EVs and Charging Stations

Innovation for Our Energy Future

Ted Sears, NREL

November 15, 2017

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Myths and Realities of Electric Vehicles (EVs)

Myths

1. EVs are too expensive
2. EVs won't perform
3. EVs have a "long tailpipe"
4. Charging infrastructure must be built before people will adopt EVs
5. Electric cars will put excessive strain on the electrical grid

Realities

1. EV prices are falling
   - Battery costs ⬇, models⬆, incentives help
   - Consumers avoid price volatility of gasoline
2. New models have greater mileage range on a single charge; no torque curve means smooth, quick acceleration; no cold or durability issues
3. EVs more efficient, such that even when electricity source is non-renewable, emissions are lower
4. EV charging is becoming more available and affordable, and owners can charge on 110-V overnight
5. Managed charging can provide demand response, and V2G can offer frequency regulation, spinning reserves, and grid backup; DCFC may present other issues

What Are Automakers' Plans for Vehicle Electrification?

Aston Martin to electrify its entire lineup by 2025.

Mercedes to offer an electrified version of every model by 2022.

Porsche to release an electric vehicle by 2020.

BMW to introduce 25 electrified models by 2025, including 12 all-electric cars.

13 hybrid, plug-in hybrid, and all-electric Ford models in the pipeline.

Daimler to electrify some, not all, commercial vehicles.

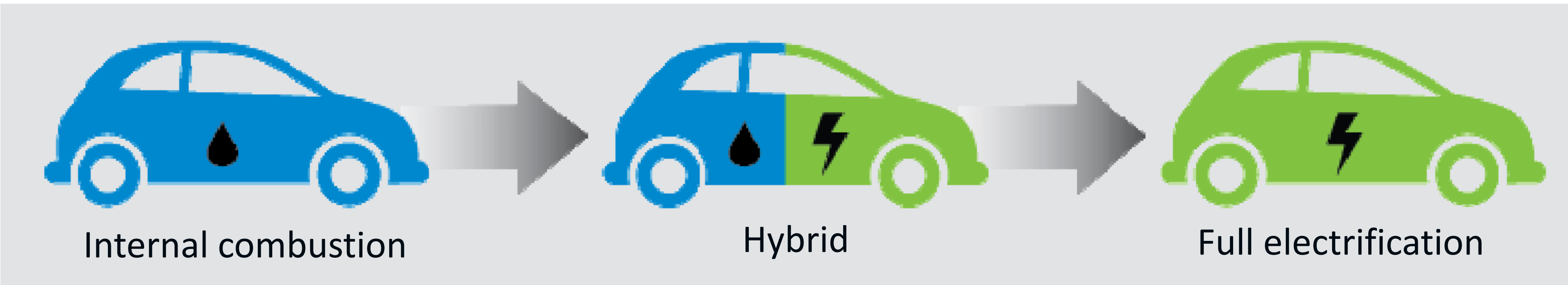
Hyundai/Kia to add 31 new all-electric and hybrid models by 2020.

Every new Jaguar to feature hybrid, plug-in hybrid, or all-electric powertrains by 2020.

Electrified models to make up two-thirds of Honda global sales by 2030.

Smart to go completely electric in 2018.

Peugeot, Citroën & DS partnership to produce 7 plug-in hybrids and 4 electric vehicles.



Toyota to launch a mass-market electric car by 2020, while continuing to sell its Prius plug-in hybrid.

Subaru to offer first plug-in hybrid in 2019, followed by all-electric versions of existing models.

Every new Volvo to have hybrid, plug-in hybrid, or all-electric powertrain by 2019.

VW/Audi to offer a hybrid or all-electric of every model by 2030.

SAAB/National Electric Vehicle Sweden (NEVS) to begin electric vehicle production in China.

GM to launch 20 new all-electric vehicles by 2023.

Renault, Nissan & Mitsubishi to launch 12 new all-electric vehicles by 2022.

Expected EV Growth

37%

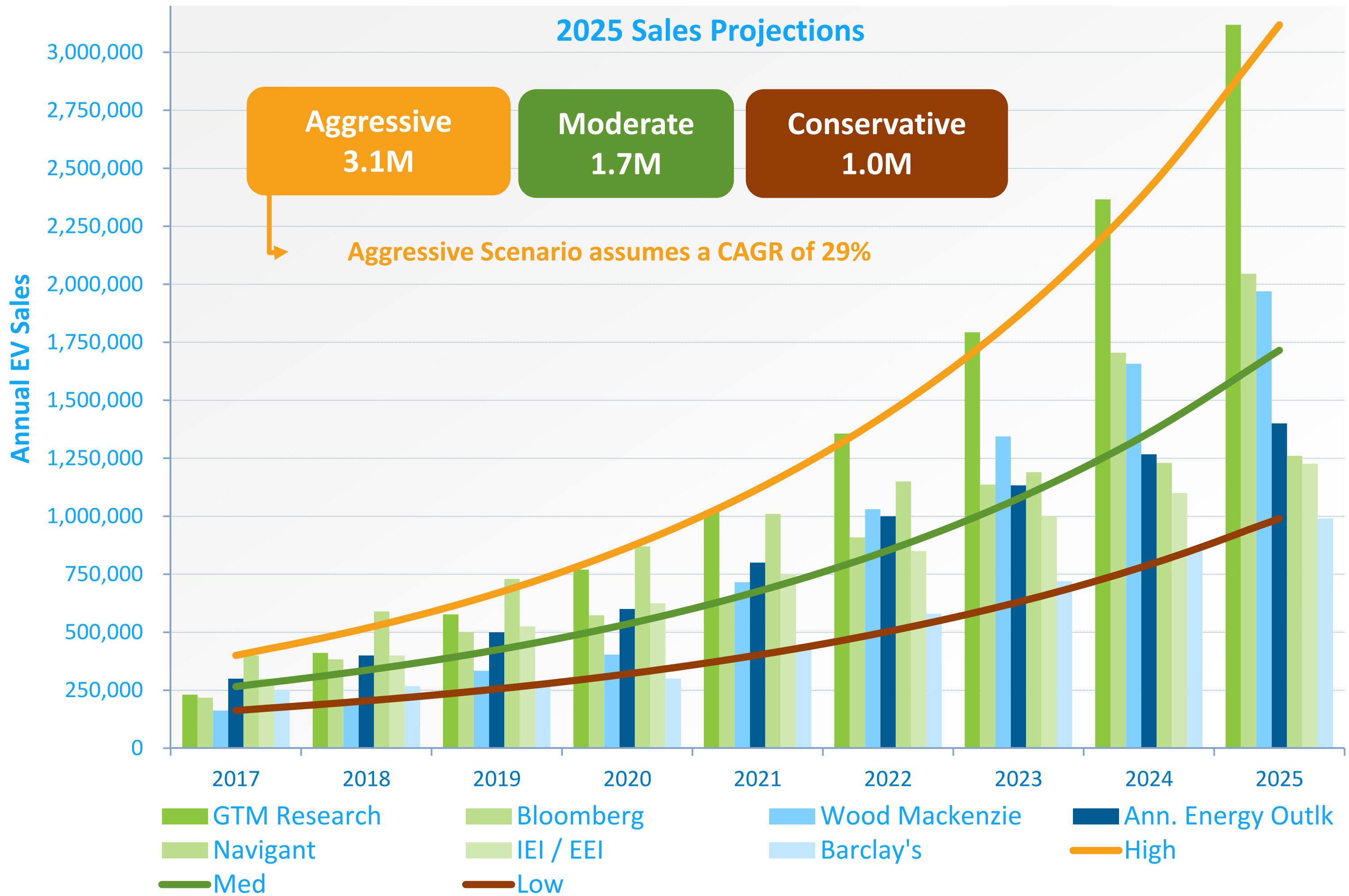
Year-over-year national sales growth of EVs in 2016

