Combining NHTS Travel Data with Electric Load Data to Evaluate Plug-in Electric Vehicle Charging Impacts

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Abstract

Motivation

Plug-in electric vehicle (PEV) charging has the potential to impact all aspects of the electric power system. The magnitude of these impacts depends crucially on *the timing of vehicle charging*. While many early studies on the impact of PEVs assumed simplistic, evening and nighttime charging scenarios, it is likely that many PEV drivers will charge their vehicles whenever the PEV is at home and the battery is depleted.

Objective

To evaluate the impact of home-based PEV charging at multiple scales using PEV charging profiles that reflect real world travel behavior.

Approach

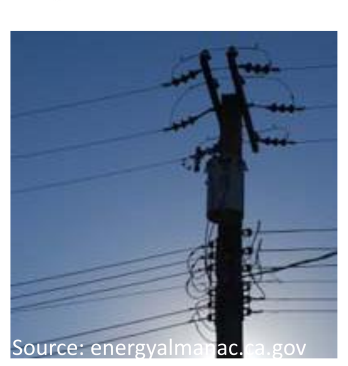
We used NHTS data (trip time, trip length, trip destination, and vehicle type) to derive time-varying PEV charging profiles that are consistent with observed travel patterns. These charging profiles incorporated difference in weekday/ weekend travel, car/light truck electric drive efficiency and Level 1 and Level 2 charging speeds.

Applications

We combined individual, NHTS-derived PEV charging profiles with publicly available load data to evaluate the impact of PEV charging at multiple levels:

We modeled the impact of PEV charging on the generating portfolio, overall generating fuel mix, and the costs of electricity generation by combining NHTS derived charging profiles with regional load data from several Independent System Operators.

We modeled the impact of PEV charging on transformer aging using household load data from the Energy Information Administration's National Energy Modeling System



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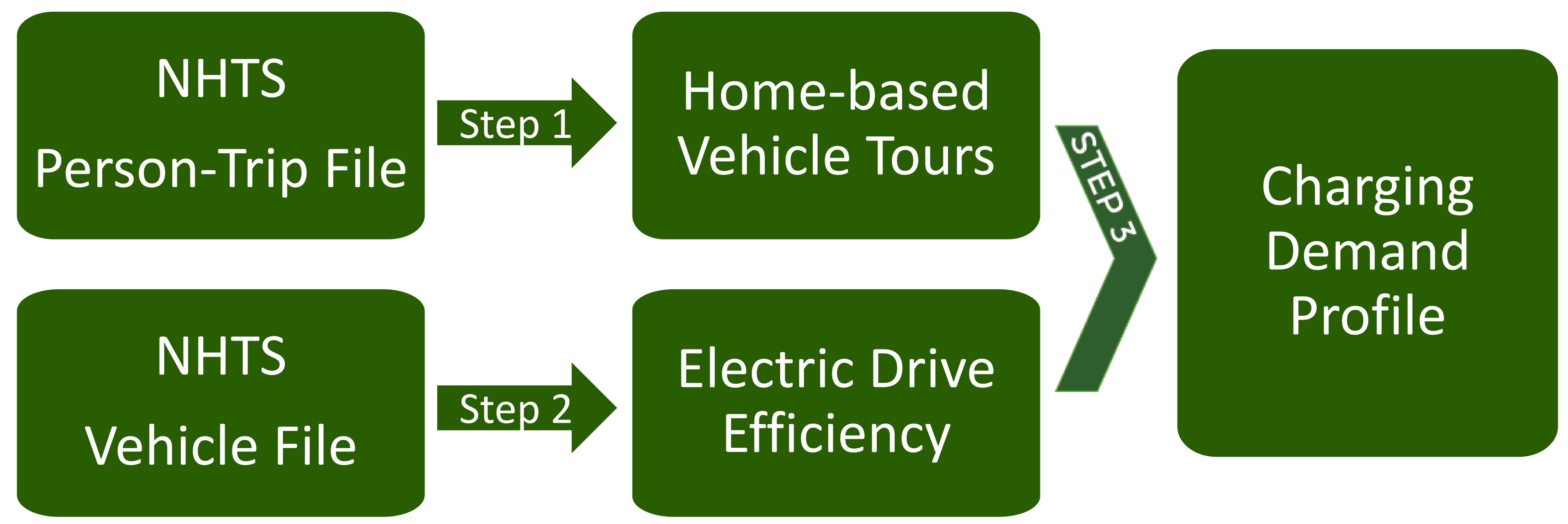
Derivation of Individual Home PEV Charging Profiles



Vehicle ID	Tour Number	Departs Home	Returns Home	Total Miles	Charge Required (kWh)
981	1	9:55 AM	12:15 PM	6.4	1.4
981	2	5:15 PM	6:45 PM	4.3	0.9
982	1	7:30 AM	4:30 PM	24.1	6.2

