Oregon
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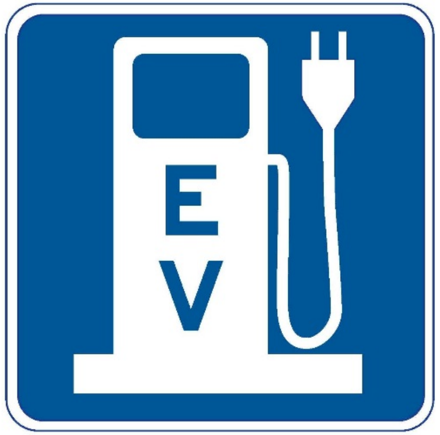
ENERGY

The Developing EV Market

Rick Wallace
9/22/2017



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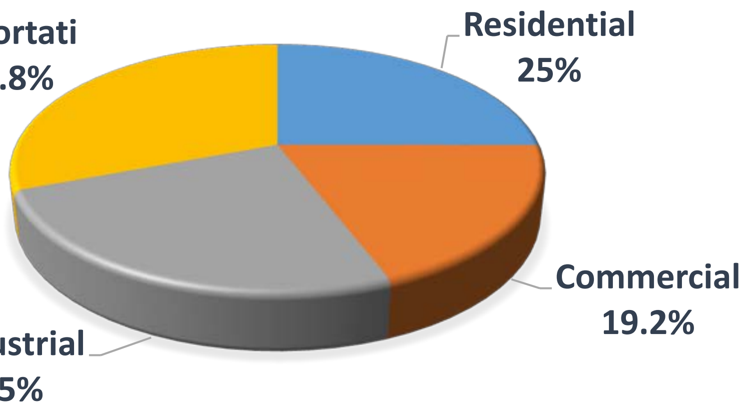
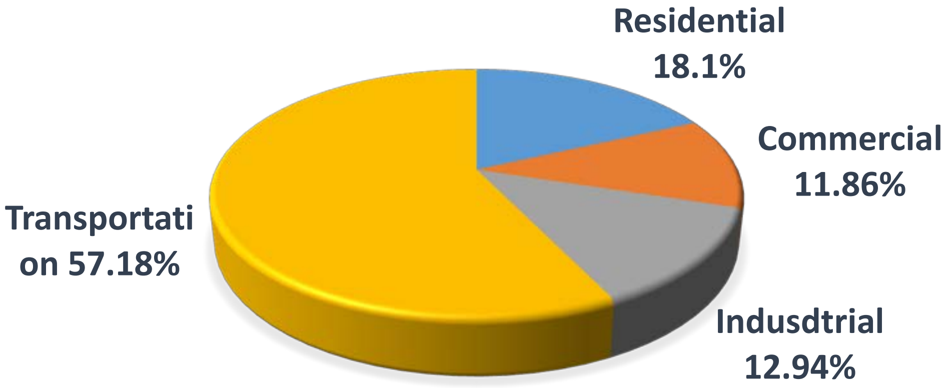
Transportation Plays a Major Role in Oregon's Energy Mix

SECTOR ENERGY CONSUMPTION
2014

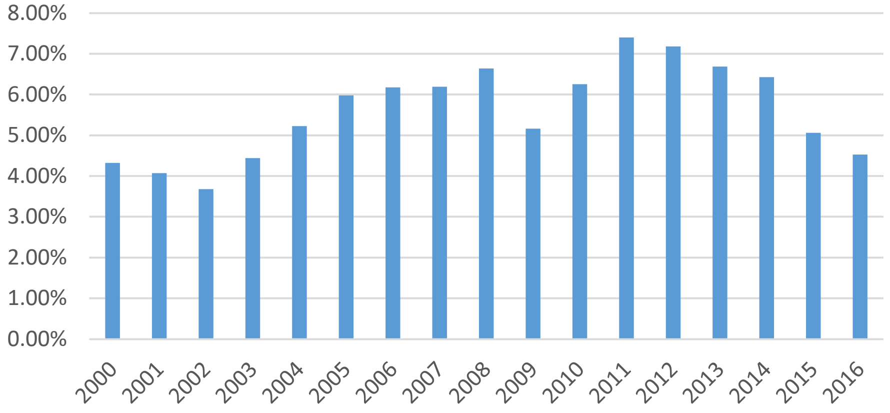


SECTOR ENERGY COST
2014



Cost to drive 100 Miles (9/13/17)
ICE = $10.39
At $2.91/gal & 28 mpg
EV = $3.08
At $0.11/kWh & 3.57miles/kWh

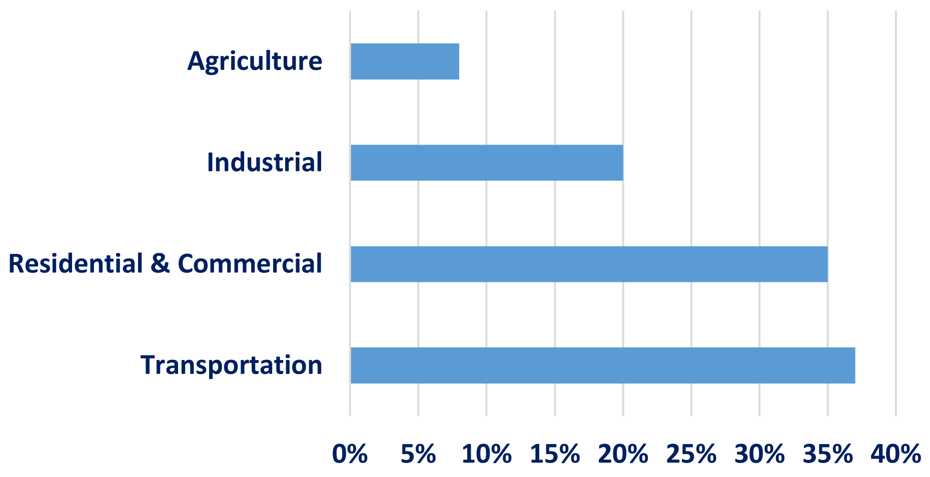
Fuel Cost As A Percent of Oregon Household
Median Income



HH Fuel Cost EV Verse ICE
2016
ICE = $2,321
EV = $ 761

Transportation & OR GHG Emissions

Oregon GHG Emissions by Sector - 2015

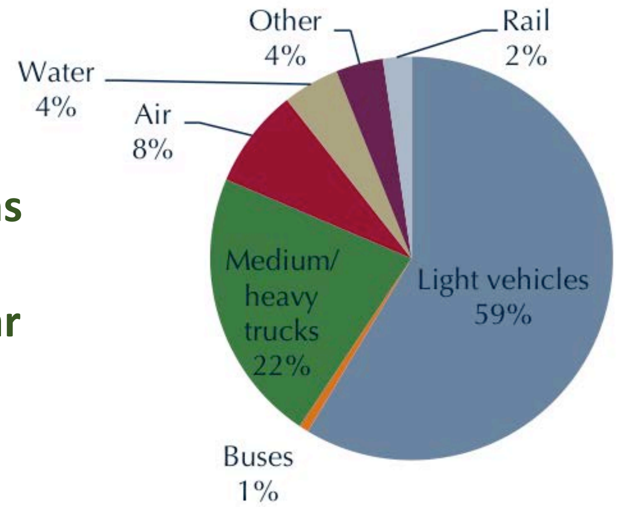


A Light-Duty EV has GHG emissions of 25% to 33% of a similar model ICE vehicle

Light-duty vehicles are a major contributor of GHG overall at about 25%

Oregon Fuel Mix

	2015 On-Highway Fuel Mix		
Fuel Type	GGE	% GGE	GHG MT
Gasoline	1,398,726,073	64.85%	16,844,859
Diesel	559,307,710	25.93%	6,795,870
Ethanol	155,831,454	7.22%	1,476,603
Biodiesel	35,958,121	1.67%	250,366
Renewable Diesel	73,856	0.003%	536
LPG	946,831	0.04%	9,401
CNG	3,140,667	0.15%	30,002
LNG	431,490	0.02%	4,872
Electricity(GGE)	2,543,081	0.12%	9,678
Petroleum	1,958,033,783	90.78%	23,640,730
All Others	198,925,500	9.22%	1,781,458
Total	2,156,959,283		25,422,188

