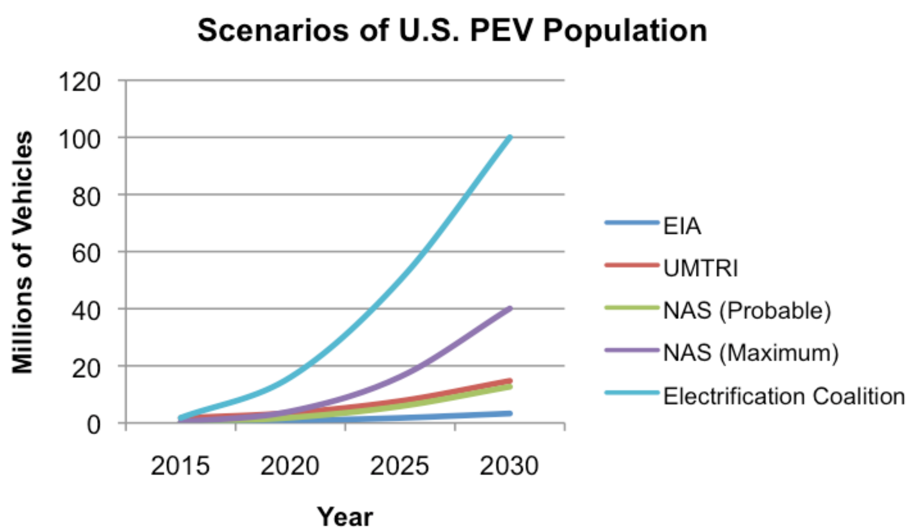
American Council for an Energy-Efficient Economy
529 14th Street, N. W., Suite 600 Washington, D.C. 20045 202.507.4000 202.429.2248 www.aceee.org

Plug-In Electric Vehicles: Penetration and Grid Impacts

Penetration Rates

The rate at which plug-in electric vehicles (PEV) enter the U.S. vehicle stock depends on many factors, including battery cost and reliability, the price of gasoline, and government incentive programs. Plausible scenarios of PEV population in the year 2030 range from a conservative 3.3 million to an aggressive 100 million, as shown in the figure below. Most of these scenarios are specifically for plug-in hybrid electric vehicles (PHEVs), i.e., plug-ins having internal combustion engines. Until recently, most projections assumed that PHEVs would be the dominant plug-in technology for many years to come. With an all-electric vehicle (EV) arriving in the U.S. later this year and renewed optimism for this technology, some manufacturers see EVs taking over before 2030.



The graph shows a range of plug-in penetration scenarios relying on diverse but plausible assumptions:

- The Energy Information Administration (EIA) in its Annual Energy Outlook (AEO) 2010 projected 3.3 million PHEV-10s and PHEV-40s (i.e., PHEVs with 10- or 40-mile, respectively, all-electric range) in 2030, assuming fuel prices averaging $3.76 per gallon over the period 2020 to 2030 (EIA 2010).
- The University of Michigan Transportation Research Institute (UMTRI) projected about 3.5 million PHEVs in 2020 and 15 million in 2030 (Sullivan et al. 2009). UMTRI's assumptions included subsidies to manufacturers that would reduce the sticker price of a PHEV-40 by $6,000 and continuation of the present tax credit for PHEVs. Gasoline price in this scenario would remain constant at $2 per gallon.
- The National Academy of Science (NAS) 2009 study "Transition to Alternative Transportation Technologies — Plug-in Hybrid Electric Vehicles" projected approximately 13 million PHEVs on the road by 2030 in a "probable penetration" scenario similar to UMTRI's. This number could rise to approximately 40 million by 2030 — about 17% of all light-duty vehicles — in a "maximum possible scenario," but this would require strong policy intervention, such as manufacturer mandates, large subsidies, and increased taxes on fuel (NRC 2009).
- The Electrification Coalition's "Electrification Roadmap" envisioned a scenario of 75% of the total vehicle miles traveled (VMT) on electricity by 2040, which would require 200 million electric and plug-in electric vehicles by that time. The Roadmap, which is not a projection but rather a call to

action, sets a target of 25% market share for PHEVs by 2020 and 90% market share for all PEVs, with EVs dominating, by 2030. This would mean 100 million PEVs (35 million PHEVs and 65 million EVs) on the road in 2030 (Electrification Coalition 2009).

