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Alternative light-duty vehicles: the role of infrastructure

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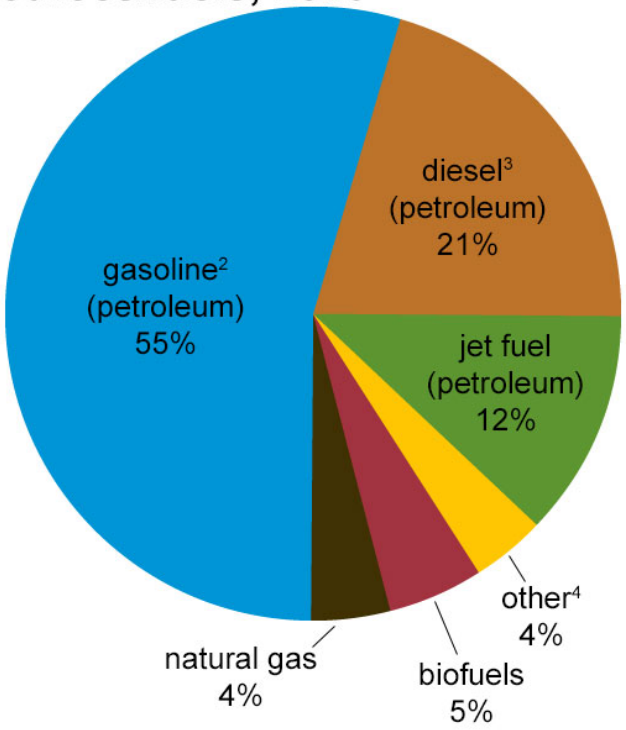
Transportation is dominated by petroleum and on-road vehicles

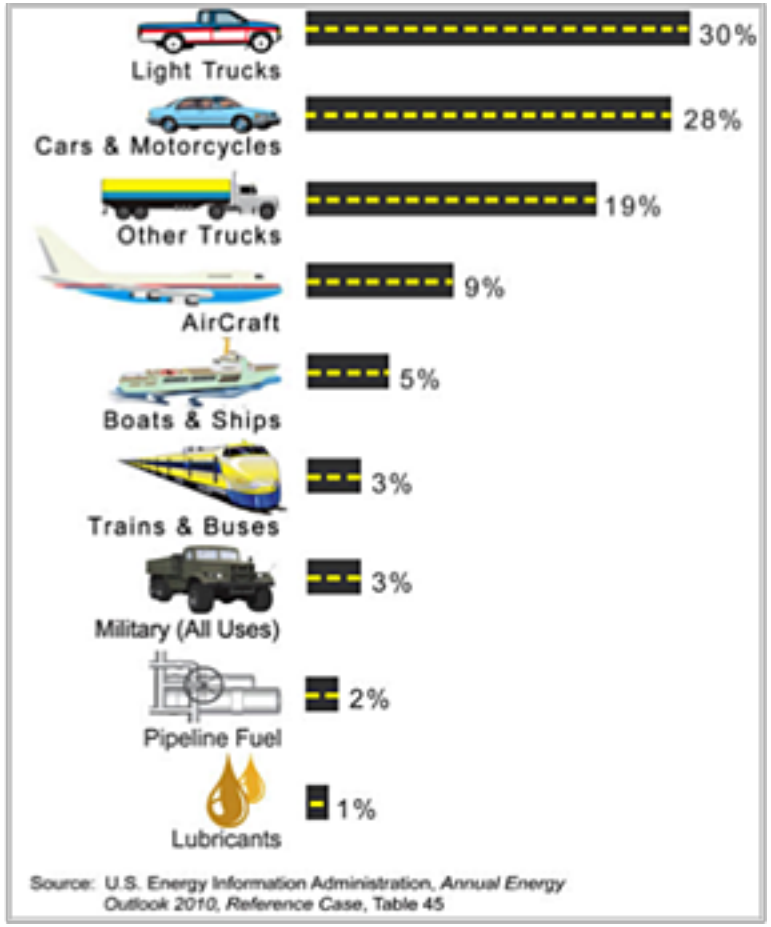
U.S. transportation energy sources/fuels, 2016[1]