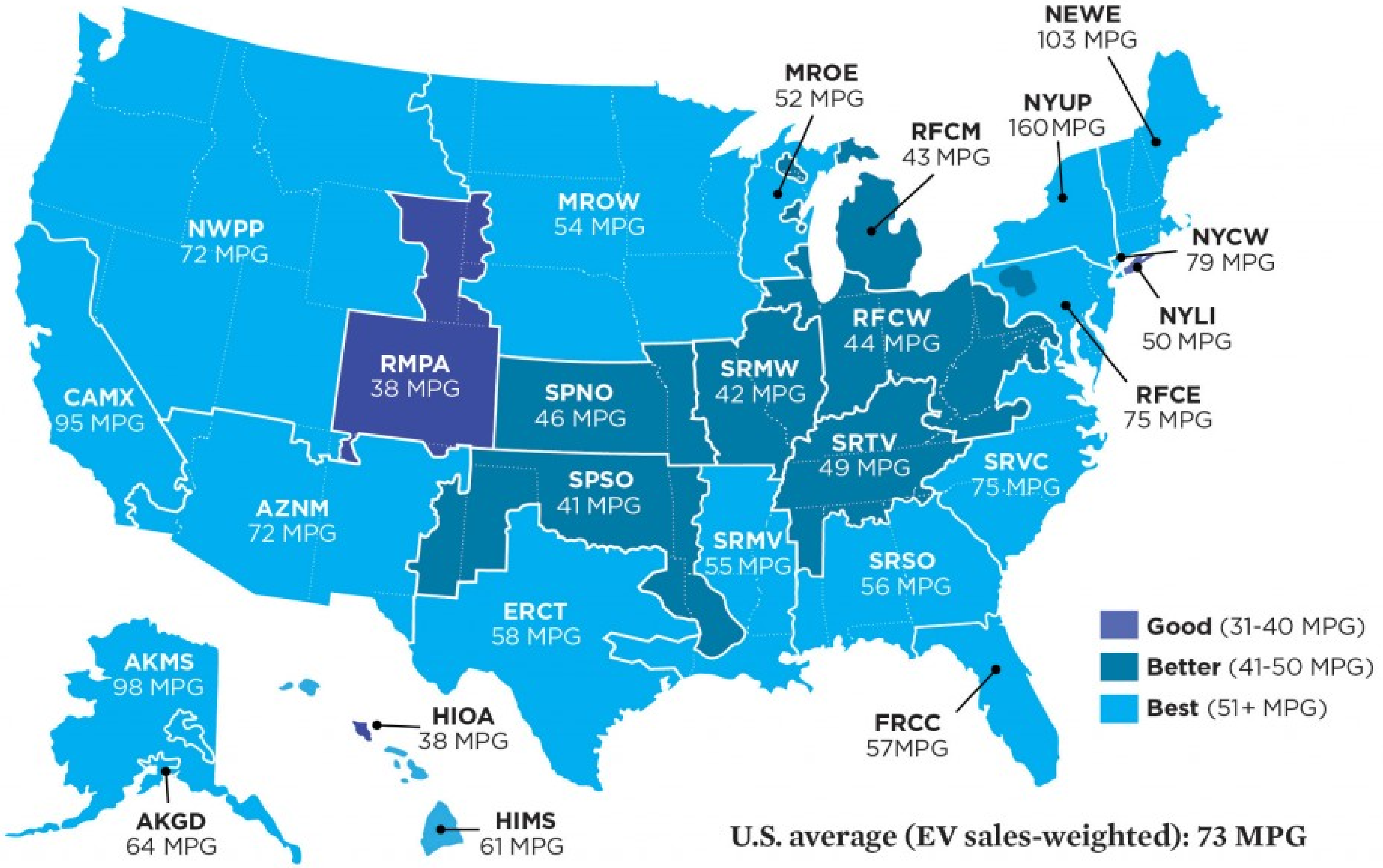


ICE GHG Emissions
28 mpg
11,346 miles/year
4.78 MT CO2e

EV GHG Emissions
3.57 m/kWh
11,346 miles/year
1.38 MT CO2e

EV GHG Emissions Vary by Region

Electric Vehicle Global Warming Pollution Ratings and Gasoline Vehicle Emissions Equivalents by Electricity Grid Region



U.S. average (EV sales-weighted): 73 MPG

Note: The MPG (miles per gallon) value listed for each region is the combined city/highway fuel economy rating of a gasoline vehicle that would have global warming emissions equivalent to driving an EV. Regional global warming emissions ratings are based on 2014 power plant data in the EPA's eGRID 2014 database (the most recent version). Comparisons include gasoline and electricity fuel production emissions. The 73 MPG U.S. average is a sales-weighted average based on where EVs were sold in 2016.

SOURCE: EPA 2015C; IHS 2015.

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Why EVs: Benefits of Going Electric

- Improved air quality, particularly in urban disadvantaged neighborhoods where vehicle emissions are high
- EV greenhouse gas emissions are far less than ICEVs
- EVs have potential to benefit the electrical grid through demand response and storage strategies to help integrate renewables, and EVs can help balance load
- EVs have superior technology to ICEVs – they do a better job of getting from A to B
- Reduced operational and maintenance costs
- EVs are safer, quieter, and don't smell
- Diversification of transportation fuels lessens petroleum supply volatility and cost fluctuations on the economy, supports energy security

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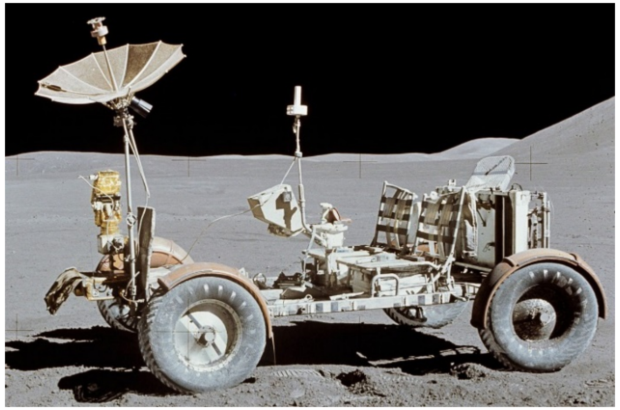
EV 2.0 Will Expand the EV Market

- EVs' range will expand to 200 to 400 miles per charge
- Battery prices have come down 73%/kWh since 2010
- Near future vehicles will be able to recharge to 80% in 15 to 30 minutes
- More models will become available
- EVs are nearing price parity to ICE vehicles

Brief History of EVs

- First successful U.S. EV made its debut around 1890
- EVs became popular in the early 1900s in urban areas
- 1908: the Model T is introduced at only $650; an EV sold for $1,750
- As petroleum became cheaper and the national road system improved, ICE dominated
- 1970s: fuel shortages create interest in EVs again
- 1990s: EPAct is passed with new requirements on emissions
- 1997: Toyota introduces the Prius hybrid
- 2006: Tesla begins producing all-electric sports cars



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Brief History of EV Batteries

Flooded lead acid batteries have been used in vehicles since the 1880s. They were not very good for the application as they were heavy and typically needed replacing every three years. Most early EVs used lead acid. EV1 began with a 16.5-18.7 kWh lead acid battery; later versions used a 26.4 kWh Nickel Metal Hydride (NiMH) battery, lead acid about 30-50 Wh/kg, and has a maintenance requirement.

Nickel Metal Hydride batteries offer low cost and long life. First gen batteries developed memory problems. Typically 70 to 80 Wh/kg for vehicle applications. Has a maintenance requirement. Used in hybrid vehicles, Prius, and first gen RAV 4 BEV.

Lithium Ion batteries are now the fastest growing battery system. Li-ion is used where high-energy density and lightweight are of prime importance. 100 to 265 Wh/kg, no maintenance requirement; lithium based batteries continue to improve. Examples include: lithium cobalt oxide, lithium manganese oxide, lithium iron phosphate, lithium nickel manganese cobalt oxide, and lithium titanate.

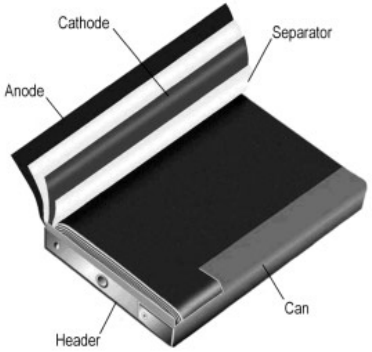
Lithium Batteries Lead the Pack

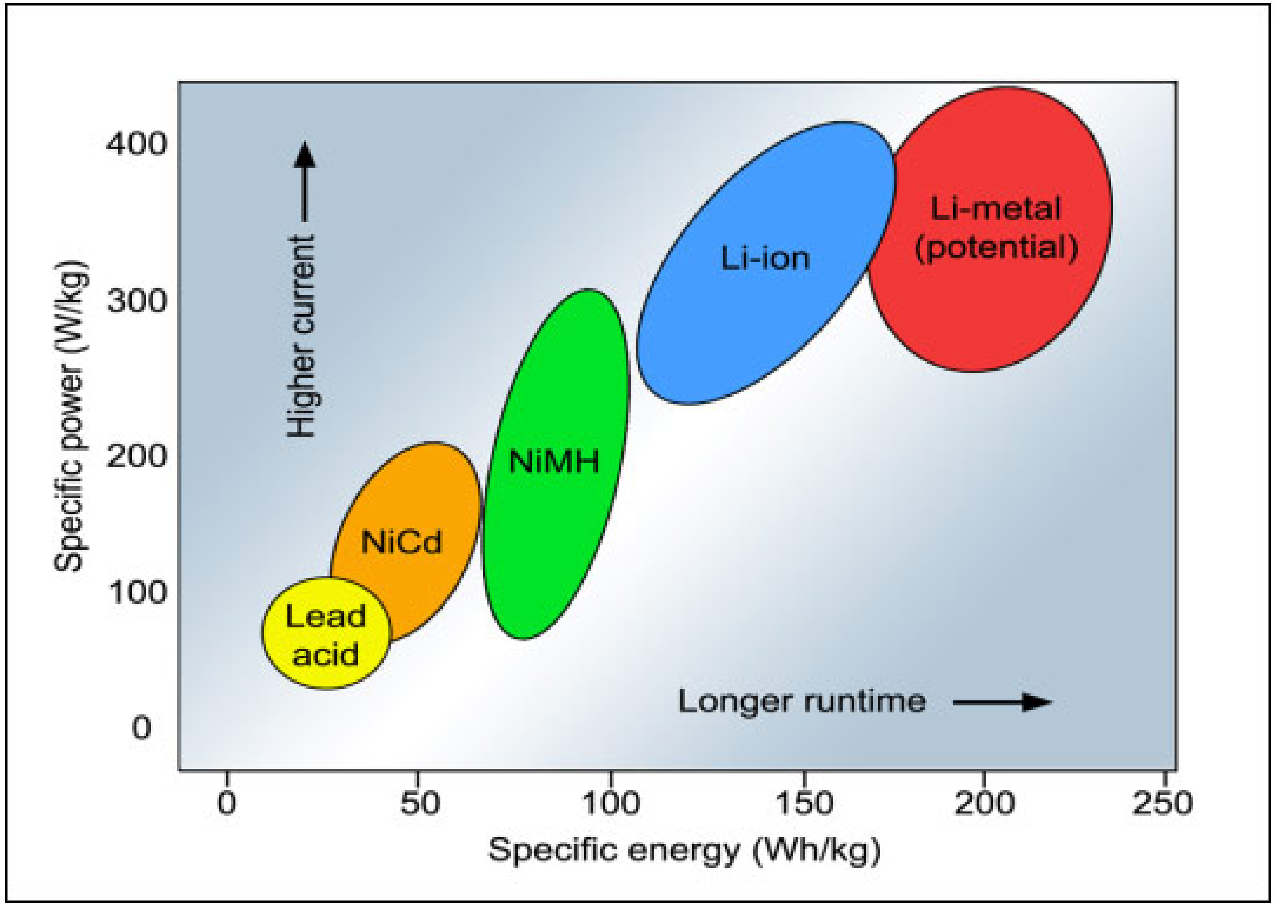
Button Cell

Cylindrical Cell

Pouch Cell

Prismatic Cell





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Battery Production Will Grow