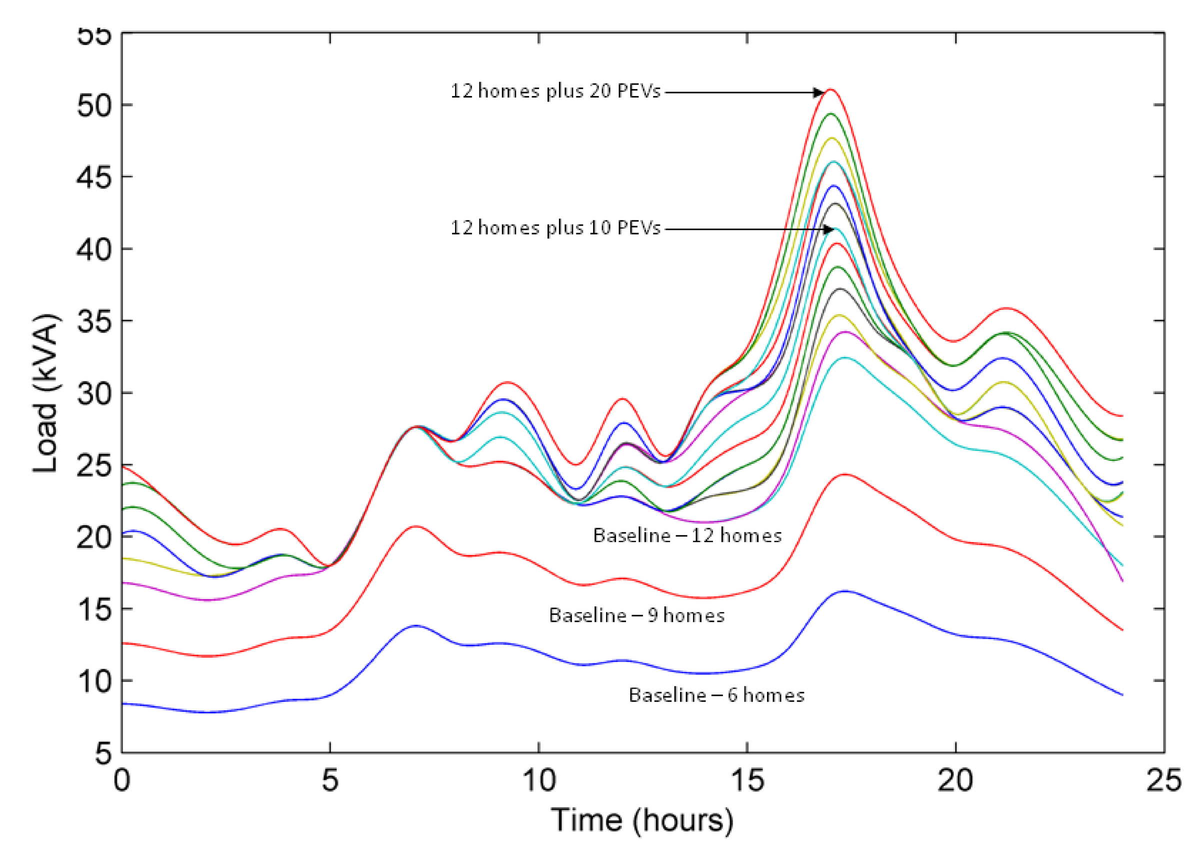
Step 1. Identify Home-to-Home Tours: Re-tabulated the NHTS person-trip file by vehicle and use the resulting vehicle-based trip file to develop home-based tours for each vehicle.

