



Alternative Light-Duty Vehicles: The Role of Infrastructure

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6th Annual OPIS LCFS & Carbon Markets Workshop

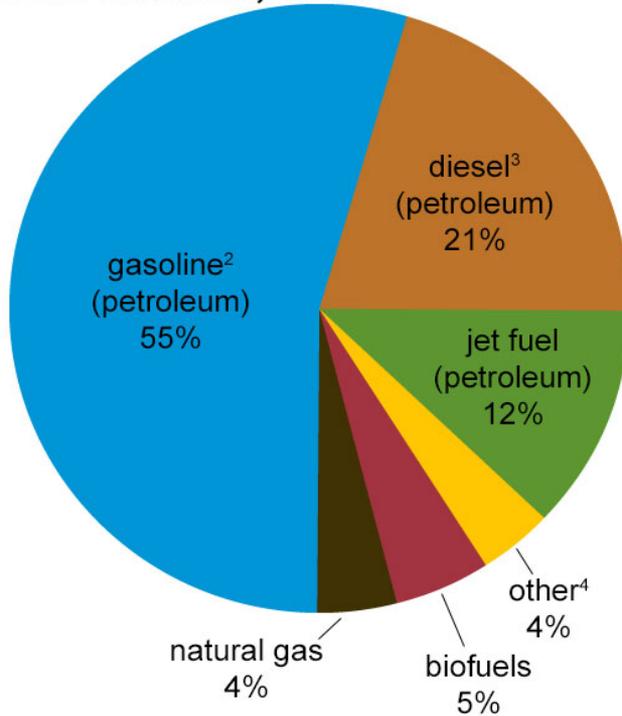
December 8th, 2017

San Francisco, California

NREL/PR-5400-70594

Transportation is dominated by petroleum and personal vehicles

U.S. transportation energy sources/fuels, 2016¹



¹ Based on energy content

² Motor gasoline and aviation gas; excludes ethanol

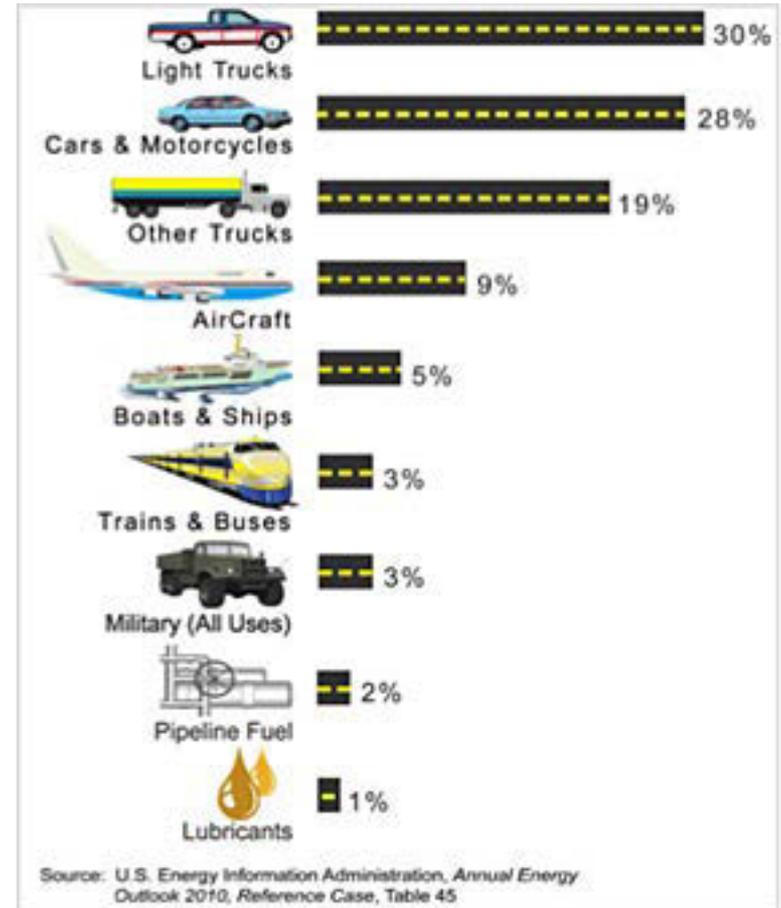
³ Excludes biodiesel

⁴ Electricity, liquefied petroleum gas, lubricants, residual fuel oil, and other fuels

Note: Sum of individual components may not equal 100% because of independent rounding.