- Increasing the scale in all aspects of battery production will drive down cost
- Electric cars and their motors require significantly fewer moving parts and less assembly work
- Battery production tends to be highly automated

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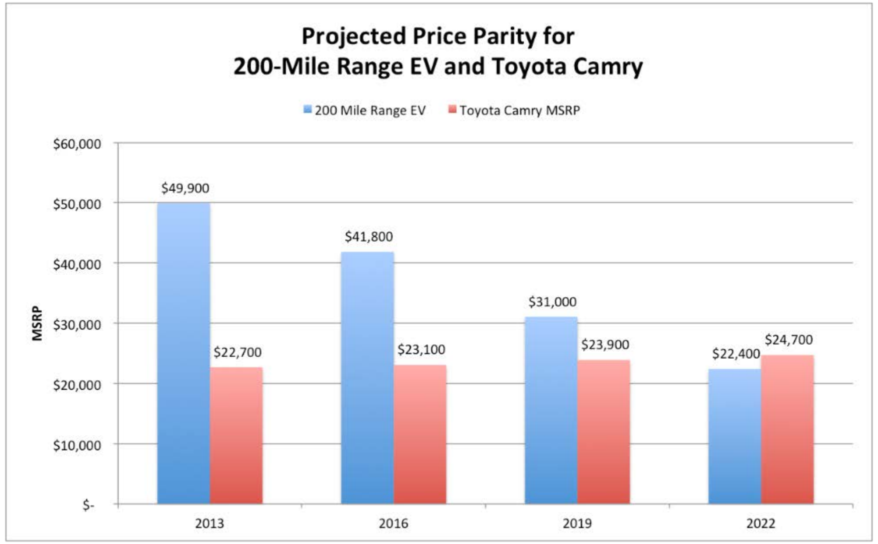
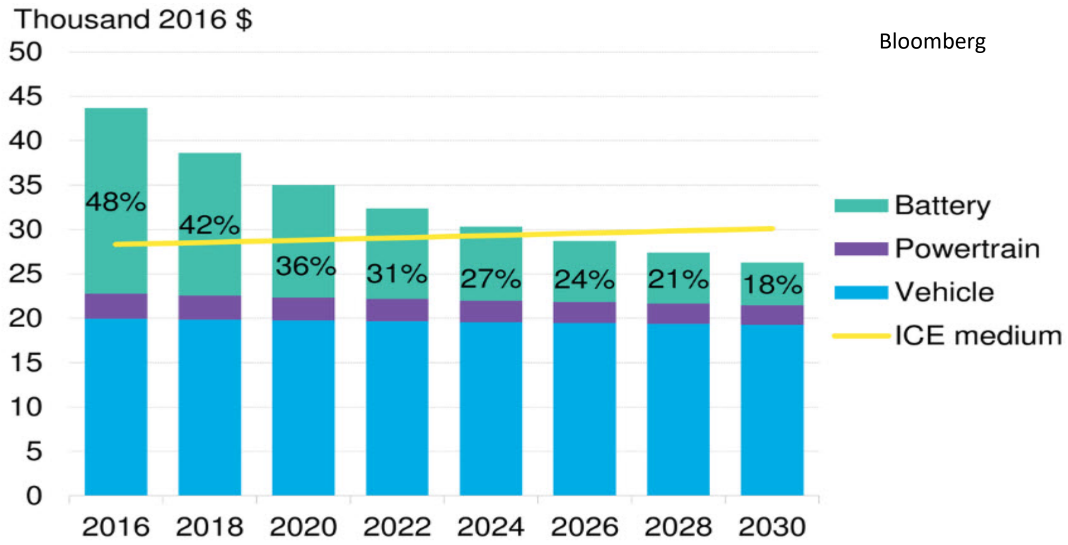
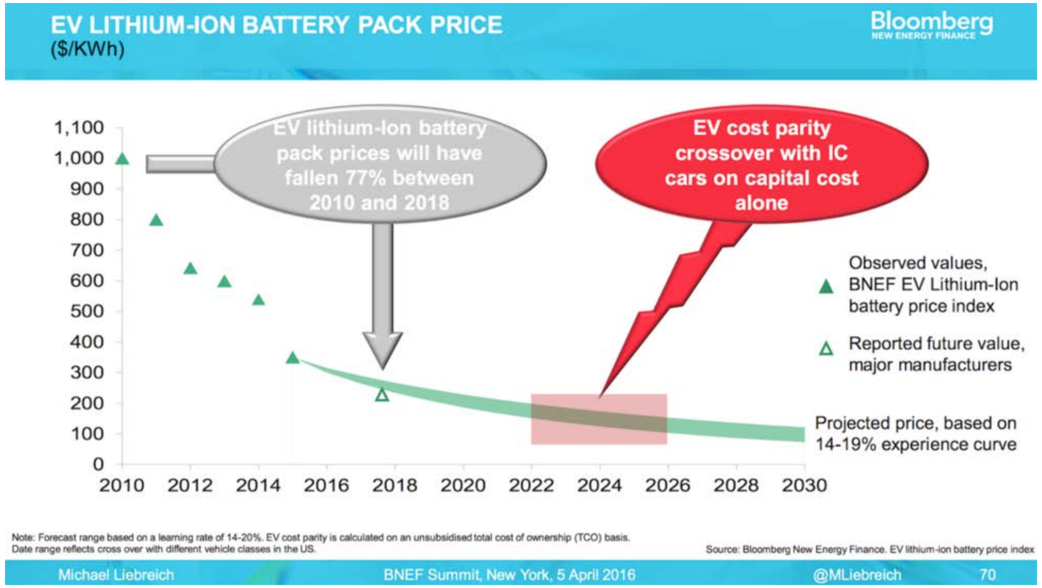
Barriers – High First Cost, Vehicle Purchase Price
Many Predictions for EV Cost Parity with ICEV



Source: NADA Guides, ARK Investment Management LLC



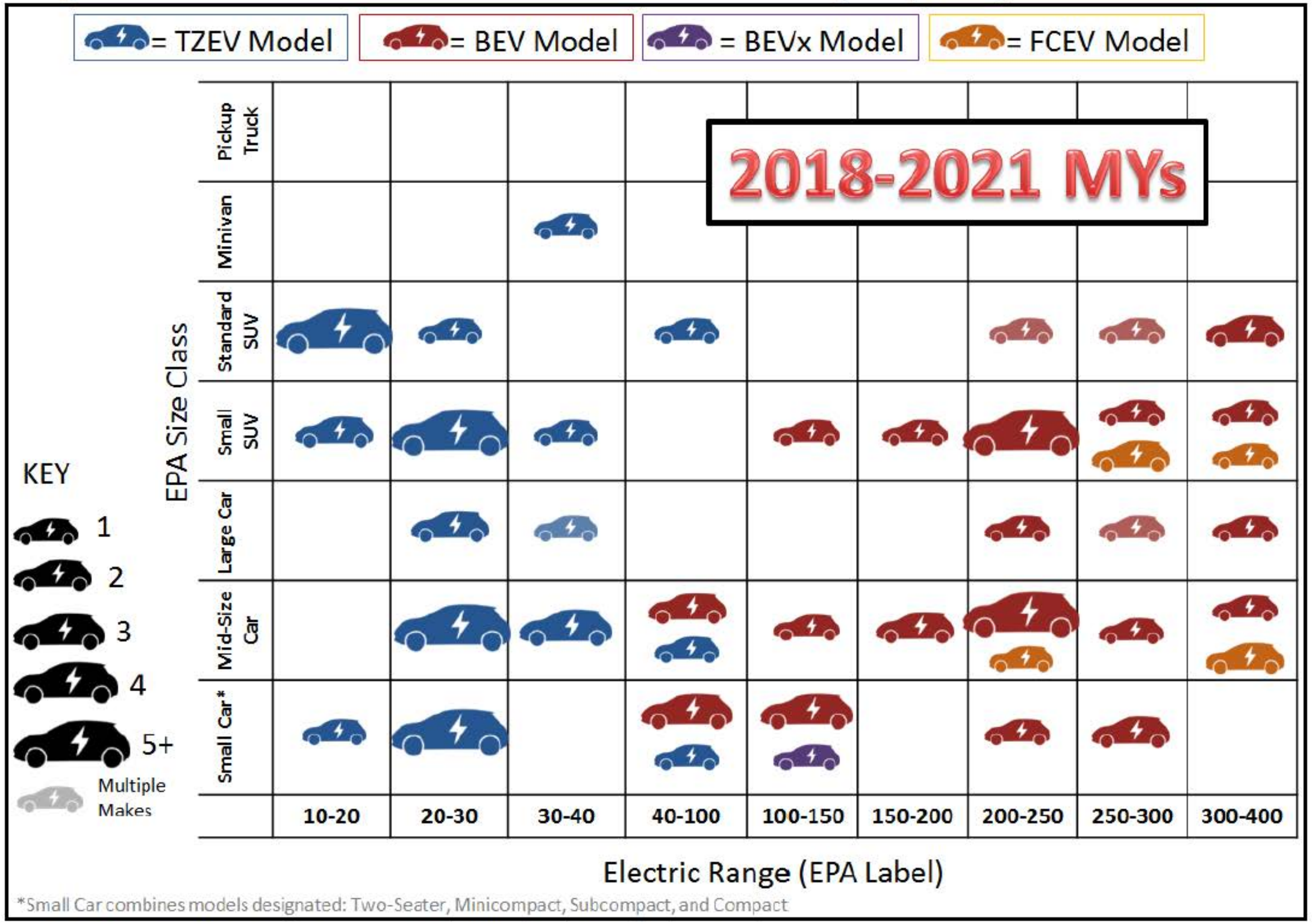


- Navigant Research forecasts cost competitiveness by 2025
- According to Goldman Sachs, battery cost and weight for EVs will decline by 63% and 52%, respectively, in the next five years, while capacity and range will improve by 50% and 72%.

