Portland General Electric

NW Energy Systems Symposium
Electric Vehicles and the Grid
March 22, 2012

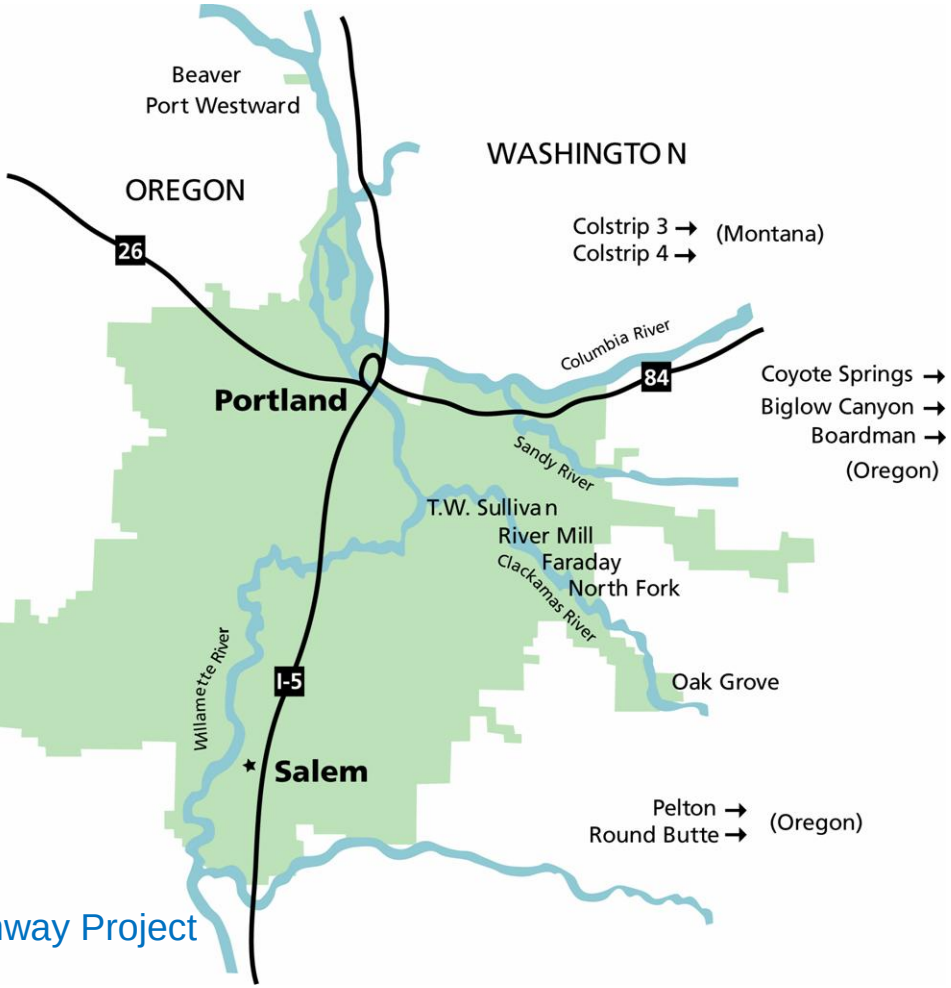
Topics

1. About Portland General Electric
2. Types of Vehicles
3. Charging Levels
4. Load Shapes
5. Load Forecasting
6. Infrastructure Projects

Baldock Solar Highway Project
1.75 MW
Portland General Electric
Oregon Department of Transportation