Source: Insideevs.com

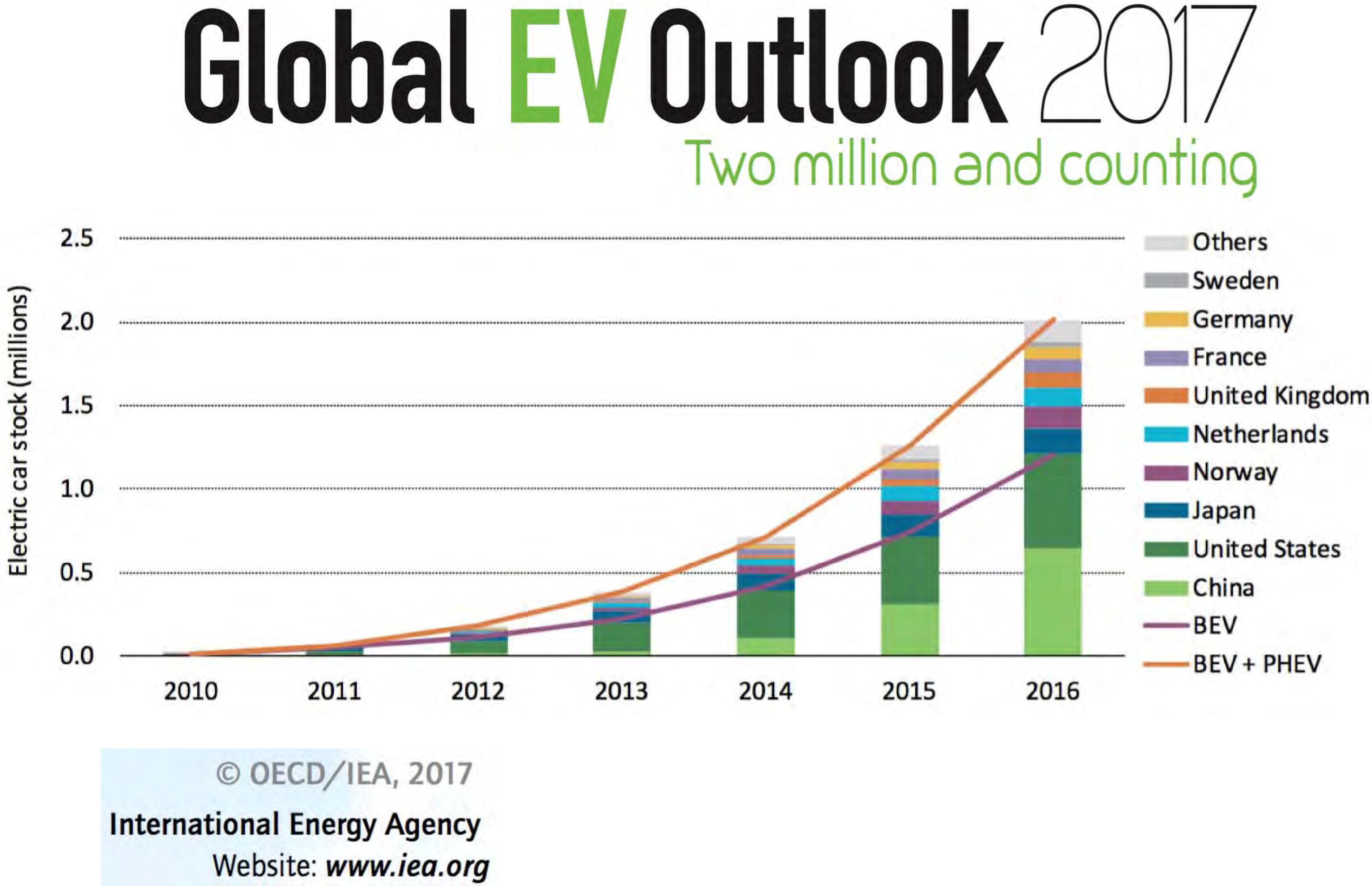
62%

Year-over-year national EV sales growth in 2017

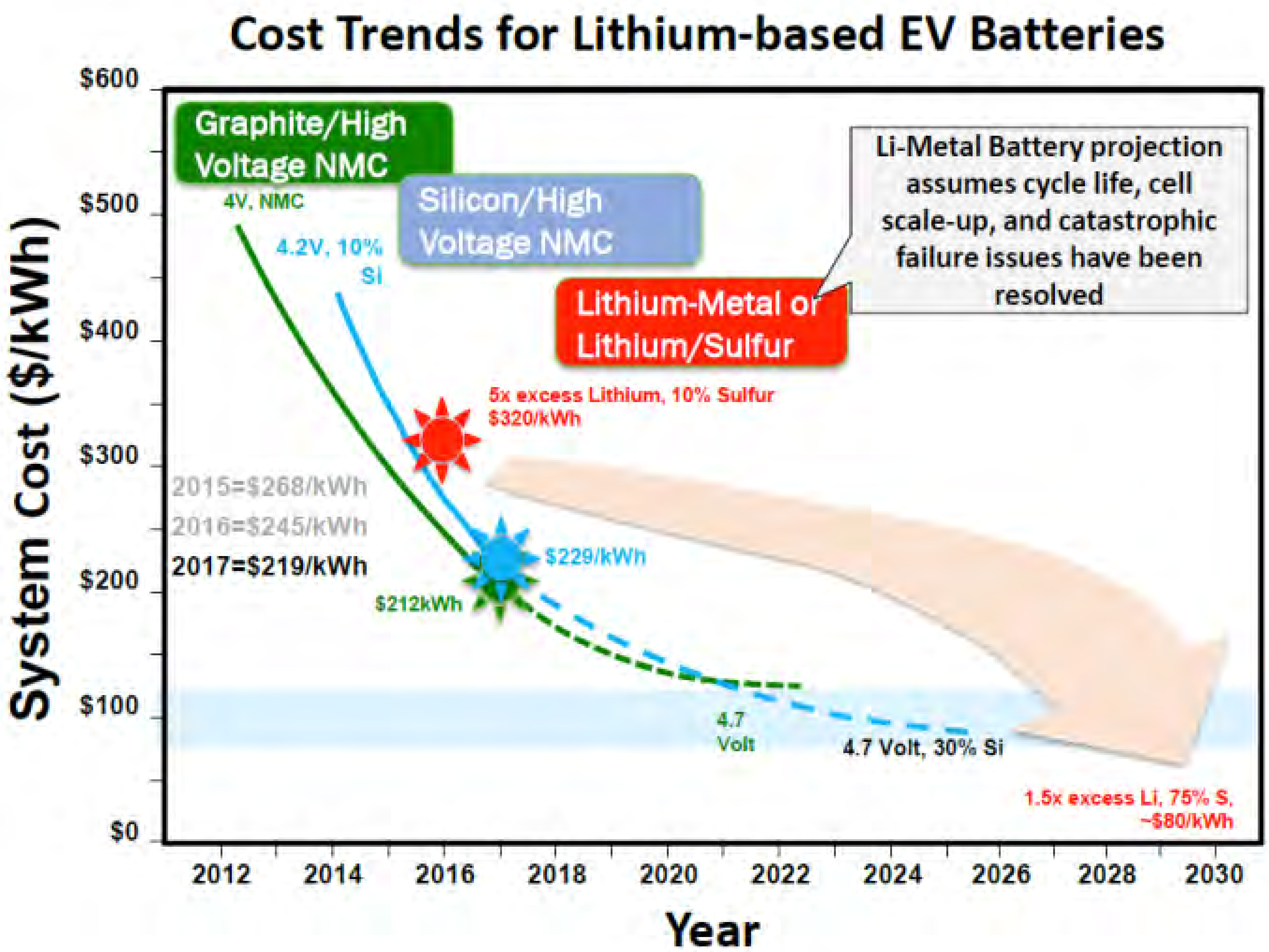
Source: Insideevs.com



Sources embedded in chart above


Global EV Outlook 2017
Two million and counting
2.5
2.0
1.5
1.0
0.5
0.0
Electric car stock (millions)
2010
2011
2012
2013
2014
2015
2016
Others
Sweden
Germany
France
United Kingdom
Netherlands
Norway
Japan
United States
China
BEV
BEV + PHEV
© OECD/IEA, 2017
International Energy Agency
Website: www.iea.org