Barriers – Popular Vehicle Types Are Unavailable in EV Platforms

The most popular vehicle models – pickups, SUVs, crossovers, and minivans – are not available or under represented in the plug-in format

Figure 15 - Future ZEV and PHEV model offerings by range and size class



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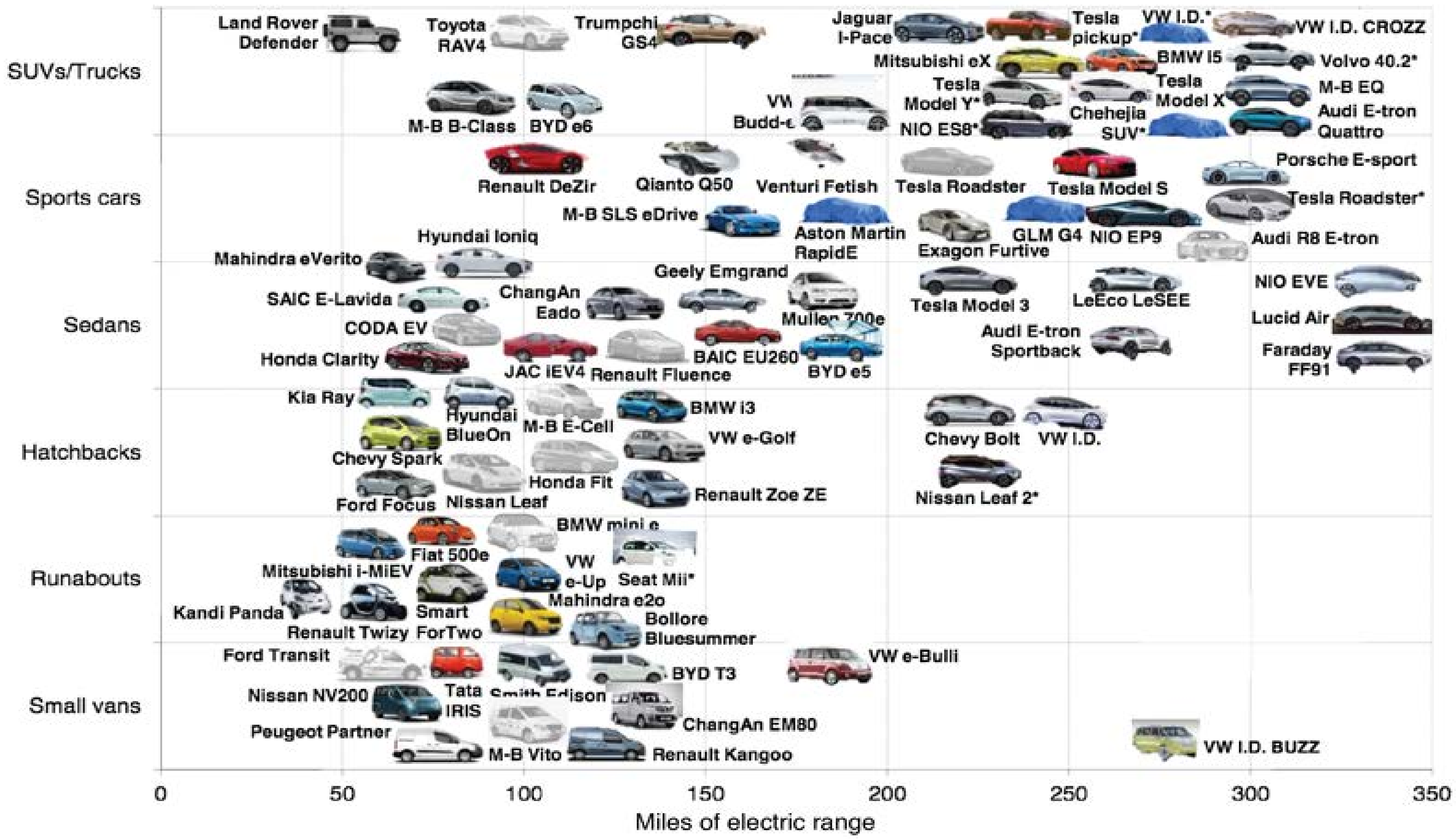
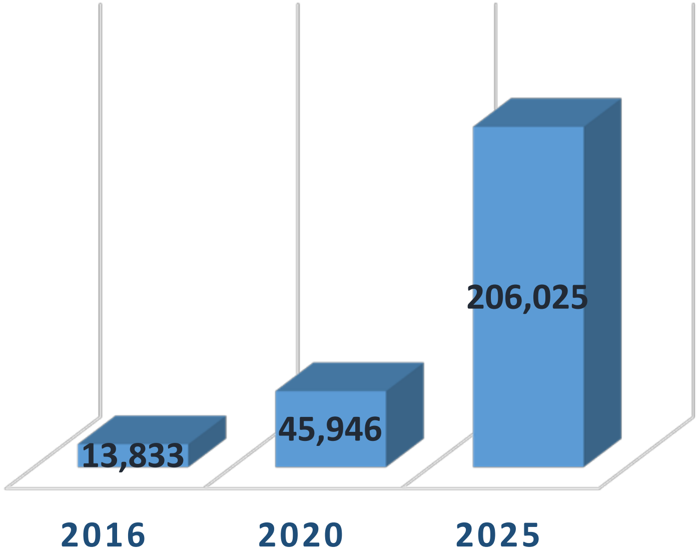
Electric Car Boom: Models by Style and Range Available Through 2020



Multiple Model Types Available at Cost Parity Will Increase EV Sales

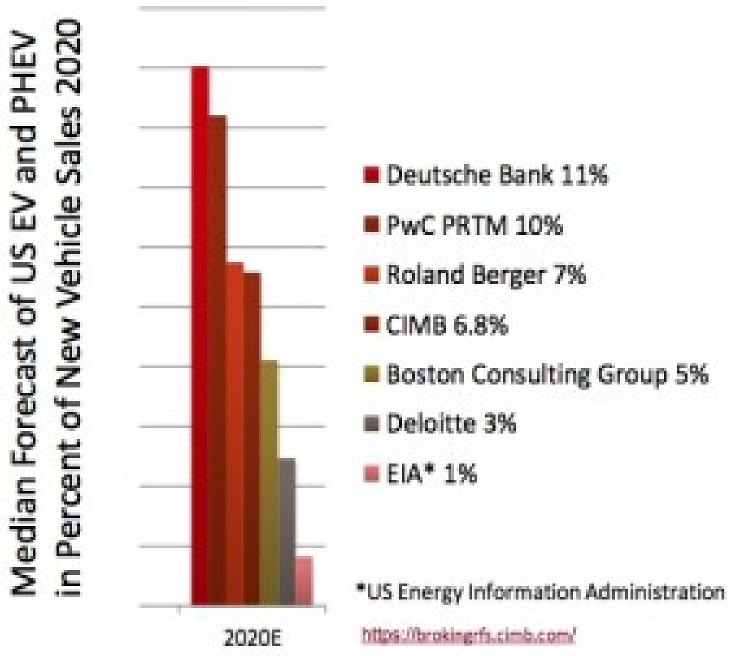
At Oregon's current adoption rate of 35% yr/yr



EVs as a percentage of car sales predicted to rise significantly

Expecting to reach 100M in new car sales by 2020

- weighted average of 8.2% penetration in 2020 for PHEV and EV
- 35% of all new car sales will be EVs by 2040 (Bloomberg)



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SYRAH RESOURCES

Federal Incentives

- Each automaker's eligible plug-in vehicles can a receive a credit of up to $7,500 until the 200,000th eligible vehicle is registered inside the U.S.
- At the time of the 200,000th sale, full credits continue for the remainder of that quarter and continue until the end of the next quarter
- Credit is then reduced to $3,750 for the next 6 months, then reduced again to $1,875 for the next 6 months before expiring completely

$7,500 Federal Credit (US) Phase-Out Estimates (data through 12/2016)

AUTOMAKER	Current	9M Change	FY-2017	Q1-18	Q2-18	Q3-18	Q4-18	Q1-19	Q2-19	Q3-19	Q4-19	Q1-20	Q2-20	Q3-20	Q4-20	Q1-21
General Motors	124,290	+24,031	180	195	7,500	7,500	3,750	3,750	1,875	1,875						
Nissan	103,597	+11,075	128	143	158	173	188	7,500	7,500	3,750	3,750	1,875	1,875			
Tesla*	110,849	+38,854	175	199	7,500	7,500	3,750	3,750	1,875	1,875						
Ford	84,681	+21,318	110	120	130	142	157	169	183	198	7,500	7,500	3,750	3,750	1,875	1,875
Toyota	47,248	+2,422	82	96	108	120	135	150	165	180	195	7,500	7,500	3,500	3,500	1,875
BMW	37,050	+14,446	72	84	96	111	126	141	156	171	186	7,500	7,500	3,500	3,500	1,875

-countdown phase -unlimited $7,500 credits -unlimited $3,750 credits -unlimited $1,875 credits -no credits available

Oregon Transportation Bill, EV Rebate Program at DEQ

- Up to $2,500 for an EV with >10kWh battery under $50,000
- Up to $1,500 for an EV with <10kWh battery under $50,000
- Oregon residents, plus companies and public entities, are eligible
- Motorcycles and low speed vehicles will be eligible in 2019
- Program funds from privilege tax on sales of vehicles, .5%
- Program to sunset December 31, 2023