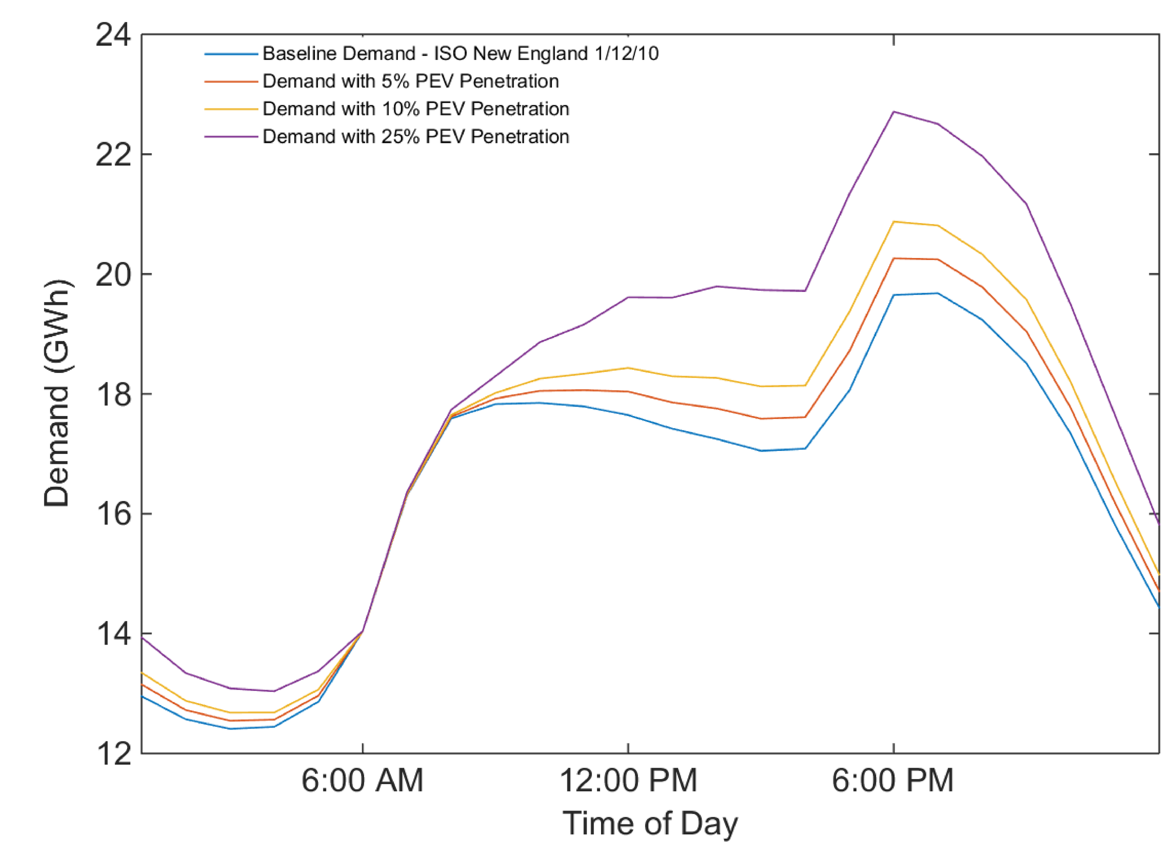
Step 2. Assign Electric Drive Efficiency Assign electric drive efficiency based on vehicle type.

Step 3. Create Charging Demand Profile Assign Level 1 (1.2 kW) or Level 2 (7.2 kW) charging. Begin charging when the vehicle returns home and continue to charge until the battery reaches capacity or the vehicle begins a new trip. A vehicle starting a second trip in the same hour that it returned home is assumed not to charge between these trips.

Aggregating PEV Charging Demand and Baseline Load

To investigate the impact of PEV charging, we combined the vehicle-type and day-of-week specific charging profiles with baseline electricity demand at varying scales.





Neighborhood level charging impacts:

PEV charging demand from 1 to 20 PEVs is combined with the baseline demand of 6, 9 or 12 households. The resulting load profiles are used to evaluate the impact of PEV charging on transformer aging.

Regional charging impacts:

PEV charging demand from hundreds of thousands of vehicles is combined with baseline demand within an Independent System Operator's territory . The resulting load profiles are used to evaluate the impact of PEV charging on generating mix, costs and emissions.

Conclusions

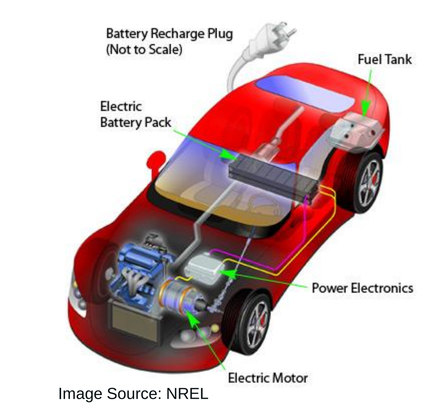
The NHTS provides a rich dataset to explore the impact of PEV charging with realistic drive behavior and charging assumptions. This data set can be used to create ***realistic time varying demand profiles*** that reflect trip:

- Timing
- Travel distances
- Vehicle choices
- Destinations

While also capturing differences in:

- Electric drive efficiency among vehicle types
- Regional fleet composition
- Weekday and weekend travel patterns
- Level 1 and Level 2 charging

As PEVs gain in market share, PEV charging will be an increasingly important component of total electricity demand. The ability to realistically model the magnitude and timing of PEV charging is vital to planning for the deployment of these vehicles.



Related Work

The charging profiles derived here where used to explore the impact of PEV charging on the cost of electricity generation, generation expansion decisions, and generator emissions in New England and the PJM Interconnect Region under varying carbon constraints. The results of this study are available in:

Jonathan Dowds, Paul Hines, Seth Blumsack, Estimating the impact of fuel-switching between liquid fuels and electricity under electricity-sector carbon-pricing schemes. *Socio-Economic Planning Sciences,* vol. 47, no. 2, pp. 76–88, 2013. Special issue on Energy Systems

The charging profiles were also used to explore the impact of PEV charging on neighborhood level distribution infrastructure. The rate of accelerated transformer aging from PEV charging depends on penetration levels as well as ambient temperature. The results of this study are available in:

Alexander D. Hilshey, Paul D. H. Hines, Pooya Rezaei, and Jonathan R. Dowds. Estimating the Impact of Electric Vehicle Smart Charging on Distribution Transformer Aging. *IEEE Transactions on Smart Grid,* vol. 4, no. 2, 2013.

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