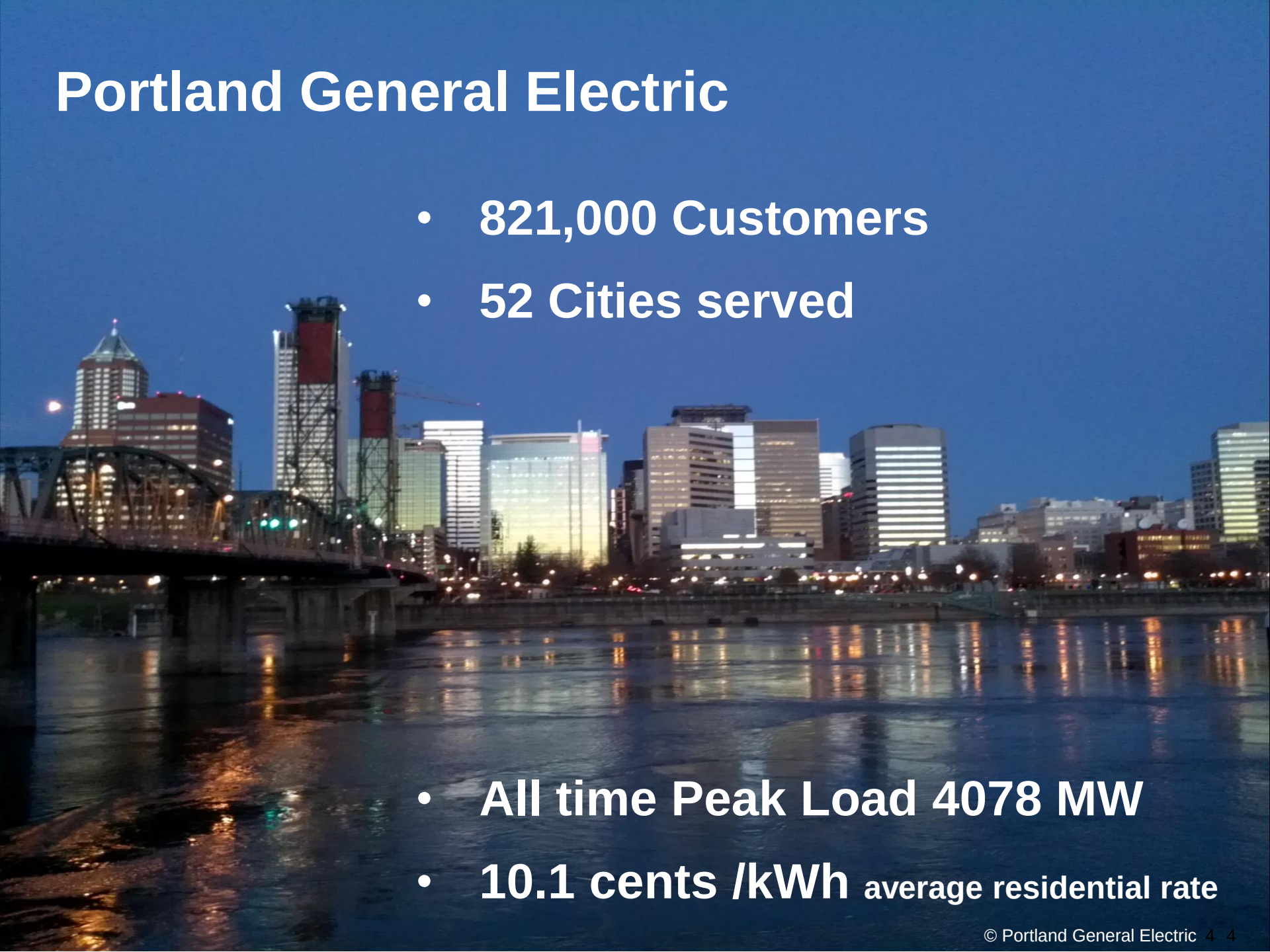
Portland General Electric

- 4,000-square-mile operating area
- 43% of Oregonians depend on PGE for electricity
- More than 200 Level 2 charging stations and 3 DC Quick charge stations



Sunway Solar Highway Project
104 kW
Portland General Electric
Oregon Department of Transportation

Portland General Electric



- 821,000 Customers
- 52 Cities served

- All time Peak Load 4078 MW
- 10.1 cents /kWh average residential rate

Types of Electric Vehicles

Attributes	Hybrid	PHEV	NEV	BEV
		Plug-in Hybrid	Neighbor-hood	Battery Electric Vehicle
Plug-In	No	Level 1, 2	Level 1	Level 1, 2 DC Quick Charge*
Range	4-500 mi.	4-500 mi.	40 mi.	80 – 240 mi.
All Electric Range	n/a	12-40	40 mi.	80 – 240 mi.
Examples	Prius Escape many others	New Prius GM Volt, Conversions	GEM Miles	Nissan Leaf * Ford Focus Mitsubishi I * Tesla Roadster