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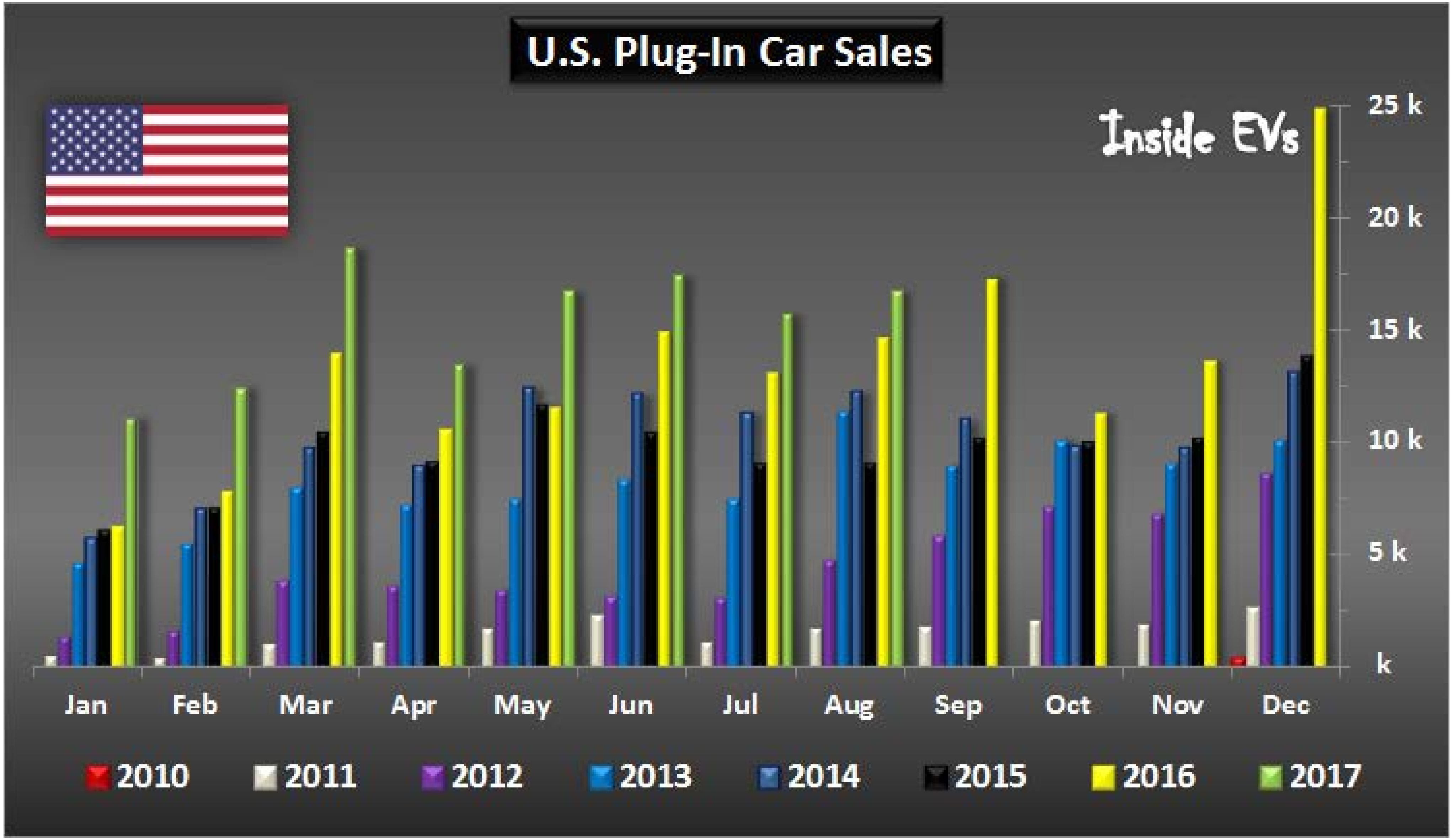
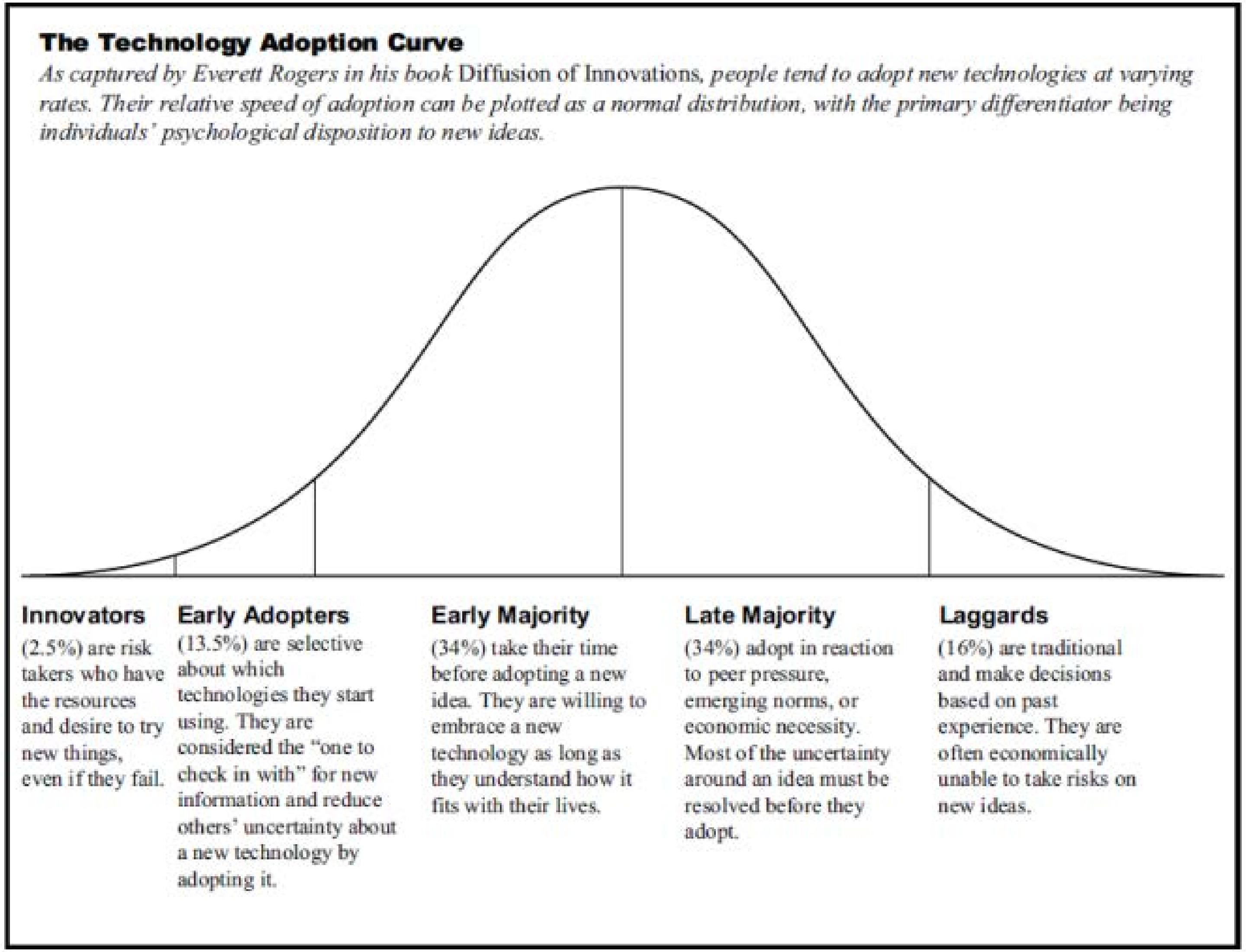
Where Are We Now: U.S.



Where Are We Now: Oregon

- 6/30/2017: Registered vehicles in Oregon included:
  - 9,529 BEVs
  - 6,414 PHEVs
  - Total of 15,943 plug-in vehicles

- 12/31/2016: 3,501,908 light-duty vehicles registered in Oregon – plug-in vehicles accounted for only .4 % of total vehicles in the state



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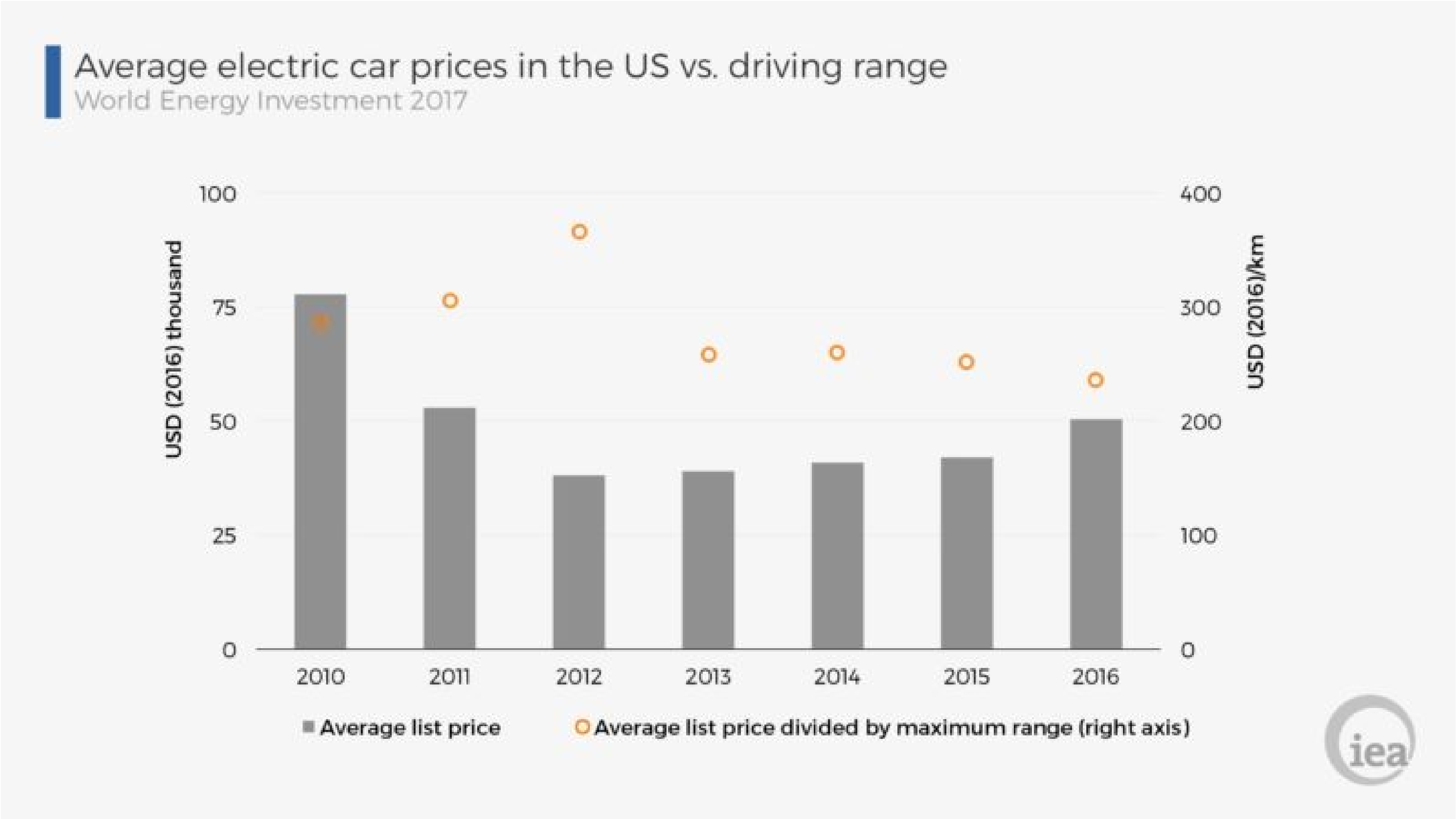
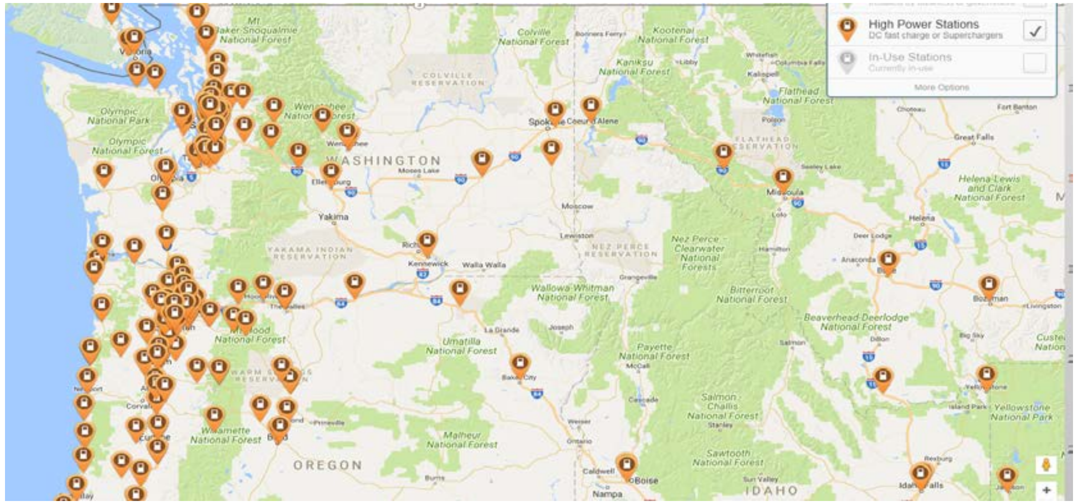
Cost per Mile of Range is Dropping