Batteries and Electrification



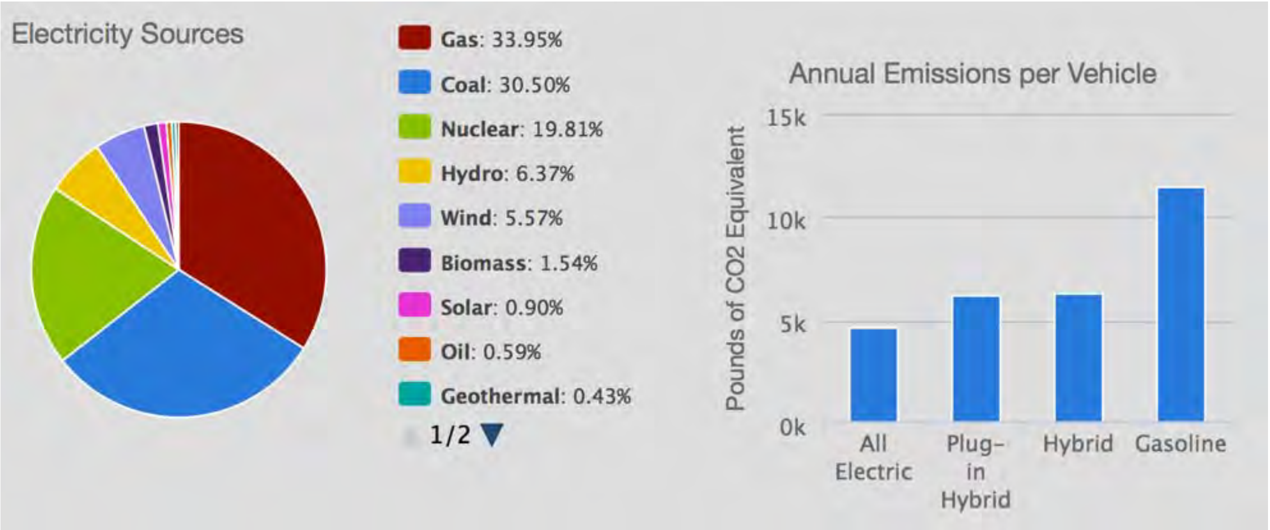
Environmental Impacts

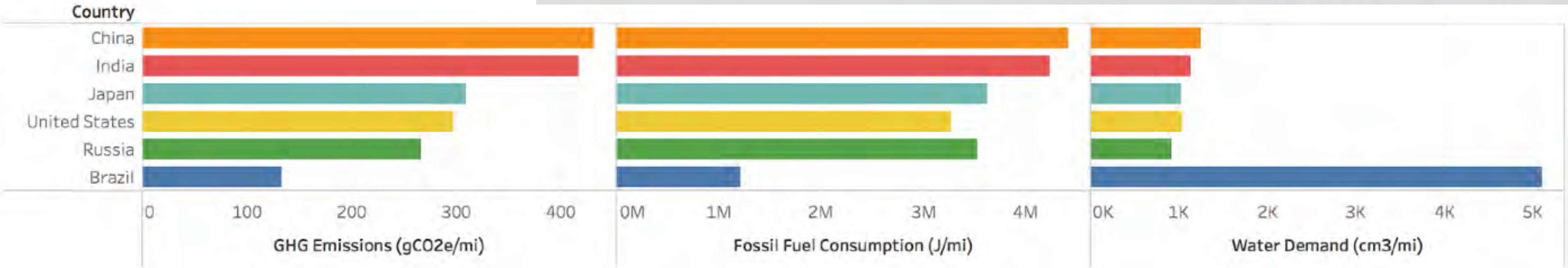
Well to Wheel Emissions

- No tailpipe emissions
- Lifecycle emissions are heavily dependent on fuel source
- Far more efficient than internal combustion engines

www.afdc.energy.gov/vehicles/electric_emissions.php

Figure created using World Energy Outlook 2013 Data and GREET Model

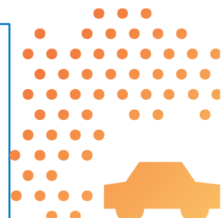




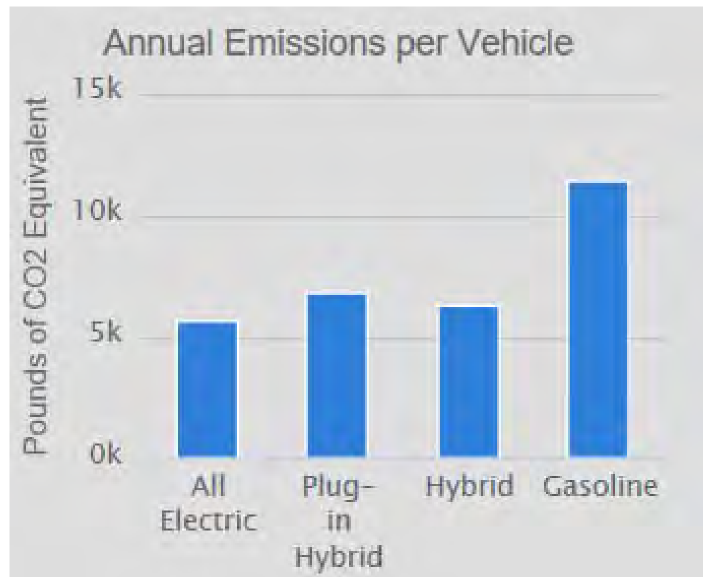
Environmental Impacts (cont'd)

An EV is responsible for just half the annual carbon emissions of a gasoline vehicle

9,276



