Charging Infrastructure for Electric Vehicles

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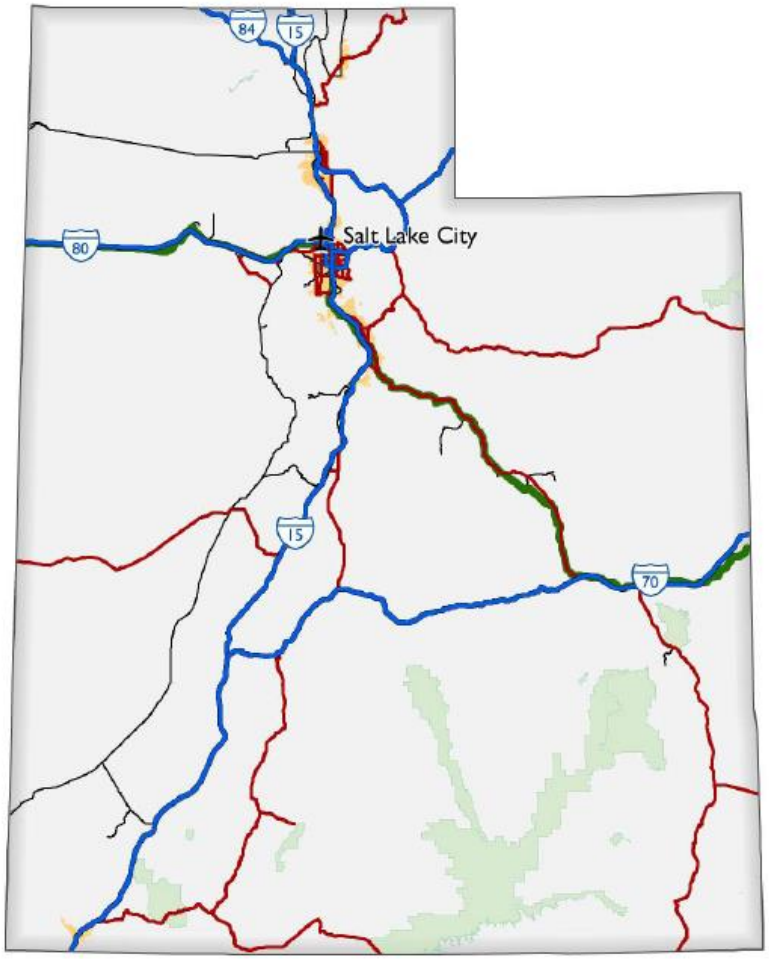
Utah Transportation by the Numbers

- Vehicles & drivers
  - Licensed drivers: 1.7 Million
  - Registered vehicles: 2.1 Million
    - 80% along Wasatch Front
    - Plug-in EVs: 2,100+
- Road miles in Utah
  - All public roads: 46,254
  - Interstate Highways: 1,100
  - US highway: 2,000
  - State Routes: 5,200
- Miles traveled
  - Highway annual: 27 billion (2013)
  - Average daily per person: 43.6 (2009)



Motivation for Electrified Transportation

- Reduce energy consumption and cost
  - Transportation accounts for 28% of US energy use
  - Electric vehicles consume 5x less energy
- Reduce impact on environment
  - Transportation accounts for 57% of fine particle emissions in the greater Salt Lake City area
  - Transportation accounts for 27% of greenhouse gas (GHG) emissions in the US
  - Transportation is the fastest growing source of emissions
- Displace petroleum as energy source
  - Transportation accounts for 71% of oil use in US
  - Petroleum comprises 93% of US transportation energy use
- Reduce utility rates
  - Properly managed can increase off-peak load to improve grid utilization, reduce rates for area sources