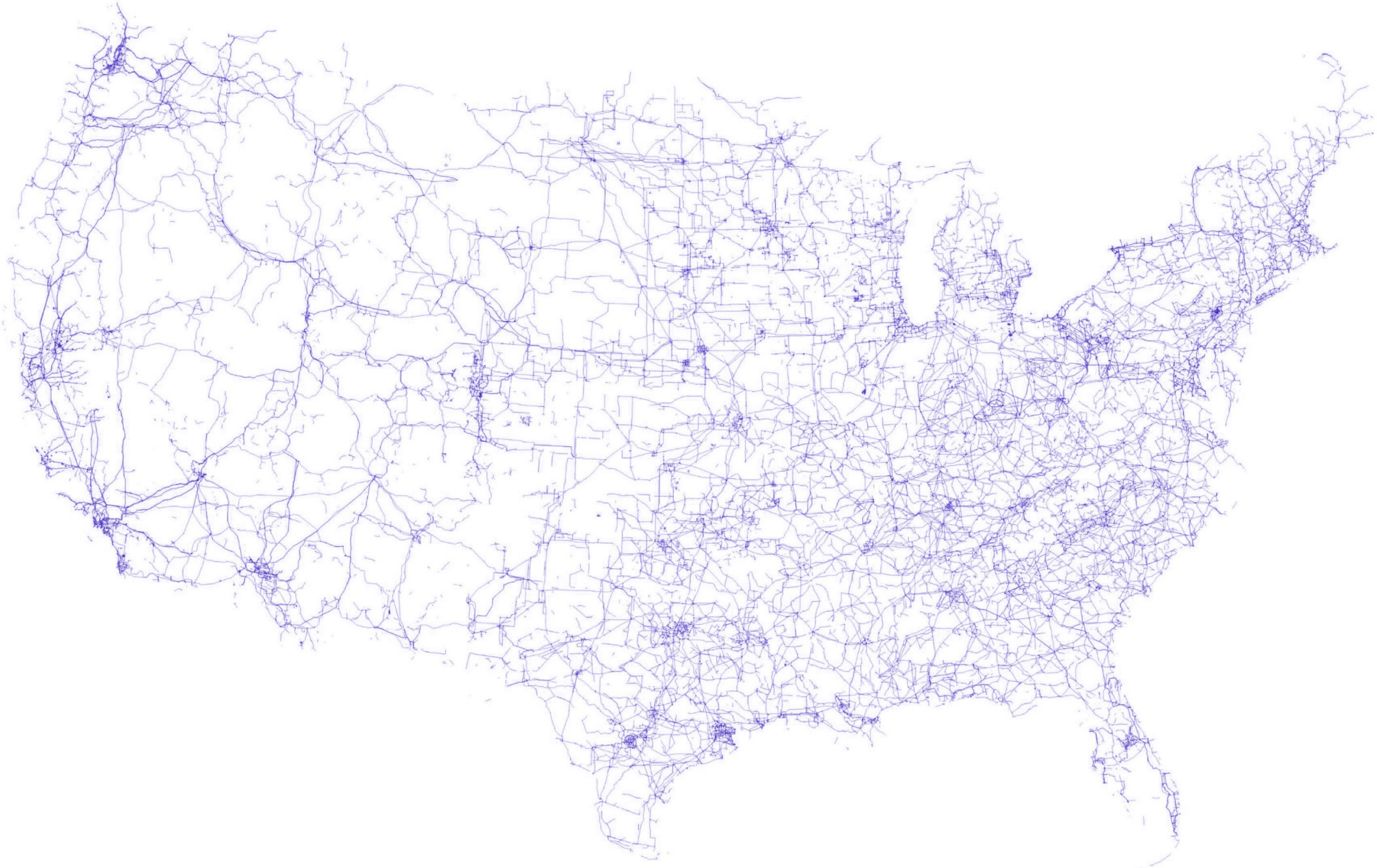
Charging Infrastructure

- Pacific Northwest is considered a leader in EV infrastructure
- As EVs evolve, so will the infrastructure: more of it and higher capacities
- Oregon currently has 1,248 public chargers in 488 locations
- 218 DCFC in 104 locations
- Seven networks operate in the state



DCFC Charging Infrastructure Map Plug-Share

Electric Grid



EV Infrastructure Will Get Faster, More Powerful

- As car batteries get larger, charging infrastructure will get more powerful, enabling more range per minute of charge
- Future charging locations will offer several chargers in a pod and variable or different charging power rates
- There will still be multiple standards for DCFC. However, most future charging locations will offer both the combo and CHAdeMO standards.

Miles per Charging Rate and Time

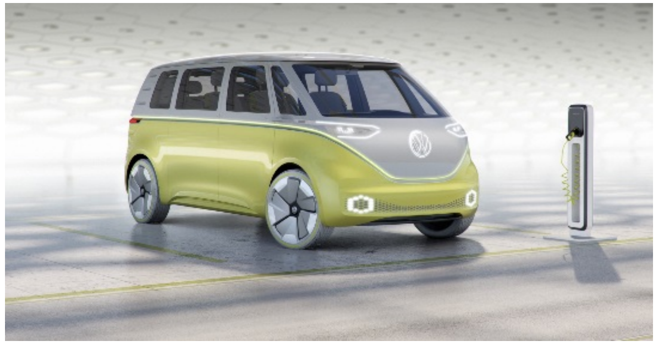
EV =	3.57	miles/kWh	
DCFC/kW	Miles per/min.	Miles per/15 min.	Miles per/30 min.
50	2.98	44.63	89.25
80	4.76	71.40	142.8
100	5.95	89.25	178.5
150	8.93	133.88	267.75
300	17.85	267.75	535.5
350	20.83	312.38	624.75

SAE Combo

CHAdeMO

VW Incentive Funds, Electrify America

- Over 10 years, VW will spend $2 billion on infrastructure – $800 million for California and $1.2 billion for the rest of the U.S.
- In the first 30 month cycle, VW has identified I-5 (10+) and I-84 (2-4) as part of a high-speed highway network
- Average station will charge five vehicles at once
- Stations will focus on 150 kW & 320 kW chargers that are 50 kW capable and support both DCFC standards
- Stations will be located about 66 miles but no more than 120 miles apart.



electrify america

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VW Incentive Funds, Electrify America

- City of Portland was chosen as one of 11 cities to get community based local network infrastructure
- Electrify America plans to invest about $40 million in local community based charging in the first 30 months, with 300+ stations
- Stations will run the gamut from level 2 to 350 kW DCFC

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Utility Programs Will Increase Infrastructure

- SB 1547 (2016) requires utilities to develop and implement transportation electrification programs
- PGE will develop & implement six pods of DCFCs in its service territory
- PacifiCorp plans to own and operate up to seven charging pods in its service territory

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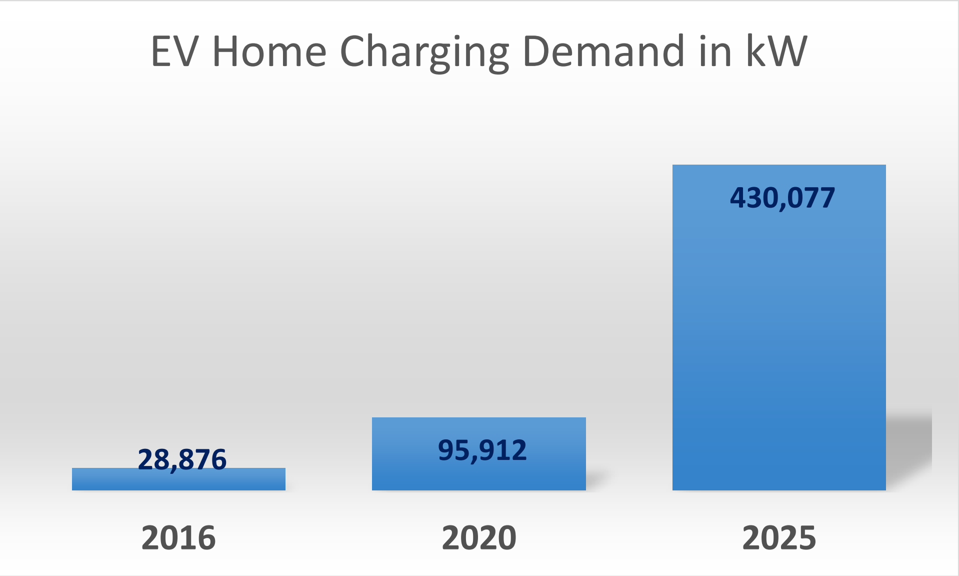
More Than 80% Charging Occurs at Home