less pounds of carbon dioxide emissions compared to a similar gasoline vehicle



Climate Action in Delaware: 2016 Progress Report

EVSE – Charging Infrastructure

Combination of fast charge batteries and a network of high capacity chargers can minimize range anxiety, promote the market penetration of BEVs, and increase total electric miles driven.

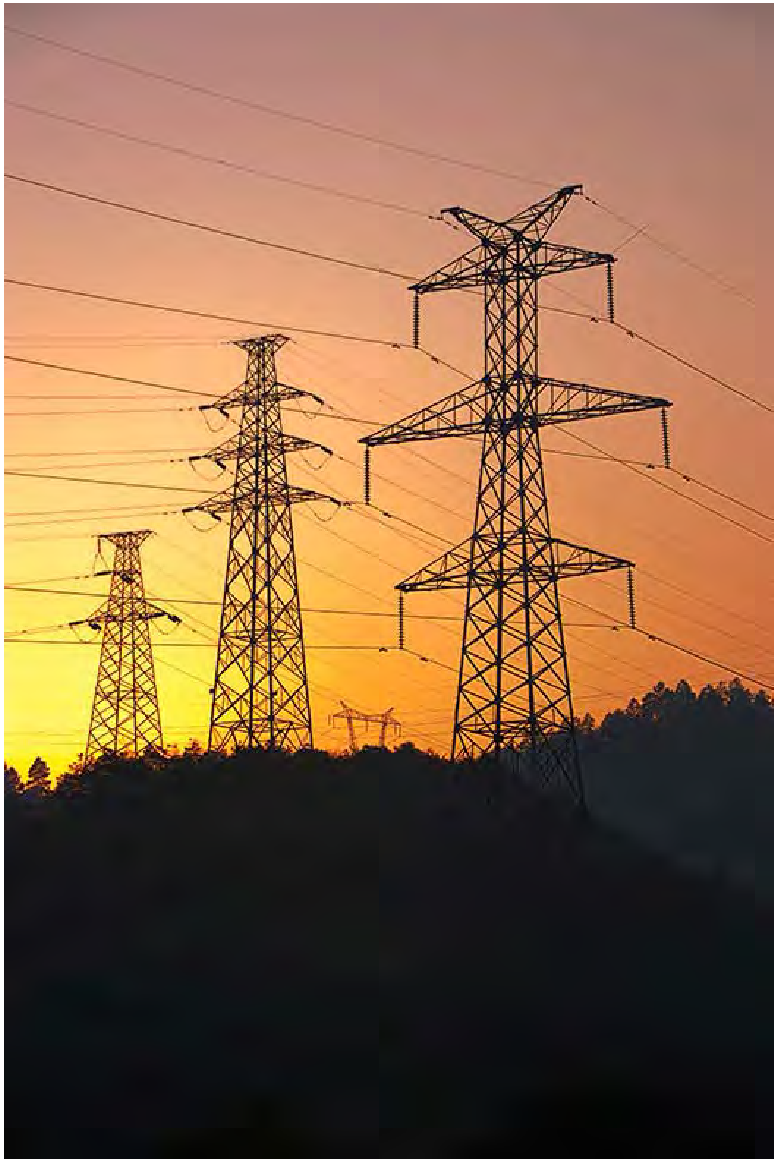
Type of Charging Station	**Level 2 220V (~7.2kW)**	**DC Fast Charger (50kW)**	**Tesla Super Charger (140 kW)**	**Extreme Fast-Charging (350kW)**
Time to charge (for 200 miles)	8 hours	2 hours	25 mins	10-15 mins
Charging Device				(TBD)

