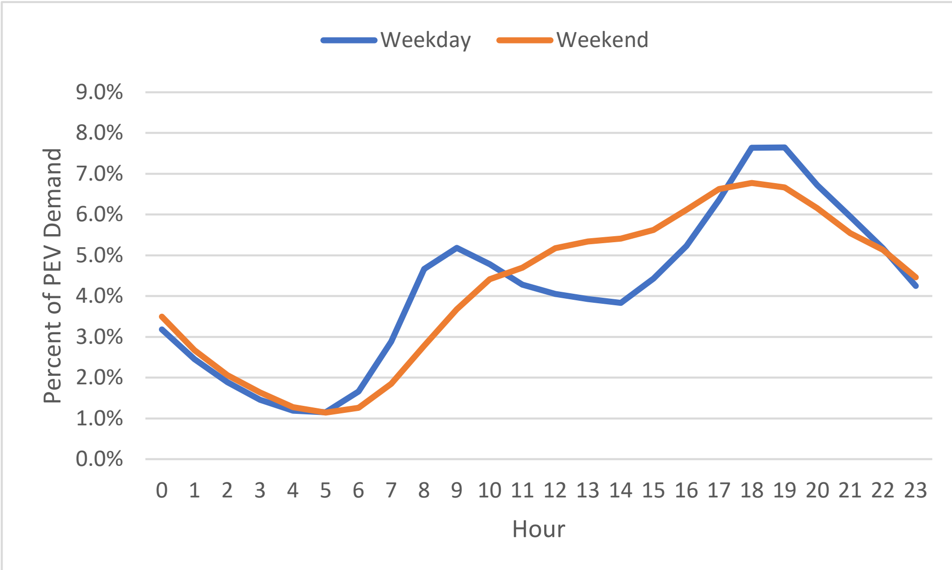

Figure 1: Charging profiles for light-duty PEV demand in the reference Case[10]

Heavy-duty vehicles comprise a broad spectrum of vehicle types and applications, and we would expect charging patterns to vary accordingly. For this reason, we develop individual charging profiles for seven vehicle categories: transit buses, school buses, other buses, refuse trucks, single unit short-haul trucks, combination short-haul trucks, and motorhomes. We start from data on vehicle soaks (or times when vehicles are not operating) in MOVES3.R1 for each of the above categories. For our analysis, we considered only soak lengths that were greater than or equal to 12 hours, using this as a proxy for when vehicles may be parked at a depot, warehouse, or other off-shift location and may have an opportunity to charge. How long a particular vehicle will take to charge will depend on a variety of factors including the vehicle's daily electricity consumption and the power level of the charging equipment. The time that charging occurs will also depend on the charging preferences of BEV owners or operators. Some may choose to start charging as soon as the vehicle is parked, while others may delay charging to accommodate other vehicles in a fleet, take advantage of time-of-use electricity rates, or for other reasons. In developing national, fleetwide profiles, we made the simplifying assumption that charging demand would be evenly distributed across the 12 hours before vehicles start daily operation, i.e. when the soak periods end.[11]

As a final step, we weight the seven individual charging profiles by the relative share of electricity demand for each vehicle category in MOVES3.R1 under the reference case. The resulting aggregate weekday and weekend profiles are shown in Figure 2.

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[8] We made the following selections: average daily miles traveled per vehicle: 35 miles; average ambient temperature: 50°F; PEVs that are all-electric: 75% (highest available option); PEVs that are sedans: 50%; mix of workplace charging: 20% Level 1 and 80% Level 2; access to home charging: 75%; mix of home charging: 50% Level 1 and 50% Level 2; preference for home charging: 100%; home charging strategy: immediate - as fast as possible; work charging strategy: immediate – as fast as possible.

[9] Profiles from the EVI-Pro Lite tool are generated in 15-minute increments. Here we have aggregated to hourly shares for use in IPM. We also normalized profiles such that the sum of hourly demand shares totals 100%.

[10] We use light-duty charging profiles to distribute PEV demand for cars, passenger trucks, and light commercial trucks (MOVES vehicle types 21, 31, and 32, see Table 3-1).