Grid Impacts

The demands plug-in vehicles will place on the grid depend on their characteristics as well as their numbers. Based on the electricity consumption per mile as calculated in Elgowainy et al. (2010), per-vehicle electricity demand for a PHEV 40 might be 3,100 kWh per year, and for a typical EV, about 5,300 kWh, based on 36 miles daily driving. With these assumptions, plug-in electricity demand in 2020 would be less than 1% of total U.S. electricity generation in all scenarios except the NAS (maximum) and Electrification Coalition scenarios. PEV electricity demand in those scenarios would be about 3% and 9%, respectively, in 2030.

Even in the less aggressive scenarios, major questions remain about peak capacity and infrastructure requirements. Where PHEV charging may stress capacity or transmission and distribution infrastructure, smart grid technology could help time plug-ins' power draw. Increased use of local renewable energy sources could tie in with expanding smart grid infrastructure to reduce the strain on the system (Pratt 2010).

The type and quantity of generation capacity available to charge PHEVs will vary greatly from region to region. These regional variations will strongly influence the pollution that will be produced in charging these vehicles. While the large share of hydroelectric generation makes electricity production in the Northwest relatively clean, for example, power plants generate high levels of carbon dioxide and other pollutants in regions where coal still dominates. As a result, greenhouse gas emissions resulting from a PEV operation will exceed those of a hybrid vehicle in many locations (Kliesch and Langer 2006). Emissions also may depend strongly upon the time of day at which vehicles are charged. A Midwestern coal plant may have ample off-peak capacity for charging cars at night, while a Northwestern hydroelectric plant may have no excess nighttime capacity (Kintner-Meyer et al 2007). Policy-makers should take such factors into consideration and promote PEV introduction where the required marginal generation mix is clean.

PEVs present technical challenges, but they also offer many opportunities. They can work in tandem with the development of smart grid and distributed generation systems to facilitate investment in renewable energy. If utilities optimize their charging schedules and fuel sources, PEVs could deliver considerable economic, societal and environmental benefits.

References

Electrification Coalition. 2009. *Electrification Roadmap: Revolutionizing Transportation and Achieving Energy Security.*

EIA. 2010. *Annual Energy Outlook 2010*. Energy Information Administration. http://www.eia.doe.gov/oiaf/aeo/.

Elgowainy, A., J. Han, L. Poch, M. Wang, A. Vyas, M. Mahalik, and A. Rousseau. 2010. *Well-to-Wheels Analysis of Energy Use and Greenhouse Gas Emissions of Plug-In Hybrid Electric Vehicles*. ANL/ESD/10-1.

Kintner-Meyer, M., K. Schneider, and R. Pratt. 2007. *Impacts Assessment of Plug-In Hybrid Vehicles on Electric Utilities and Regional U.S. Power Grids: Part 1: Technical Analysis.* Pacific Northwest National Laboratory.

Kliesch, J. and T. Langer. 2006. *Plug-In Hybrids: An Environmental and Economic Performance Outlook*, American Council for an Energy-Efficient Economy. T061.

NRC. 2009. *Transition to Alternative Transportation Technologies — Plug-in Hybrid Electric Vehicles*. National Research Council, National Academy of Sciences.

Pratt, R.G., P.J. Balducci, C. Gerkensmeyer, S. Katipamula, M.C.W. Kintner-Meyer, T.F. Sanquist, K.P. Schneider, and T.J. Secrest. 2010. *The Smart Grid: An Estimation of the Energy and CO_2 Benefits.* PNNL 19112, Revision 1. Pacific Northwest National Laboratory.

Sullivan, J.L., I.T. Salmeen, and C.P. Simon, 2009. *PHEV Marketplace Penetration: An Agent Based Simulation*, University of Michigan Transportation Research Institute (UMTRI) 2009-32.