Source: Alternative Fuels Data Center afdc.energy.gov; 2015 NACS Retail Fuels Report, http://www.nacsonline.com/YourBusiness/FuelsReports/2015/Documents/2015-NACS-Fuels-Report_full.pdf;

Utility Implications of High PEV Penetration

Utility Stresses

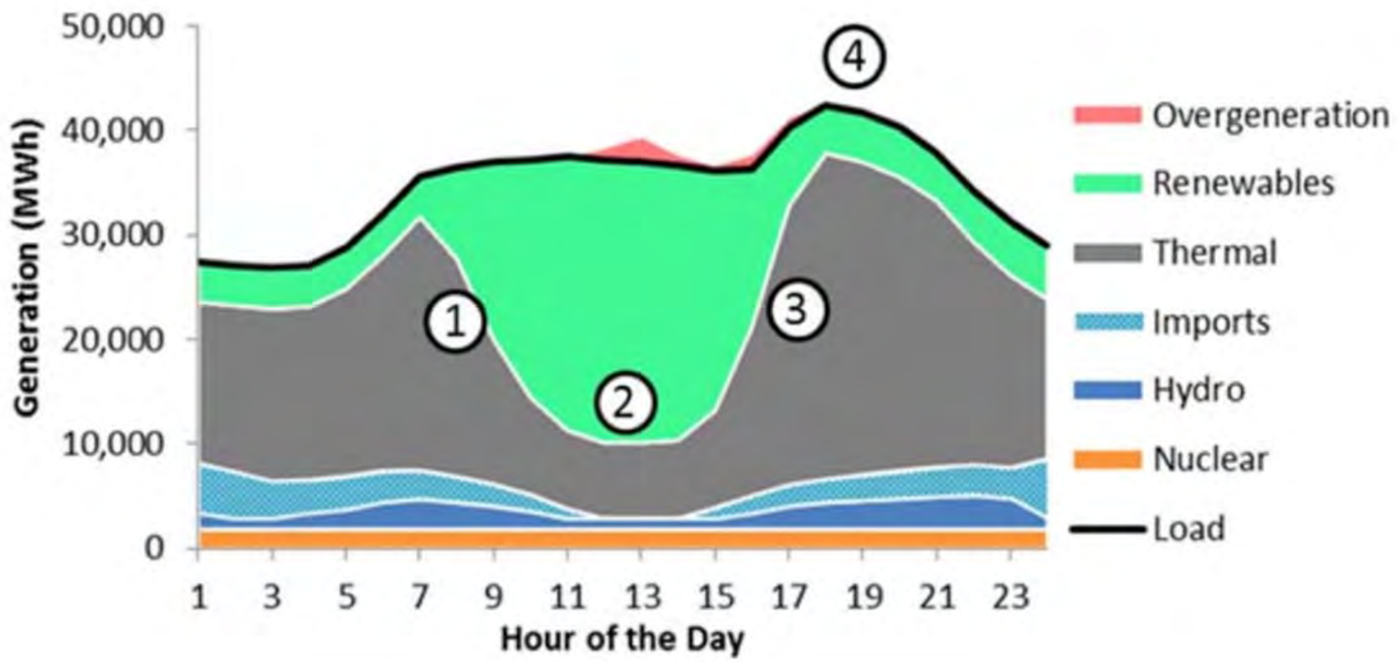
- DC Fast Chargers presently can use up to 145 kW for passenger cars or 500kW for transit buses
- Banks of Level 2 EVSE can raise facility demand by hundreds of kW
- PEVs could represent a 16% increase to California's peak summer demand by 2025
- Controlled charging could avoid peak time charging almost completely AND align with intermittent renewable generation
- V2G could shave peak demand



Transmission Grid and Renewables

Transmission Grid Issues

- Individual's charging times aggregated affects overall load
- Intermittent renewable generation (particularly solar) can stress the grid
- EVSE can act as demand response (and even storage)



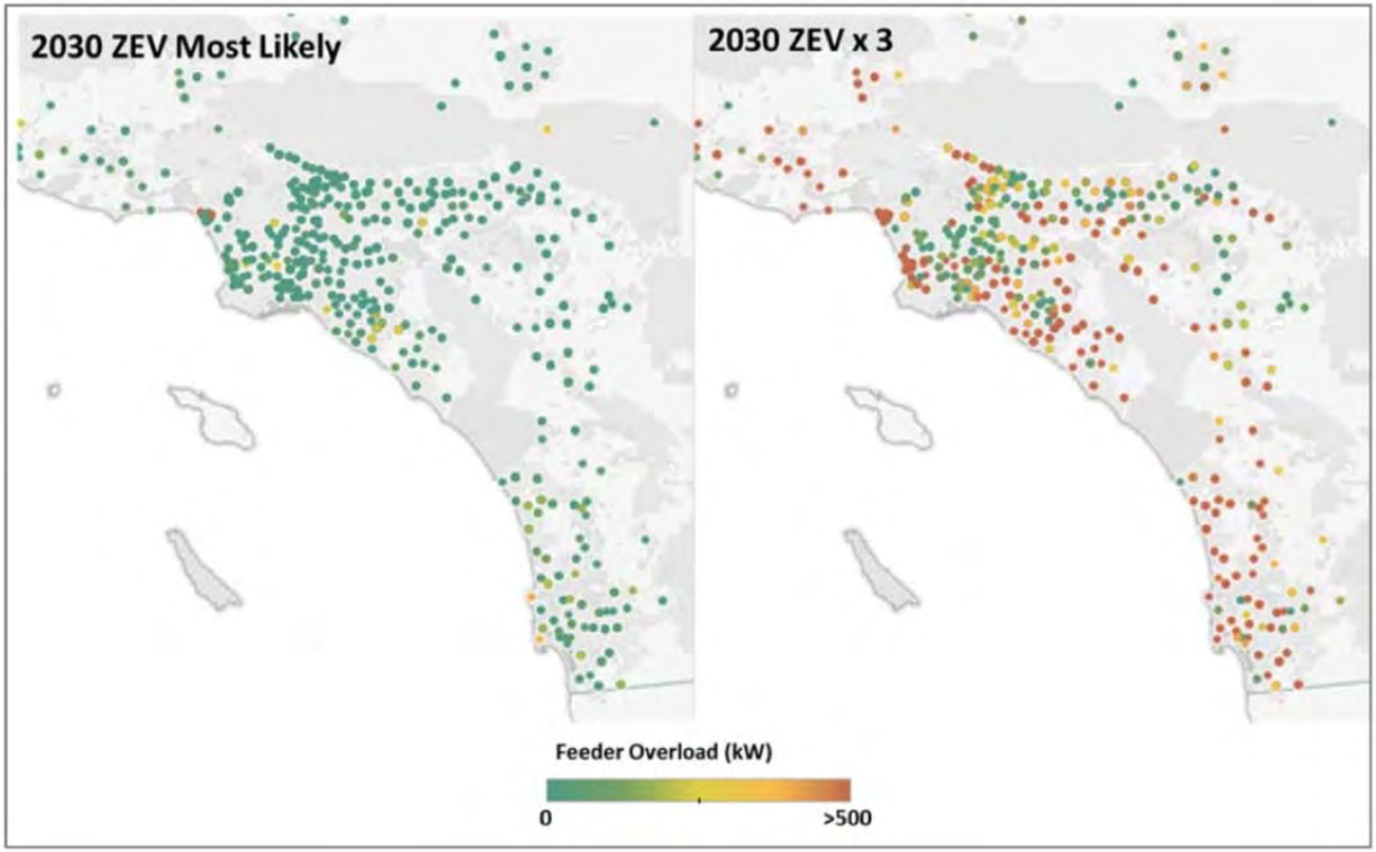
California Electric Transportation Association