- Home charging rates can be anywhere from 1.75kW to 19.7kW
- EV demand can ramp up quickly, and if not managed appropriately can occur during the Northwest’s traditional peak period

At 7PM, 50% of EVs are plugged-in at home

(INL data)

If 50% = 1.75kW & 50% = 6.6kW



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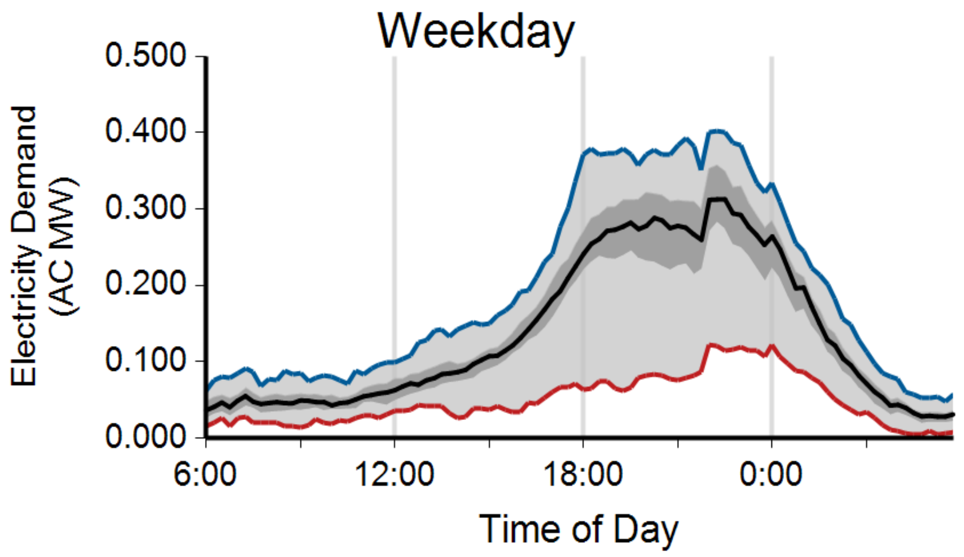
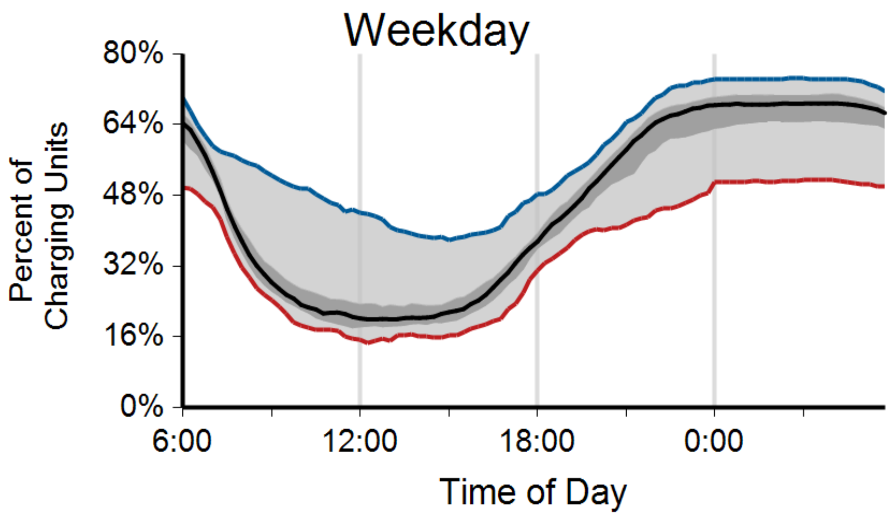
2013, 4th Quarter EV Project Oregon Data

Oregon Residential Charging Demand versus Time of Day



Range of Percent of Oregon Residential Charging Units with a Vehicle Connected versus Time of Day



Most charging happens at home beginning at 6 PM until about 11 PM. Nearly 80 percent of vehicles are plugged-in from 6 PM until 6 AM. Much of the charging occurs during the recognized Northwest peak time of 4 PM to 8 PM.

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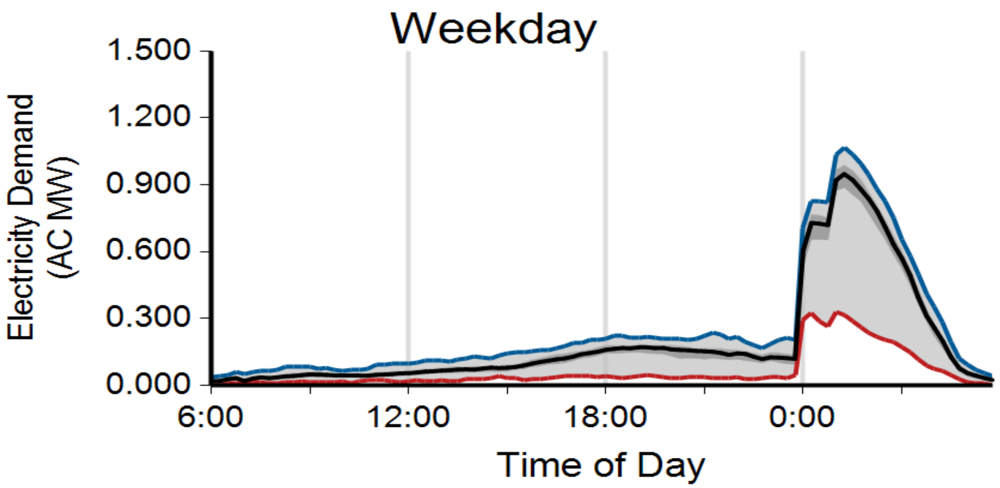
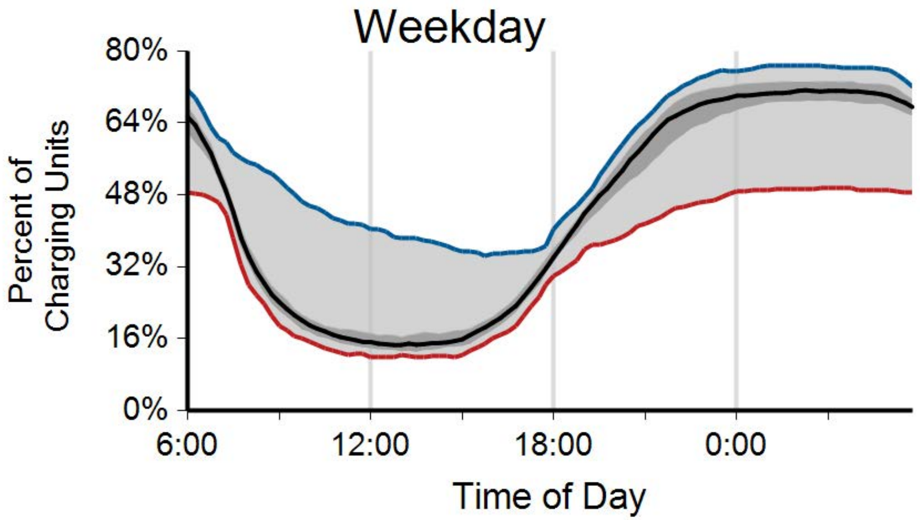
2013, 4th Quarter EV Project San Diego Data

San Diego Residential Charging Demand versus Time of Day



Range of Percent of San Diego Residential Charging Units with a Vehicle Connected versus Time of Day



The percent of time that the vehicle is plugged in versus time of day is very similar to Oregon. However, the charging demand versus time is very different due to SDG&E's rate structures encouraging TOU.

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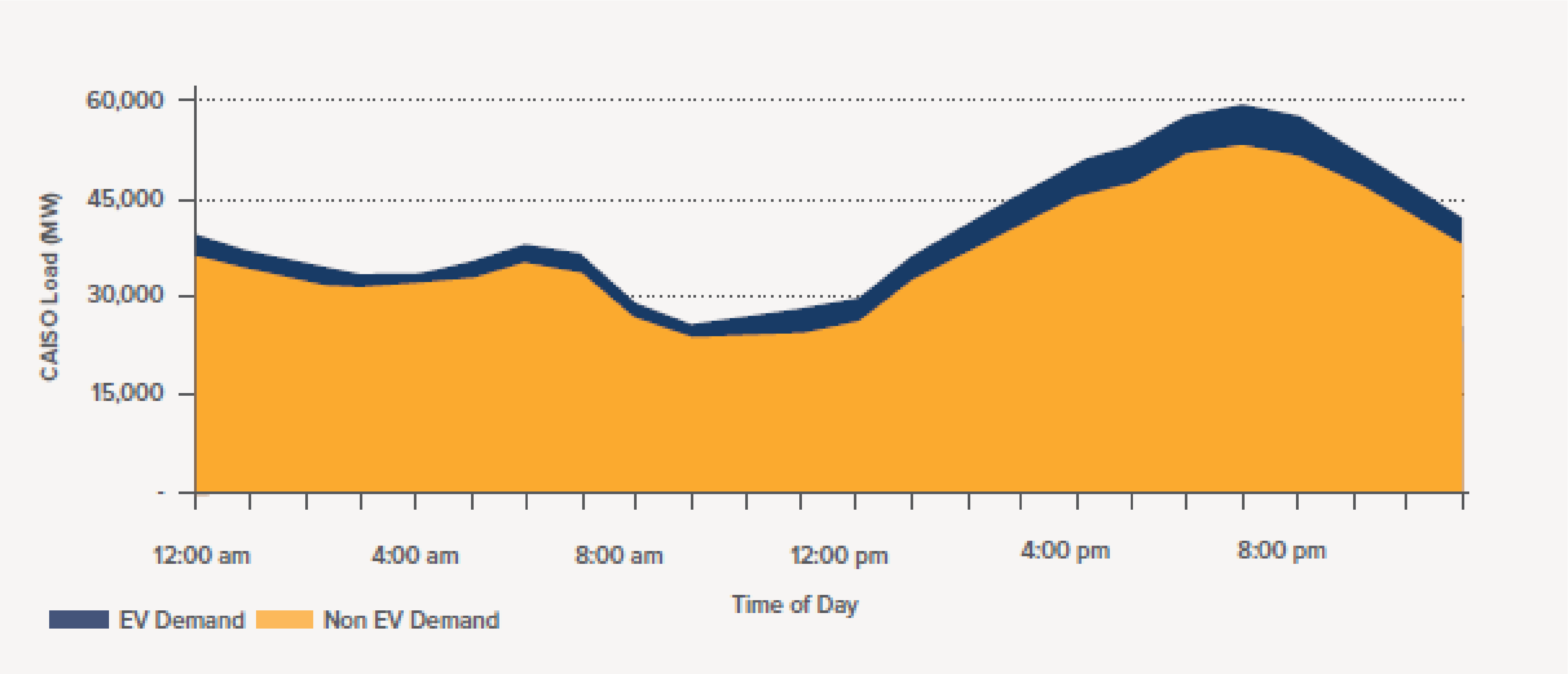
Projected California Uncontrolled EV Demand