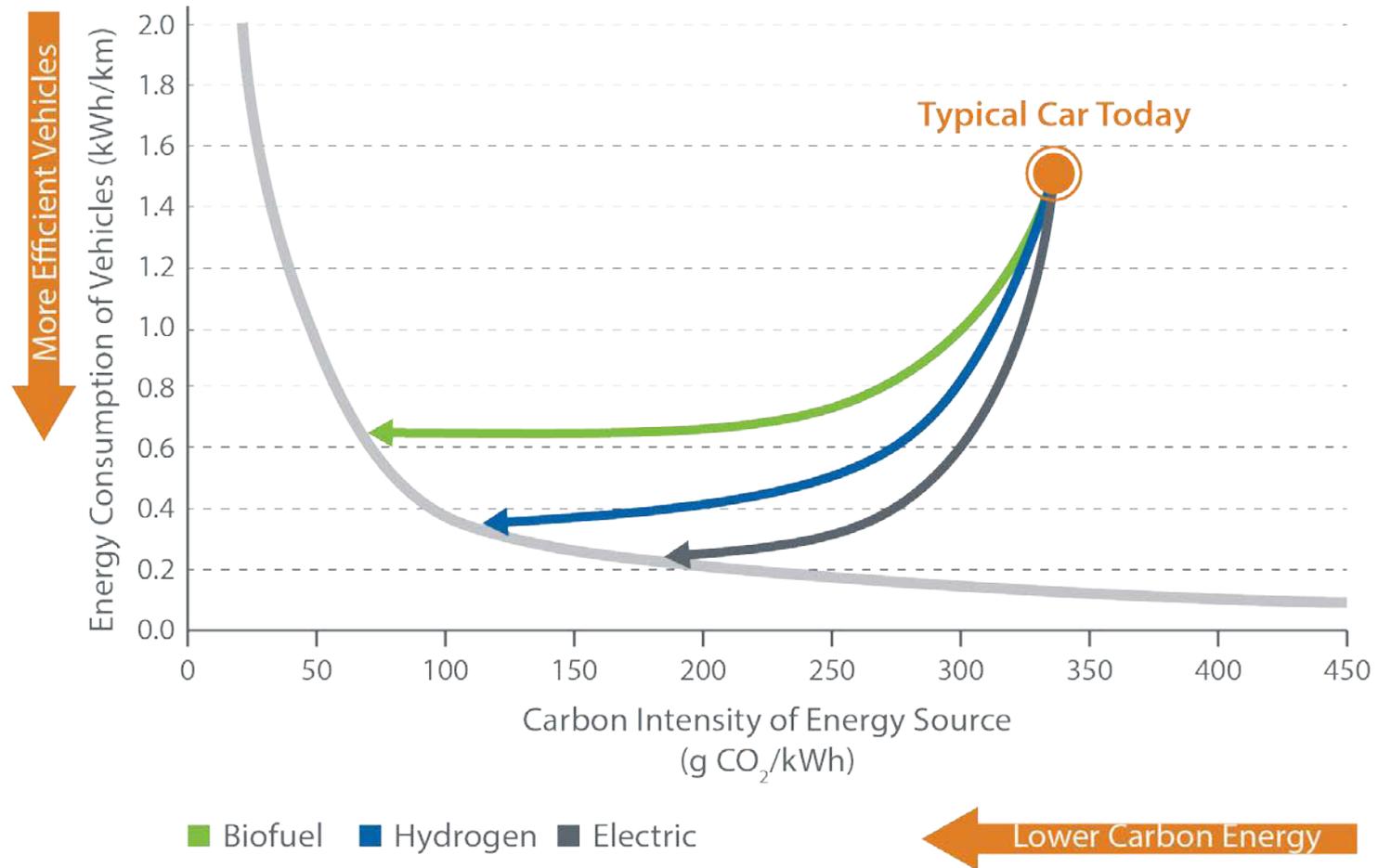


Source: U.S. Energy Information Administration, *Monthly Energy Review*, Tables 2.5 and 3.8c, April 2017, preliminary data