Distribution Grid

Distribution Grid Issues

- System upgrades
- Distributed generation interaction
- Demand management

2030 Distribution System Upgrades Driven by PEV Charging: Los Angeles Area



California Transportation Electrification Assessment Phase 2: Grid Impacts

Utility Rates

Demand Charges

- Can exceed 90% of total cost for charging with underutilized DC fast chargers or poorly managed banks of Level 2 EVSE

Time of Use Rates

- PEV charging can shift to off-peak hours in most cases
- May result in response peaks

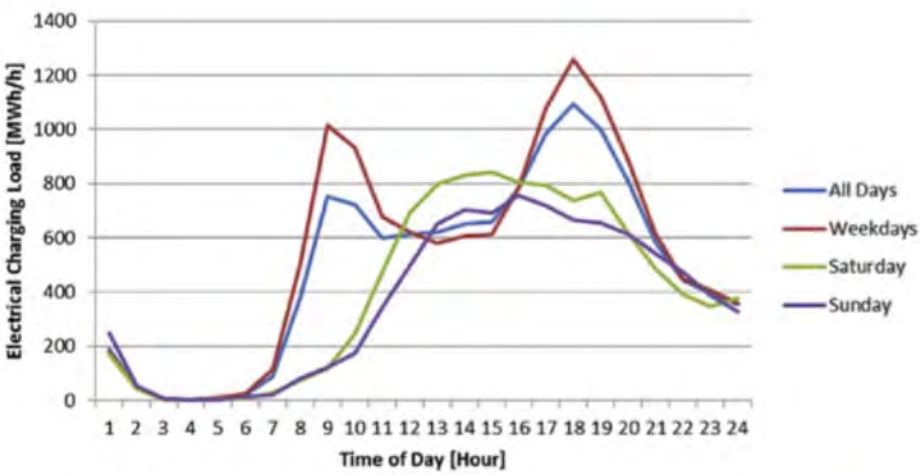


Fig. 3. Daily EV charging load with dumb charging all day in Denmark [25].

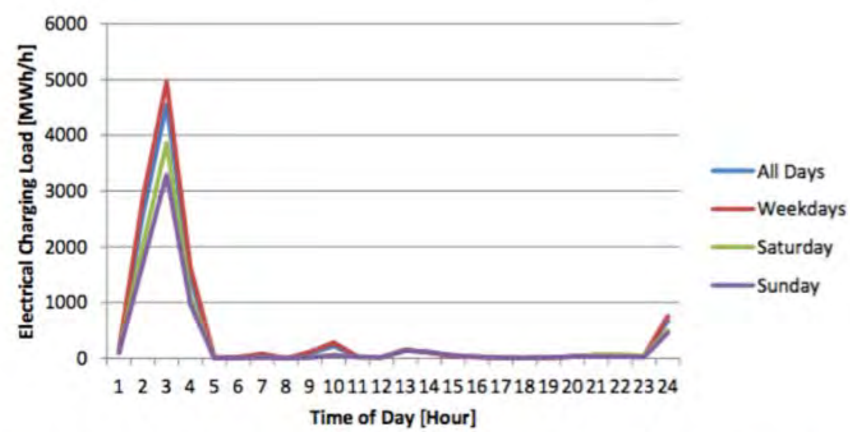
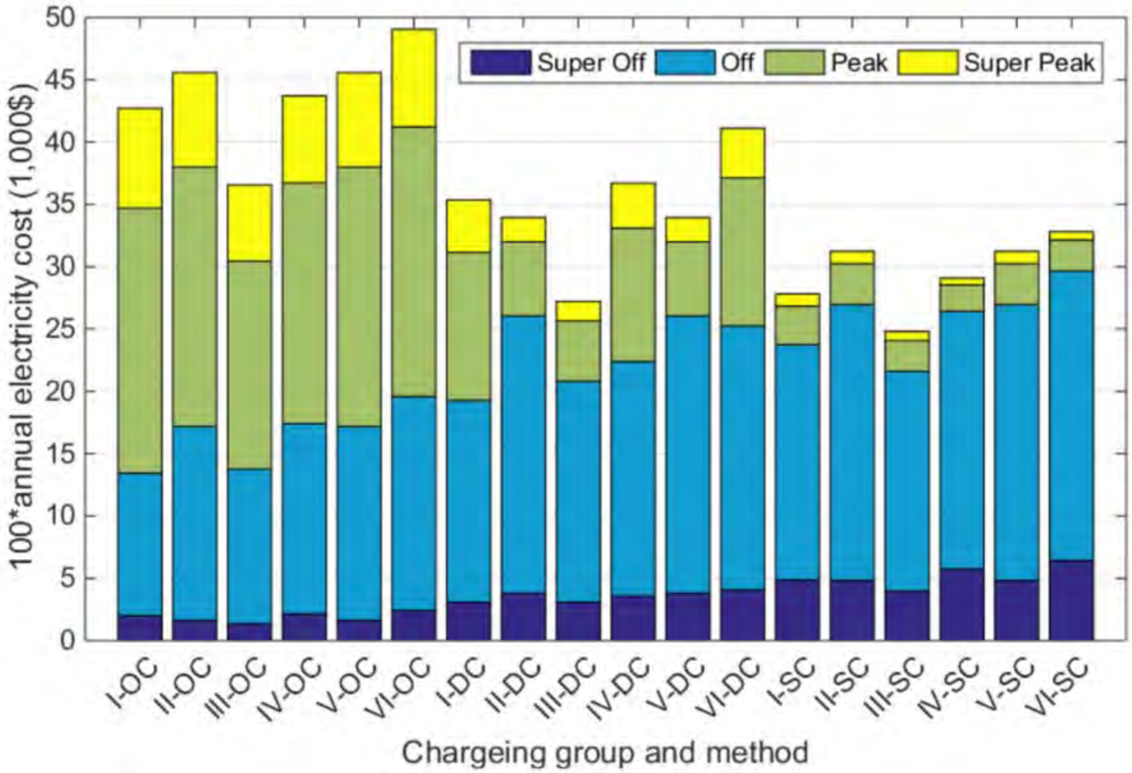