Zero Tailpipe Emissions

75 % reduction in PM10 / 2.5

50% reduction in CO_2

Electric Vehicle Terminology

- Internal Combustion Engine (ICE) Vehicle
  - Gasoline powered only
- Hybrid Electric Vehicle (HEV)
  - Combination of a gasoline-powered ICE and electric drive
  - Regenerative breaking, no idling, small battery
- Plug-in Electric Vehicle (PEV)
  - Plug-in Hybrid Electric Vehicle (PHEV)
    - Same efficiency improvements as HEV
    - Larger battery for an all-electric range
  - All Electric Vehicle (AEV), Battery Electric Vehicle (BEV)
    - No ICE, much larger battery
    - No tailpipe emissions

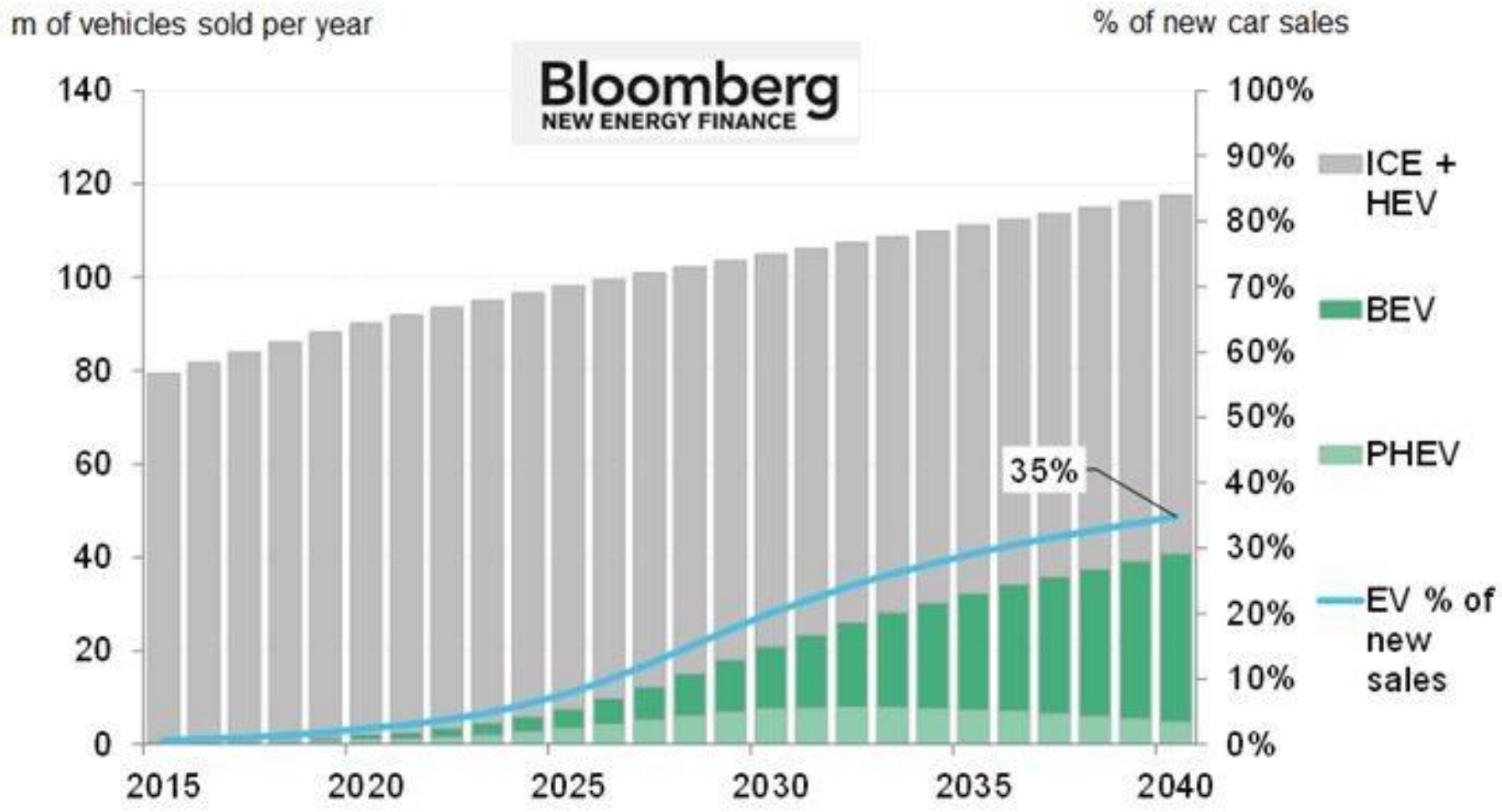
Sample Electric Vehicles on the Market

	Toyota Prius	GM Chevy Volt	Nissan Leaf	Tesla Model S
Class	HEV	PHEV	BEV	BEV
Electric Range	0 miles	38 miles	84 miles	240 miles
Battery Size	1.3 kWh	16 kWh	24 kWh	70 kWh
Price	$24,000	$34,000	$30,000	$70,000