Source: U.S. Energy Information Administration, *Annual Energy Outlook 2010, Reference Case, Table 45*

Several alternative fuel vehicles are proposed for the future



Source: Gearhart, Chris. (2016). *Implications of sustainability for the United States light-duty transportation sector*. MRS Energy & Sustainability V3 e8.

Petroleum fuel refueling network:

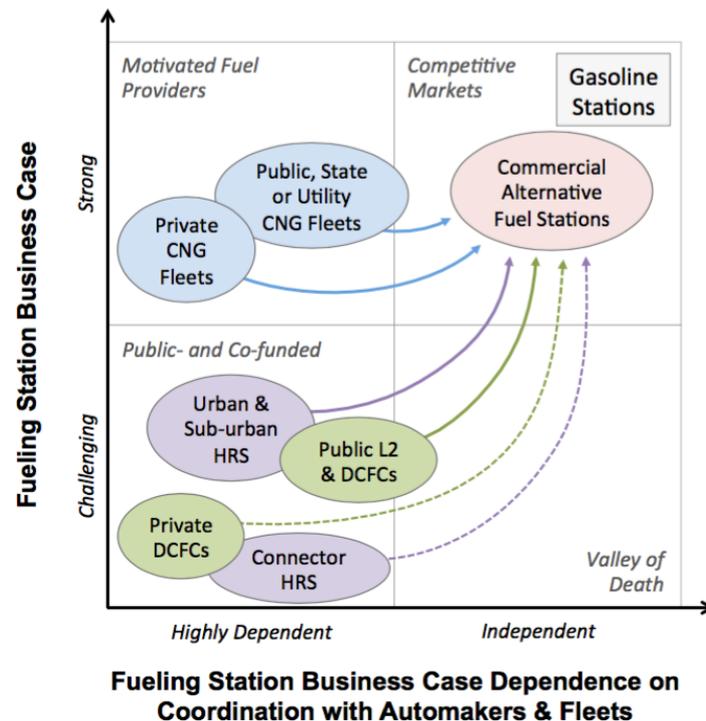
- Approximately 130,000 convenience stores (2015 NACS Retail Fuels Report) sell liquid fuels to support the fleet of ~264M personal vehicles in the U.S.
- 1 station per ~2000 vehicles

Electricity and hydrogen networks:

- 0.6M PEVs served by ~16,000 public stations (not including residential plugs)
- At the end of 2016, 33 retail HRSs served approximately 1,000 FCEVs in the United States

Market for alternative fuel stations

To reach a competitive market, commercial alternative fuel stations have to transition through a “valley of death”, as vehicle adoption increases and the network achieves good utilization levels and economies of scale.



Melaina, M., Muratori, M., McLaren, J., & Schwabe, P. (2017). *Investing in Alternative Fuel Infrastructure: Insights for California from Stakeholder Interviews* (No. 17-05279).