Fig. 4. Daily EV charging load with spot price based charging all day in Denmark [25].

SINTEF Energy Research in Norway and Center for Electric Power and Energy in Denmark

Demand Management Strategies

- Charging managed by customer (opportunity charging) or customer allows system operator to manage charging
- Delayed charging is a simple and effective method for moving charging to off-peak periods
- Cost of communications, load monitoring, and calculation of bills may outweigh benefit of smart charging



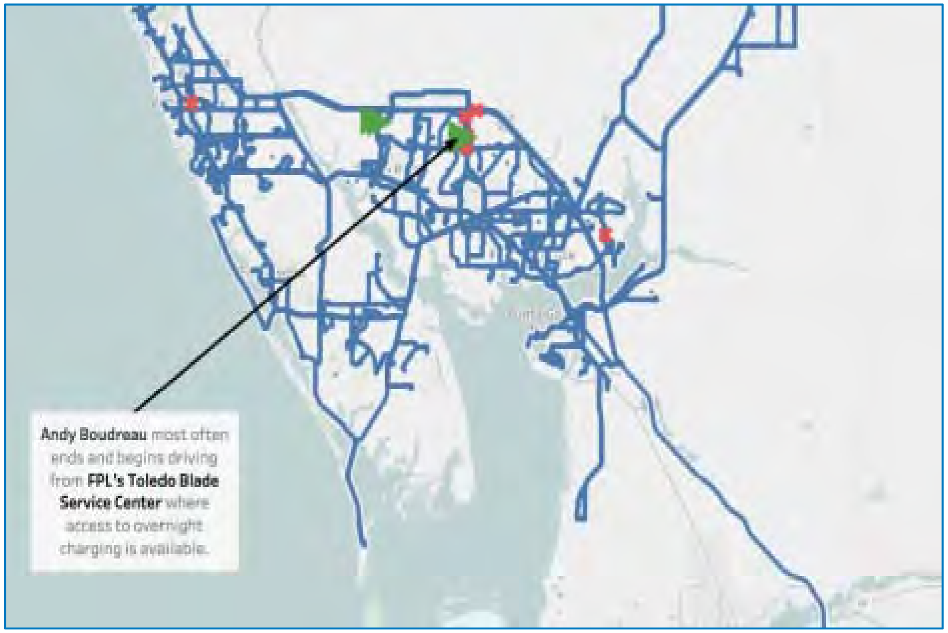
- Opportunity charging (OC) is the most expensive and shifts load from peak periods least
- Delayed charging (DC) reduces peak loading and costs
- Smart charging (SC) is the most effective for reducing peak load and costs, but public charging is needed to fully realize benefits

Zhang and Markel: Charge Management Optimization for Future TOU Rates.

Fleets and EVs

- Fleets want in
  - EPAct 1992 requires federal and certain state agency fleets to acquire alternative fuel vehicles
  - Fear price tag of a poor decision
- Pilot project demonstration for low-cost telematics approach
  - Small-scale pilot analysis of light-duty vehicles
  - 5 fleets: state, university, and utility
  - Deploy smartphone telematics
  - Use of telematics → ezEV analytics
  - Establish individual vehicle suitability for transition to EVs
  - Analysis to inform cost-effective rollout of EVs and EVSE

Fleets and EVs (cont'd)