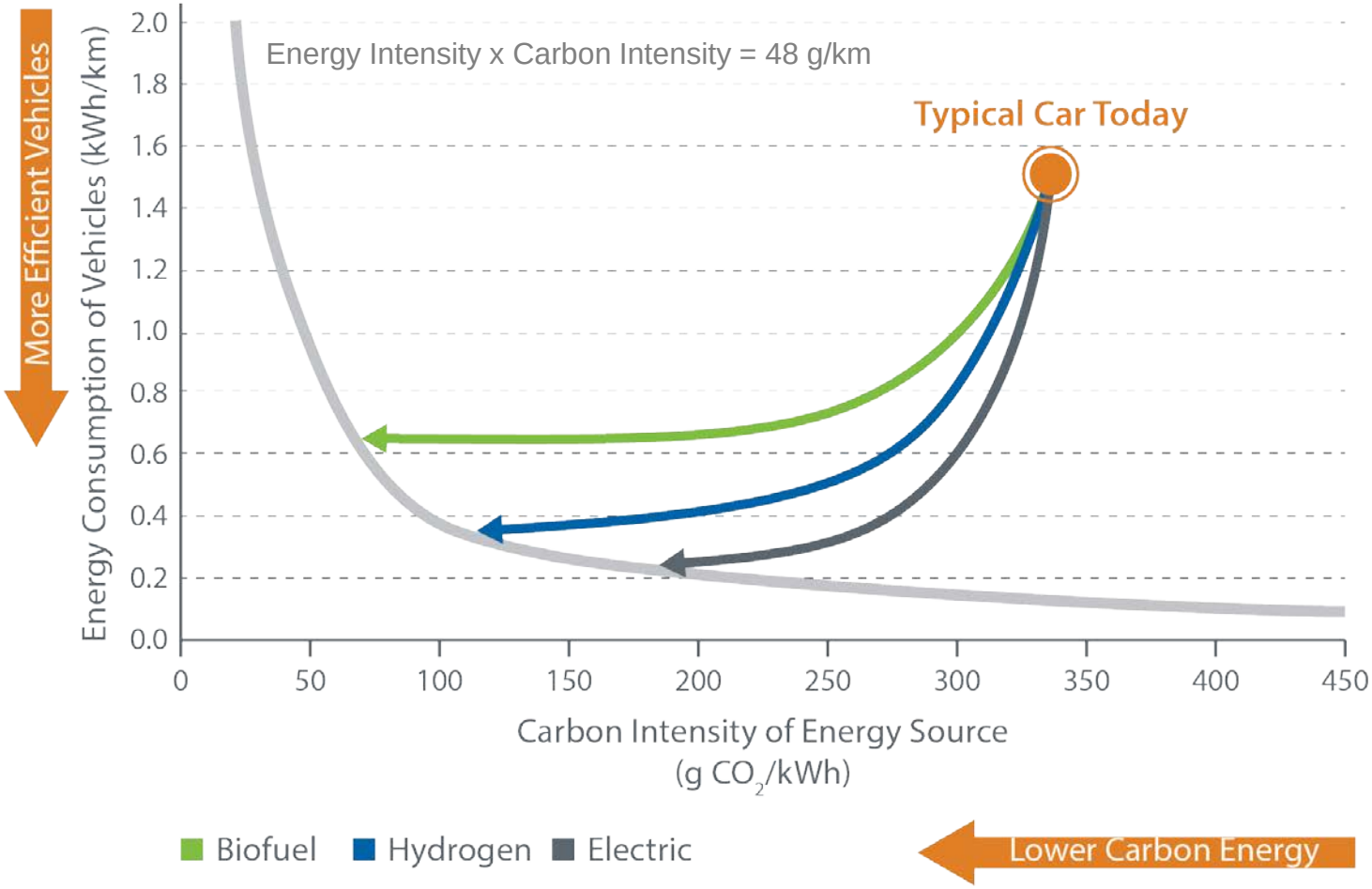
[1] Based on energy content
[2] Motor gasoline and aviation gas; excludes ethanol
[3] Excludes biodiesel
[4] Electricity, liquefied petroleum gas, lubricants, residual fuel oil, and other fuels

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



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.

Infrastructure requirements

Petroleum fuel refueling network:

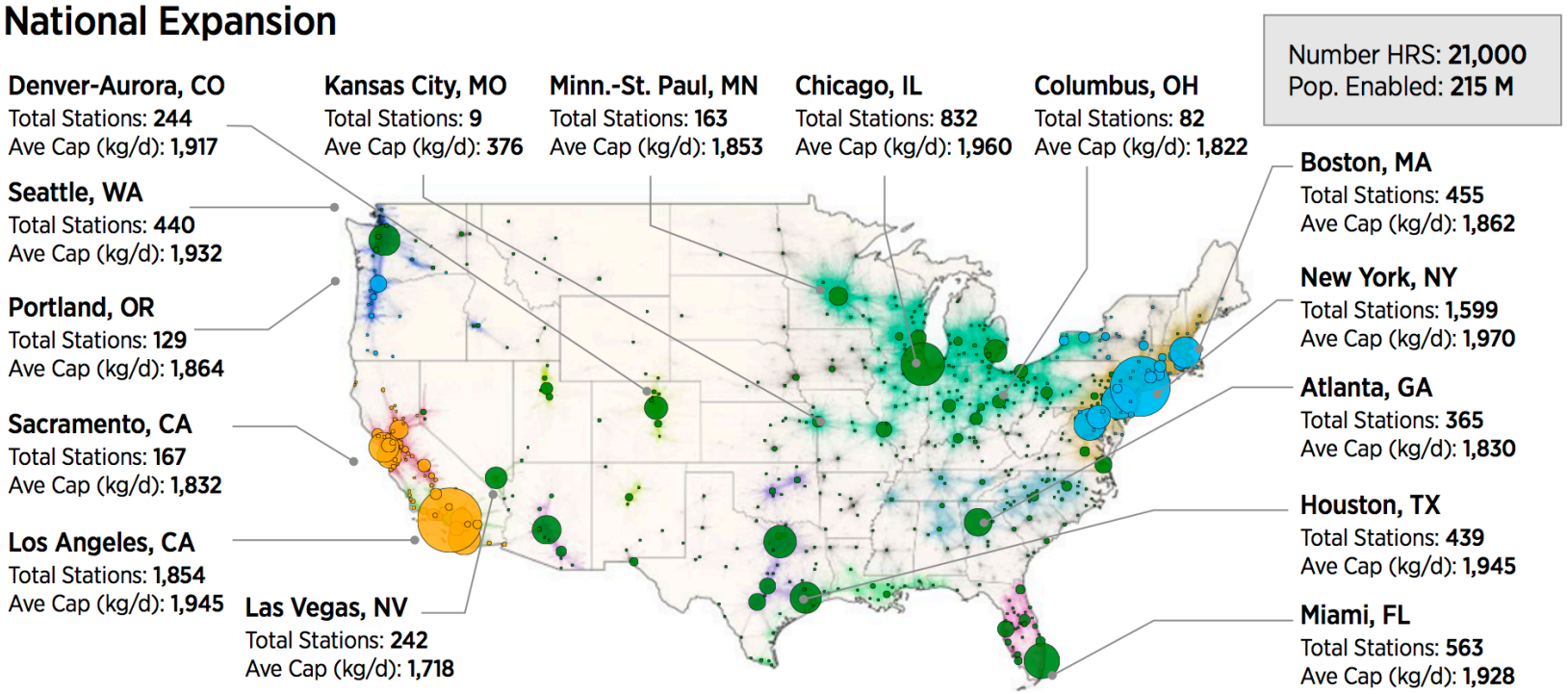
- Approximately 130,000 convenience stores (2015 NACS Retail Fuels Report) sell liquid fuels to support the fleet of ~264M personal vehicles in the U.S.
- 1 station per ~2000 vehicles

Electricity and hydrogen networks:

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

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

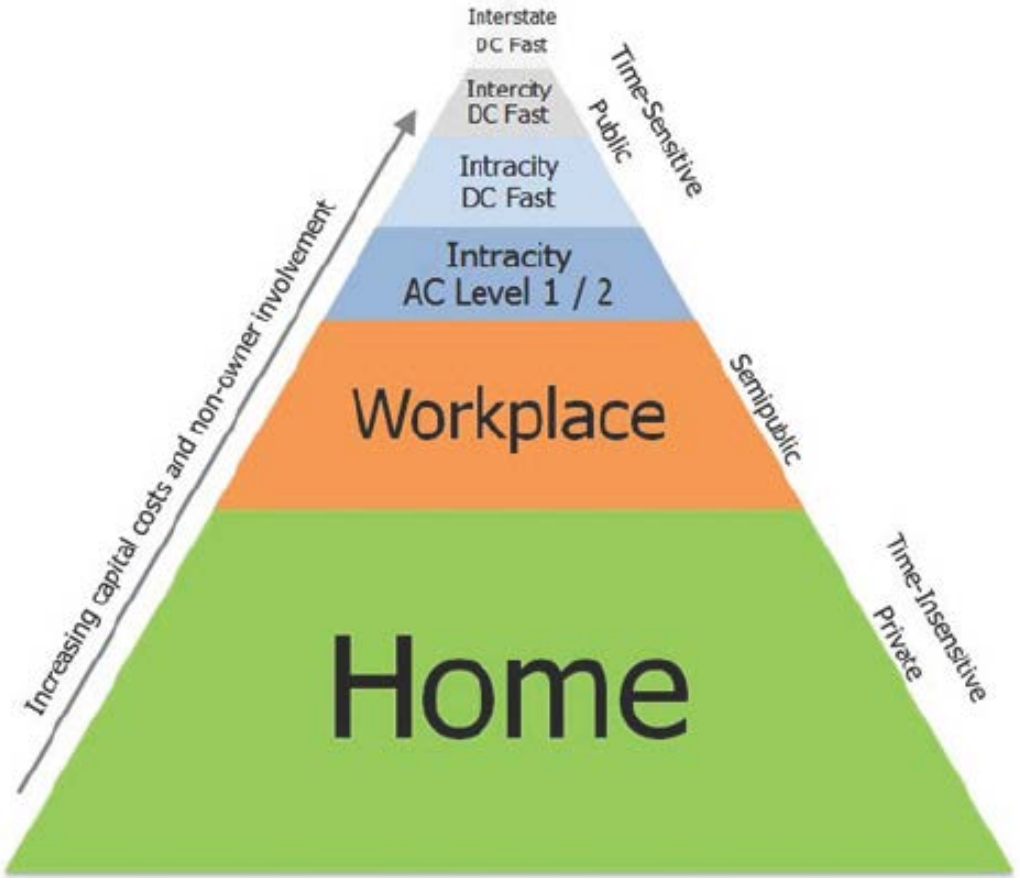


Melaina, M., B. Bush, M. Muratori, J. Zuboy and S. Ellis, 2017. National Hydrogen Scenarios: How Many Stations, Where, and When? Prepared by the National Renewable Energy Laboratory for the H2 USA Locations Roadmap Working Group.

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:

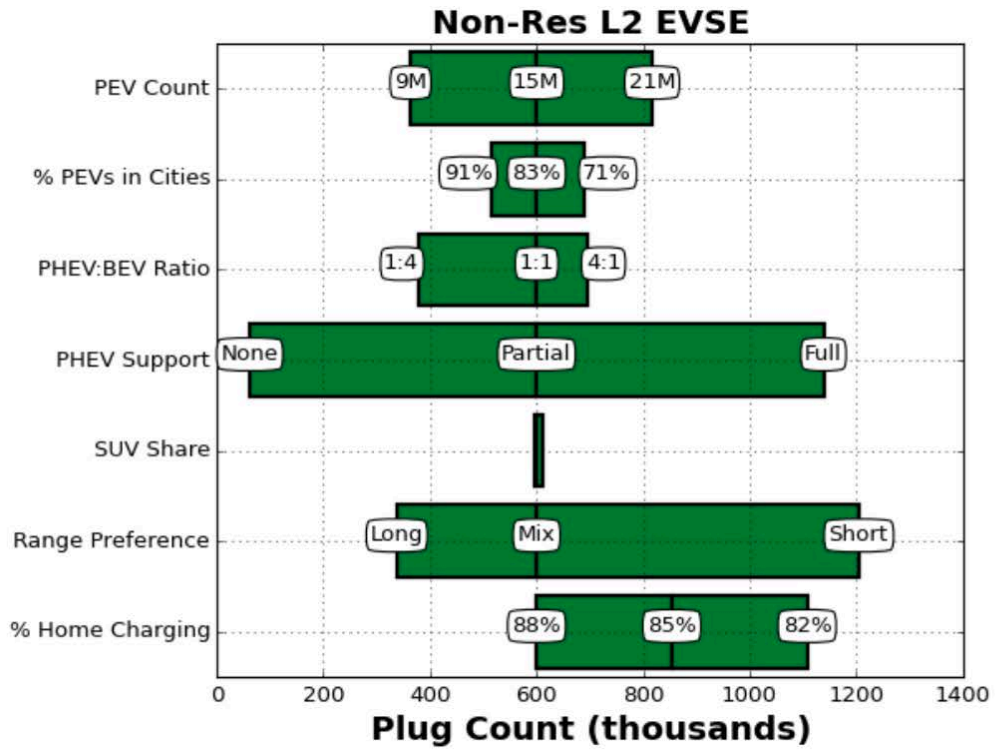
- adopters that cannot reliably charge at home
- enable long-distance travel
- cope with range anxiety