Plug-in Electric Vehicles: Infrastructure Requirements

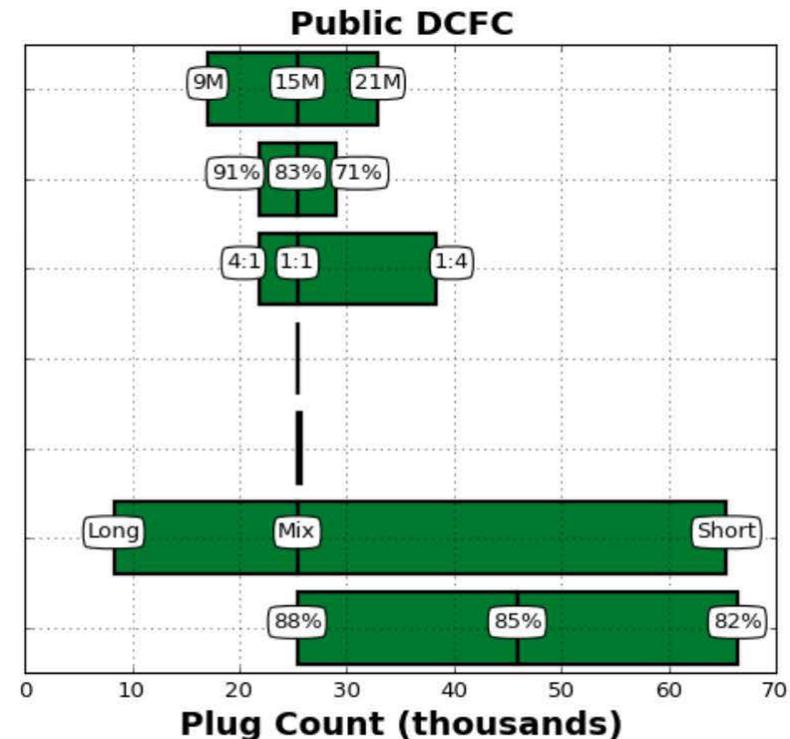
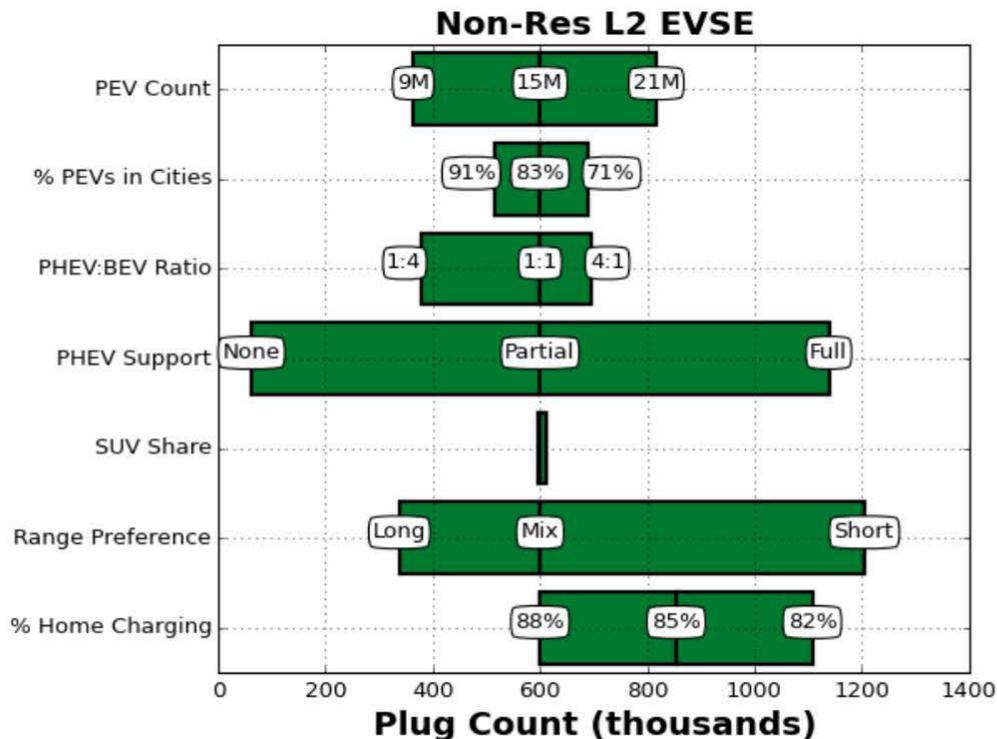
While the majority of plug-in electric vehicles charging is expected to come from residential plugs, a network of public stations is still required for those adopters that cannot reliably charge at home, to enable long-distance travel, and to cope with range anxiety



National Research Council. *Overcoming barriers to deployment of plug-in electric vehicles*. National Academies Press, 2015.

Plug-in Electric Vehicles: Infrastructure Requirements

A recent [EERE report](#) from NREL shows that about 8,100 DCFC stations are required to provide a minimum level of nationwide coverage in the communities where 81% of people live.