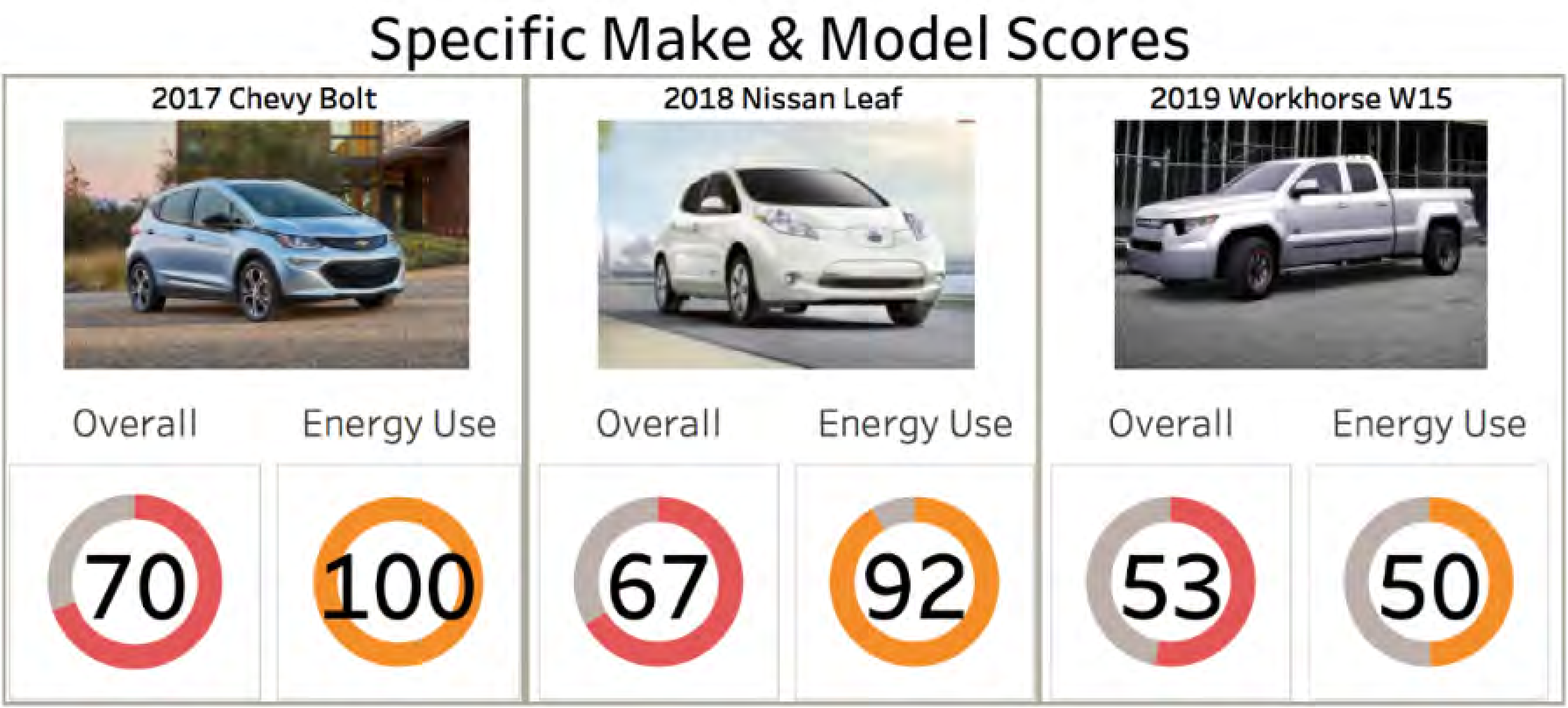
Basic Stats

- 17 drivers
- 814 days of use
- 10,152 trips
- 68,900 miles
- Parking locations

Takeaways

- Service territory fleet
- Highly variable daily driving needs
- Low-mileage trips but high-mileage overall
- Nearly across the board, transitioning to EVs makes sense, but not always, or not always pure EVs
- Data Source: Petrolr/ezEV

Fleets and EVs (cont'd)



Recommendations:

- 10 Chevy Bolts, 5 Nissan Leafs
- In a PHEV, these vehicles would average 81% of miles on electricity
- Use of existing EVSE at 9 FPL facilities; addition of EVSE at 6 facilities

Federal Fleets and EVSE

Deploying Electric Vehicles and Electric Vehicle Supply Equipment

Tiger Teams offer project assistance for federal fleets

EVSE Tiger Teams

- Team of EVSE experts and electrical engineers from NREL

Objectives

- Develop plans for charging infrastructure
- Save money on installation

Activities

- Visit potential EVSE locations
- Develop site-specific recommendations

Federal Fleets and EVSE Tiger Team -- Project Approach

Review Materials

- Completed Questionnaires
- Anticipated PEV Acquisitions
- Aerial Maps
- Assess Workplace Charging

Phased Approach to Implementation

- Where is Level 2 Necessary?
- Socialize PHEVs in High Use Areas
- BEVs in Areas of High Utilization but Low Maximum Distance
- Combine with Workplace Charging

Assess Electrical Infrastructure

- Identify Transformers Near PEV Parking
- Electric Panels with Additional Circuits
- Minimize Trenching

Minimize Electricity Costs

- Manage Charging to Avoid Demand Charges
- Consider Level 1 or Limited Level 2
- Integrate with Workplace Charging Needs and Facility Demand

FEMP Federal Energy Management Program

Federal Fleet EVSE Tiger Team
Questionnaire for Federal Fleet EVSE Planning

Step	Description	Number of Vehicles Planned	Preferred Make	Preferred Model	Normal Trip Type	Alternative Trip Type	Average Miles Per Trip	Average Trips Per Day	Maximum Mileage Per Day	Annual VMT Estimate (auto calc)
1	Anticipated PEV Acquisitions									-
										-

Step	Description	Vehicle Parking Options	Preferred/ Alt Site?	Recurring Destinations	Site Plan Attached ?	Available Electrical Amperage	Available Electrical Voltage	Distance from EVSE to Electrical Service	Total Planned Number of Level 1 EVSE Connectors	Total Planned Number of Level 2 EVSE Connectors
2	EVSE Location Plan and Electrical Input									

Step	Description	Number of Employees Driving BEVs and PHEVs	Number of Employees Considering BEVs or PHEVs	Employee Parking Options	Preferred/ Alt Site?	Available Electrical Amps	Available Electrical Voltage	Distance from EVSE to Electrical Service	Total Planned Number of Level 1 EVSE Connectors	Total Planned Number of Level 2 EVSE Connectors
3	Workplace Charging									

Federal Fleets and EVSE Tiger Team --Aerial Map

Federal Fleets and EVSE Tiger Team -- EVSE Installation

Completed 14 Tiger Team visits in 2016 calendar year

- Estimated savings between $5,000 and $20,000 per EVSE

Ten agencies have requested site visits

- Over 120 sites would like support
- Army is seeking funding to support Tiger Teams at every installation

Federal Fleets and EVSE Tiger Team -- Controlling Charging Times

	PEV Interface	EVSE Network	Facility Energy Management	Price Signals
Administrator	Consumer, fleet manager	Consumer, fleet manager, facility manager, utility	Facility manager	Utility, facility manager
Application	Control individual vehicle	Control individual or multiple vehicles	Control building and vehicles	Influencing charging using electricity price
Benefits	No cost, simple	Programmable for multiple vehicles, simple, flexible	Improved facility load control	Aggregated at utility level, relies on downstream controls
Drawbacks	Does not offer aggregation	No facility integration, not standardized across brands, added cost	Distance of control from users, administrative costs	Potential rebound peaks or complex price signals and automated controls, communication

Thank You

Questions?

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