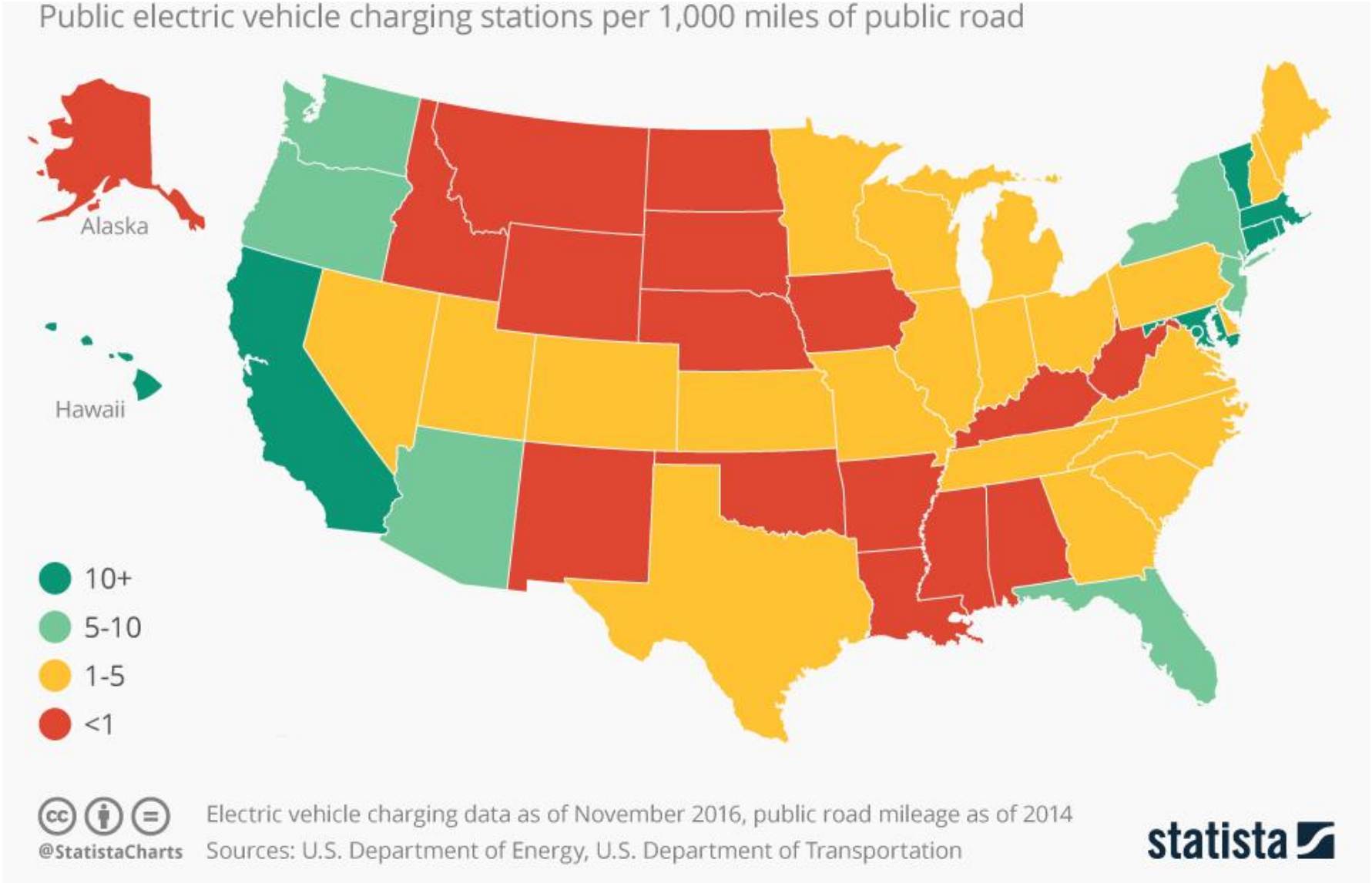
200+ Mile Range Light Duty Vehicles

- Chevy Bolt
  - 238 mile range, 0-60 in 6.5 sec
  - $37k (before tax incentives)
  - Broad availability 2017
- Tesla Model 3
  - 215 mile range, 0-60 in <6 sec
  - $35k (before tax incentives)
  - Release in late 2017
- Nissan LEAF
  - 200+ miles, ProPILOT
  - Near future
- Ford small SUV
  - >300 mile range
  - By 2020
  - Also: PHEV F-150 & Mustang