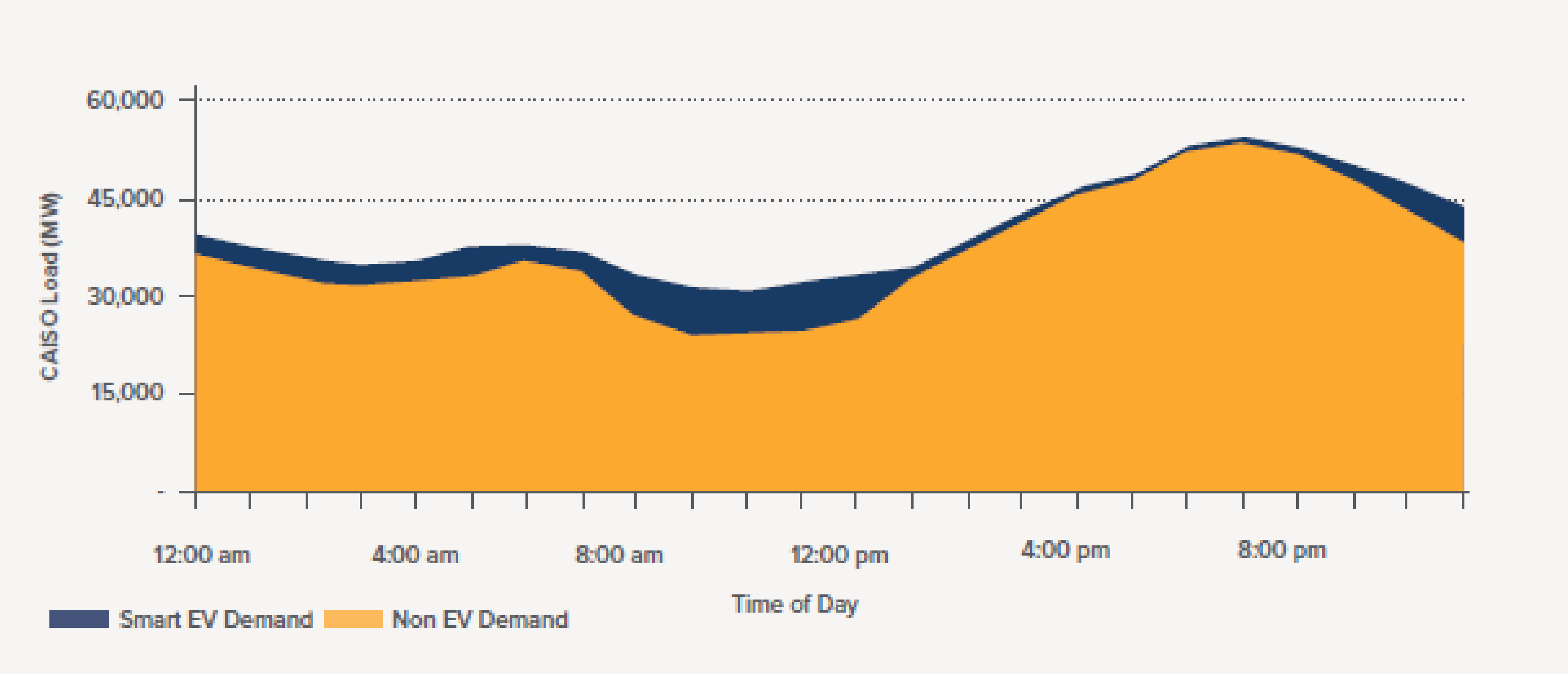
FIGURE 10: PROJECTED CAISO DEMAND WITH 23% EV PENETRATION AND 2031 RE PENETRATION GOALS WITH UNCONTROLLED EV CHARGING



Source: RMI

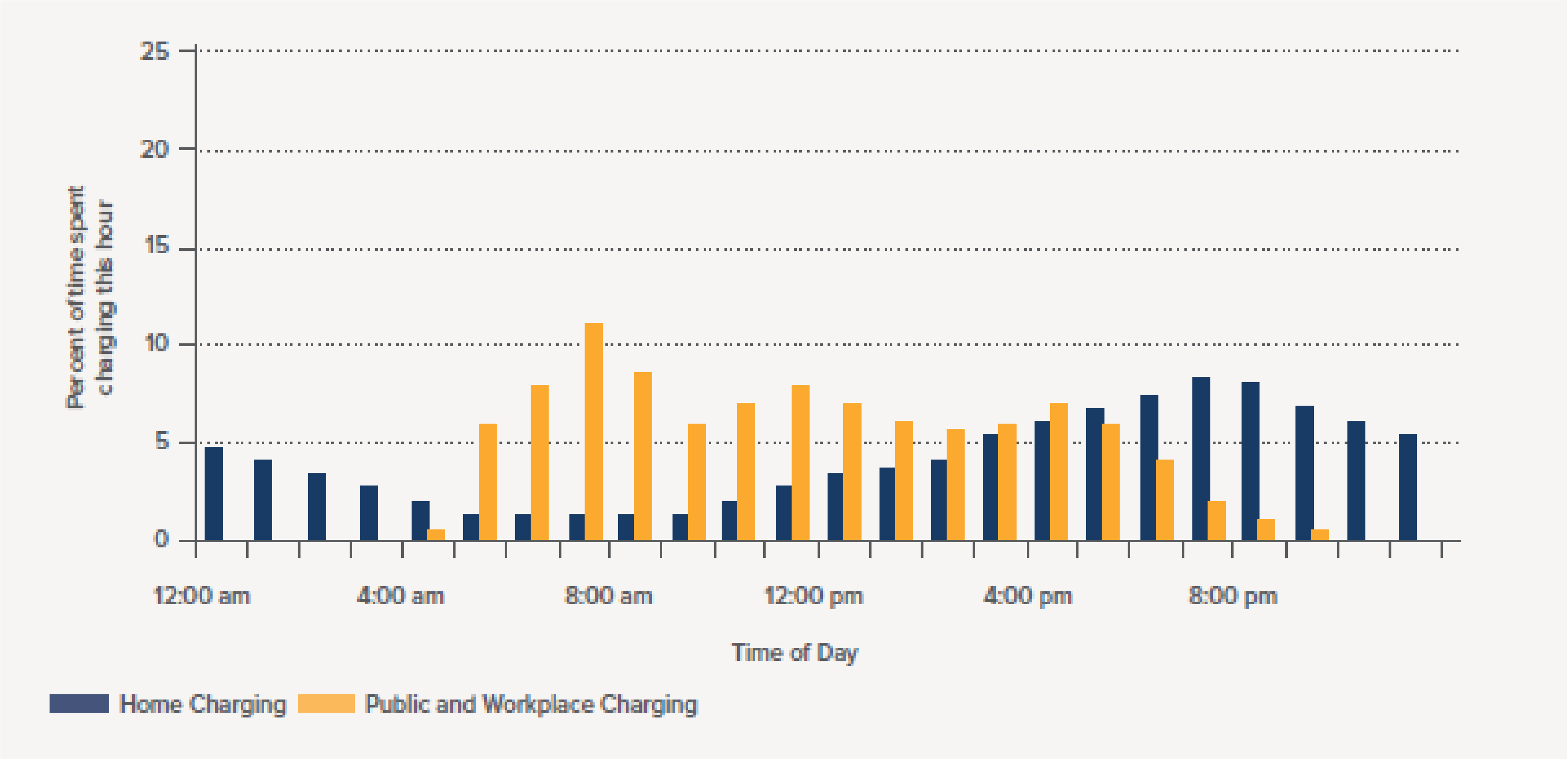
California Optimized EV Charging

FIGURE 11: CAISO DEMAND WITH 23% EV PENETRATION AND OPTIMIZED CHARGING



Source: RMI

Uncontrolled, Aggregate EV Charging Load



Source: RMI

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Smart Charging Benefits

- The ability to flexibly manage charging while still meeting customer requirements can provide a new kind of distributed resource
- Once the utility is in the house managing EV demand, the next steps to managing other sources of demand – such as water heaters, HVAC and refrigerator/freezers – will be easier
- New communications and control technologies, together with innovative tariffs and incentive structures, enable utilities to tap the potential of smart electric-vehicle charging to benefit the grid, utility customers, and the utilities' bottom line
- The Clean Fuels Program offers a unique opportunity to provide participants incentives for chargers and management of the chargers

Questions?

PHEV Expected to be the Most Popular Platform

Figure 9 - Expected ZEV and PHEV models by model year