Wood, Eric W., Clement L. Rames, Matteo Muratori, Seshadri Srinivasa Raghavan, and Marc W. Melaina. *National Plug-In Electric Vehicle Infrastructure Analysis*. No. NREL/TP-5400-69031; DOE/GO-102017-5040. National Renewable Energy Laboratory (NREL), Golden, CO (United States), 2017.

Fuel Cell Electric Vehicles: Infrastructure Requirements

FCEV would require a network of refueling stations similar to the “gasoline model”. A recent [H2USA report](#) from NREL shows how many stations are needed to support 60M FCEVs

National Expansion

Denver-Aurora, CO

Total Stations: 244
Ave Cap (kg/d): 1,917

Kansas City, MO

Total Stations: 9
Ave Cap (kg/d): 376

Minn.-St. Paul, MN

Total Stations: 163
Ave Cap (kg/d): 1,853

Chicago, IL

Total Stations: 832
Ave Cap (kg/d): 1,960

Columbus, OH

Total Stations: 82
Ave Cap (kg/d): 1,822

Number HRS: 21,000
Pop. Enabled: 215 M

Seattle, WA

Total Stations: 440
Ave Cap (kg/d): 1,932

Portland, OR

Total Stations: 129
Ave Cap (kg/d): 1,864

Sacramento, CA

Total Stations: 167
Ave Cap (kg/d): 1,832

Los Angeles, CA

Total Stations: 1,854
Ave Cap (kg/d): 1,945

Las Vegas, NV

Total Stations: 242
Ave Cap (kg/d): 1,718

Boston, MA

Total Stations: 455
Ave Cap (kg/d): 1,862

New York, NY

Total Stations: 1,599
Ave Cap (kg/d): 1,970

Atlanta, GA

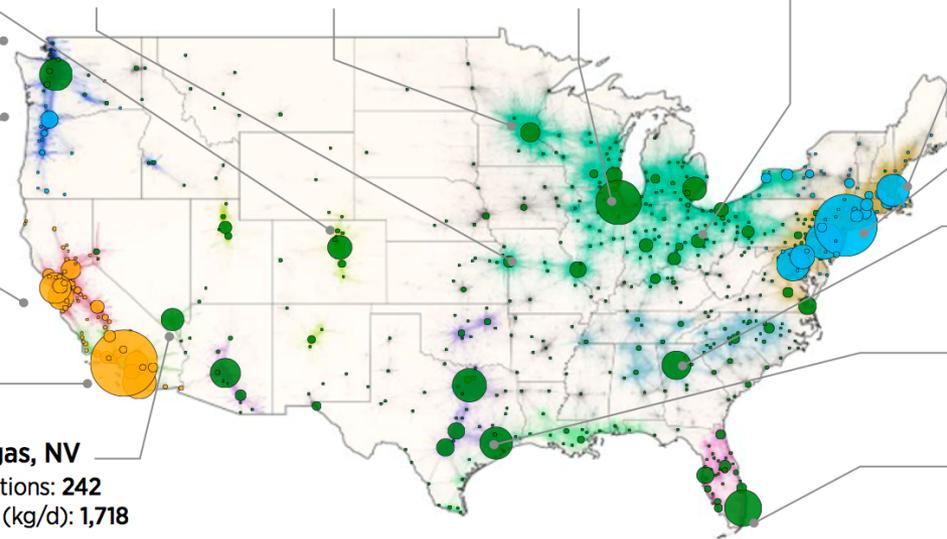
Total Stations: 365
Ave Cap (kg/d): 1,830

Houston, TX

Total Stations: 439
Ave Cap (kg/d): 1,945

Miami, FL

Total Stations: 563
Ave Cap (kg/d): 1,928



Melaina, M., B. Bush, M. Muratori, J. Zuboy and S. Ellis, 2017. National Hydrogen Scenarios: How Many Stations, Where, and When? Prepared by the National Renewable Energy Laboratory for the H2 USA Locations Roadmap Working Group.

Thank you!

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