PEVs to Hit 35% of New Global Sales by 2040



Density of PEV Charging Stations in the US



PEV Charger Overview

Level 1 AC
120 VAC
~1.4 kW

Level 2 AC
240 VAC
~7.2 kW

DC Fast Charger
480 V 3ph AC
50 kW

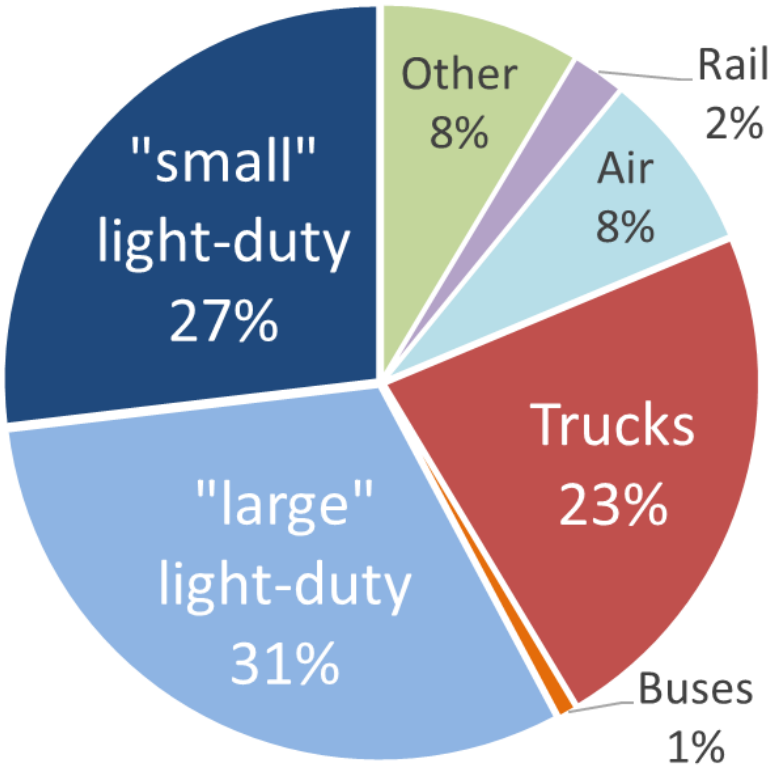
PEV Charger Comparison

Type of Charging	Level 1 AC 120VAC (~1.4 kW)	Level 2 AC 240VAC (~7.2 kW)	DC Fast Charger (50 kW)	Tesla SuperCharger (140 kW)
Overview	On-board charger Standard electrical outlet Up to 1.9 kW (16 A)	Limited by on-board charger Up to 19.2 kW SAE J1772 connector Majority of stations in US	Off-board charger DC directly to the vehicle SAE J1772 "combo" and CHAdeMO connectors	Only available for Tesla vehicles
Range per Hour of Charge*	3-5 miles	25 miles	165 miles	460 miles
Time to Charge for 200 miles*	43 hours	8.3 hours	1.2 hours	26 minutes