[11] See "Heavy-duty BEV Charging Profiles.xlsx," available in the docket.

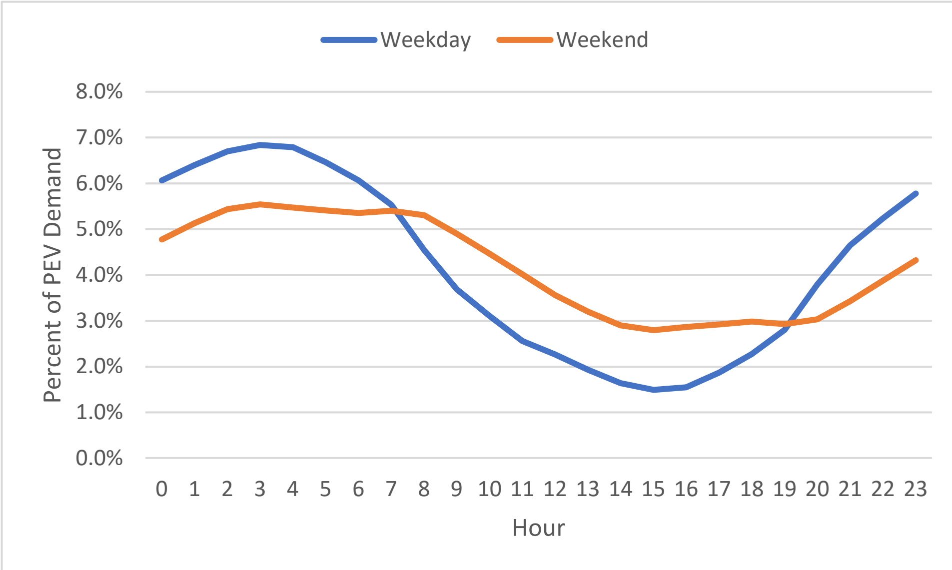

Figure 2: Charging profiles for heavy-duty PEV demand in the reference case[12]

Finally, upstream emissions that would be incurred for fuel cell electric vehicles (FCEVs) due to the production of hydrogen are not captured by MOVES. We made a simplifying assumption that all hydrogen used to fuel FCEVs is produced via the electrolysis of water, and thus in this analysis, all hydrogen production is represented as additional demand to EGUs and the emissions are modeled using IPM. Hydrogen in the U.S. today is primarily produced via steam methane reforming (SMR) largely in support of petroleum refining and ammonia production. New transportation demand and economic incentives may shift how hydrogen is produced, and electrolysis is a key mature technology for hydrogen production. The relative emissions impact of hydrogen production via SMR versus electrolysis depends on the source of electricity generation, and this varies significantly by region across the country. Electrolysis powered by electricity from the grid on average in the U.S. may overestimate the upstream emissions impacts that are attributable to HD FCEVs in the near-term.

We developed yearly scalar multipliers which were applied to MOVES FCEV energy consumption to represent total grid demand from the hydrogen production necessary to support the projected levels of FCEVs. First, we assumed hydrogen is produced by a series of decentralized, grid-powered polymer electrolyte membrane (PEM) electrolyzer systems, each with a hydrogen production capacity around 1,500 kilograms per day.[13,14] Next, we assumed the gaseous hydrogen is compressed and pre-cooled for delivery to vehicles using grid-powered electrical equipment. Finally, we assumed a linear improvement between our estimated current and future efficiency for hydrogen production. The linear interpolation is between current values that start in 2025 and future values represented for 2055, assuming a period of diffusion for more efficient electrolysis technology improvements to spread. The final scaling factors range from 1.748 in 2025 to 1.616 in 2055.

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[12] We use heavy-duty charging profiles to distribute demand for PEVs of MOVES vehicle type 41 and higher (see Table 3-1).
[13] This is based on assumptions from the Hydrogen Analysis Production (H2A) Model from the National Renewable Energy Laboratory (NREL).
[14] National Renewable Energy Laboratory (NREL). "H2A: Hydrogen Analysis Production Model: Version 3.2018". Available online: https://www.nrel.gov/hydrogen/h2a-production-archive.html