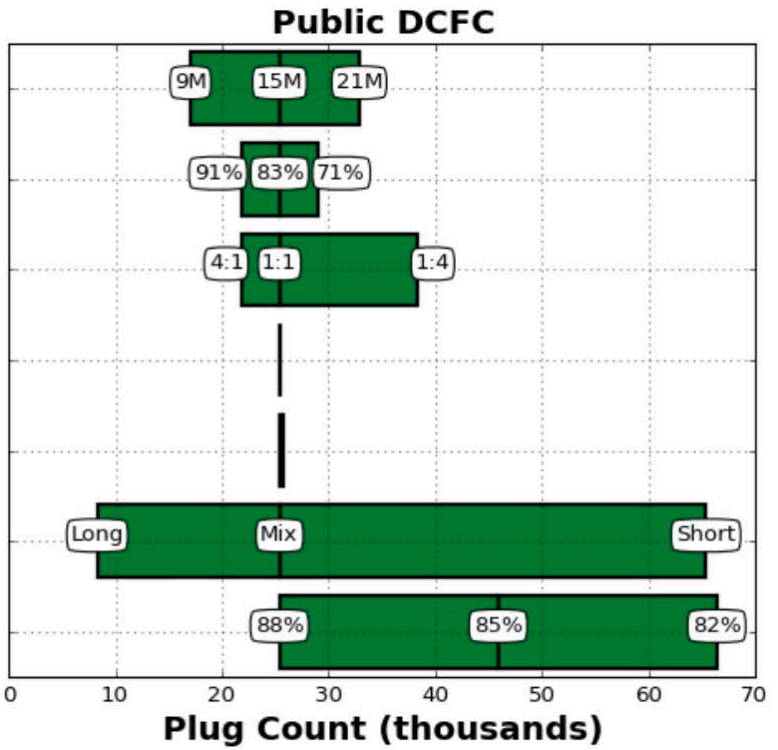


National Research Council. *Overcoming barriers to deployment of plug-in electric vehicles*. National Academies Press, 2015.

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.

Questions?

Thank you!

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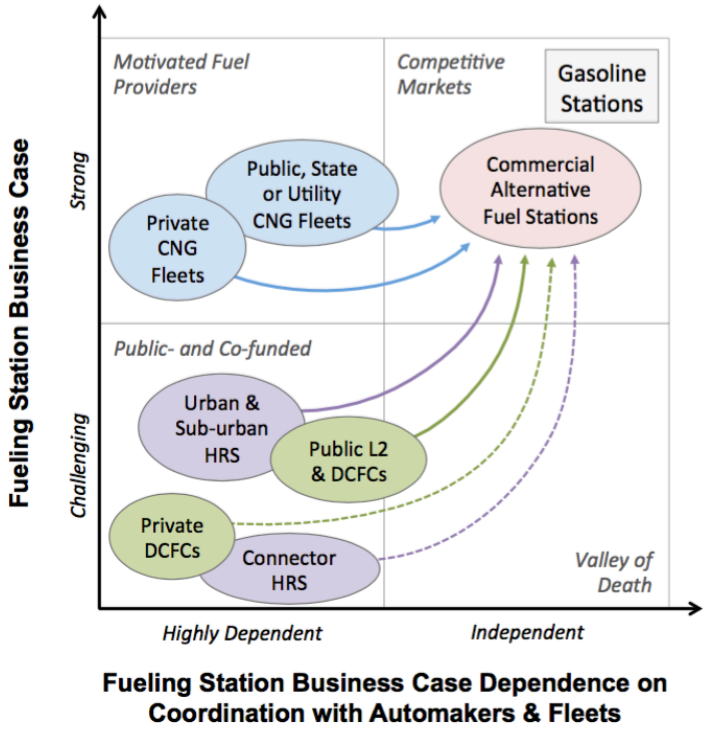
Market for alternative fuel stations

To reach a competitive market, commercial alternative fuel station 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).

Results – Central Scenario & Sensitivity Analysis

Central Scenario

		Cities	Towns	Rural Areas	Interstate Corridors
PEVs		12,411,000	1,848,000	642,000	---
DCFC	Stations (to provide coverage)	4,900	3,200	---	400
	Plugs (to meet demand)	19,000	4,000	2,000	2,500
	Plugs per station	3.9	1.3	---	6.3
	Plugs per 1,000 PEVs	1.5	2.2	3.1	---
Non-Res L2	Plugs (to meet demand)	451,000	99,000	51,000	---
	Plugs per 1,000 PEVs	36	54	79	---

Estimated requirements for PEV charging infrastructure are heavily dependent on:
1) evolution of the PEV market, 2) consumer preferences, and 3) technology development

Sensitivity Analysis