Average Cost w/ Installation	AC plug included	Residential: ~3,000 Commercial: ~$10,000	$50,000	n/a

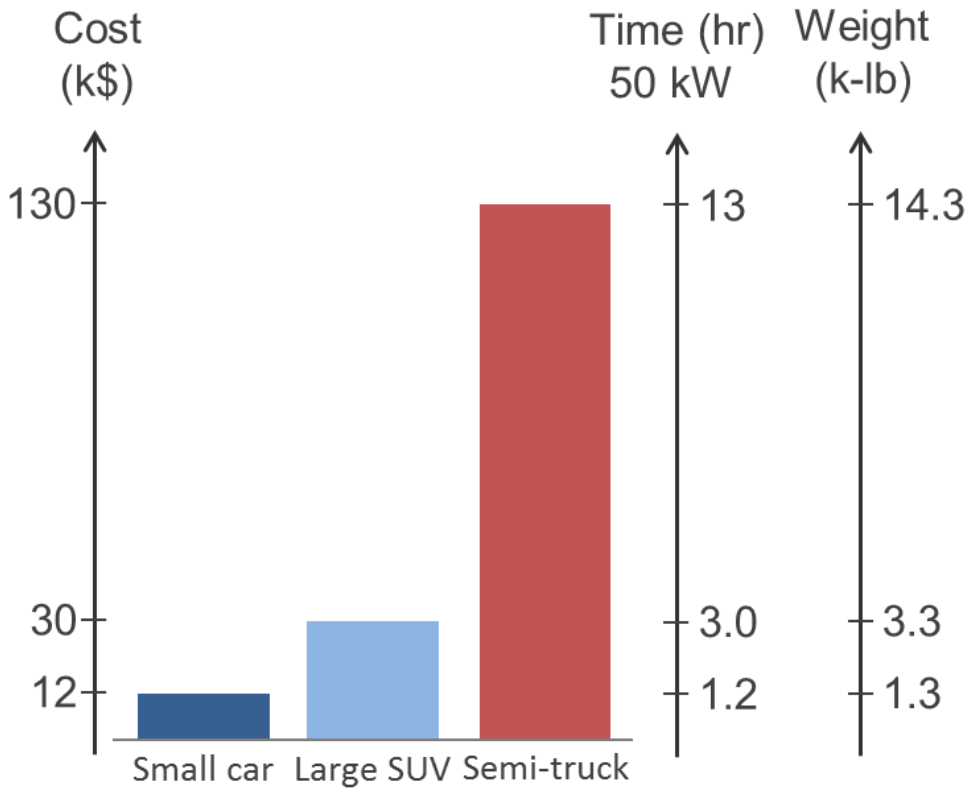
* Estimates based on small light duty vehicles (~300 Wh per mile)

Challenges for Electrifying Larger Vehicles

US transportation energy use by vehicle type



Battery cost, charge time, and weight for 250 mile range



Moving Forward with EVs in Utah

- 200+ mile range PEVs are rolling out
- PEV charging infrastructure is a limiting factor for growth in Utah
- Level 2 or higher charging needed at work, retail outlets
- DC fast charging or higher needed along highways, commuting corridors
- New solutions needed for larger vehicles, freight, gas-pump equivalent convenience
  - 350+ kW ultra fast charging
  - Charge-as-you-go electric highways