EVs in Oregon

Here Now

Staples

Frito-Lay

Smith-Newton
Delivery Trucks

Tesla Roadster

Smart Car ED

Nissan Leaf

Ford Transit Connect
Fleet

Mitsubishi I

Chevrolet Volt

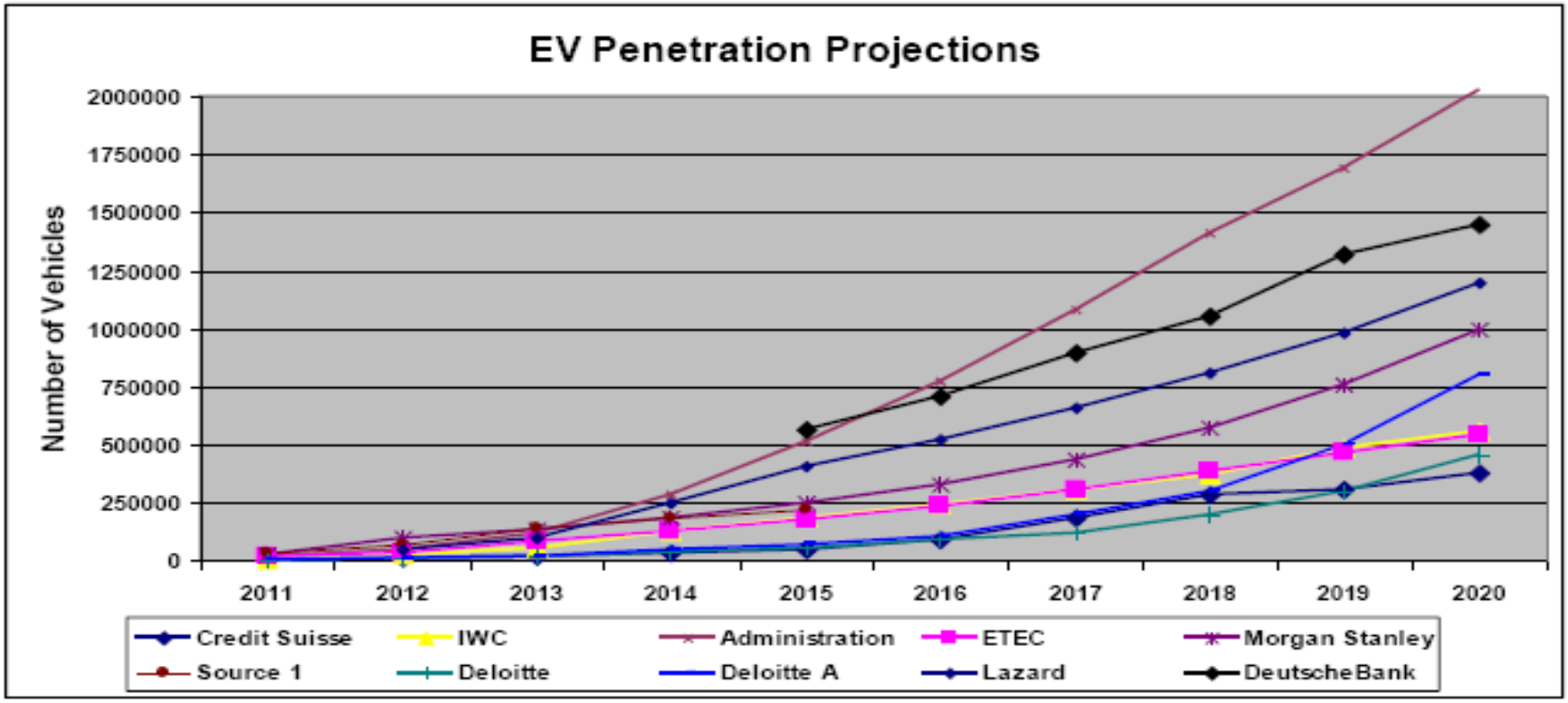
Coming in 2012

Ford Focus

Toyota Prius
10 Demo cars in
Oregon now

Tesla Model S

Vehicle Sales Projections in U.S.



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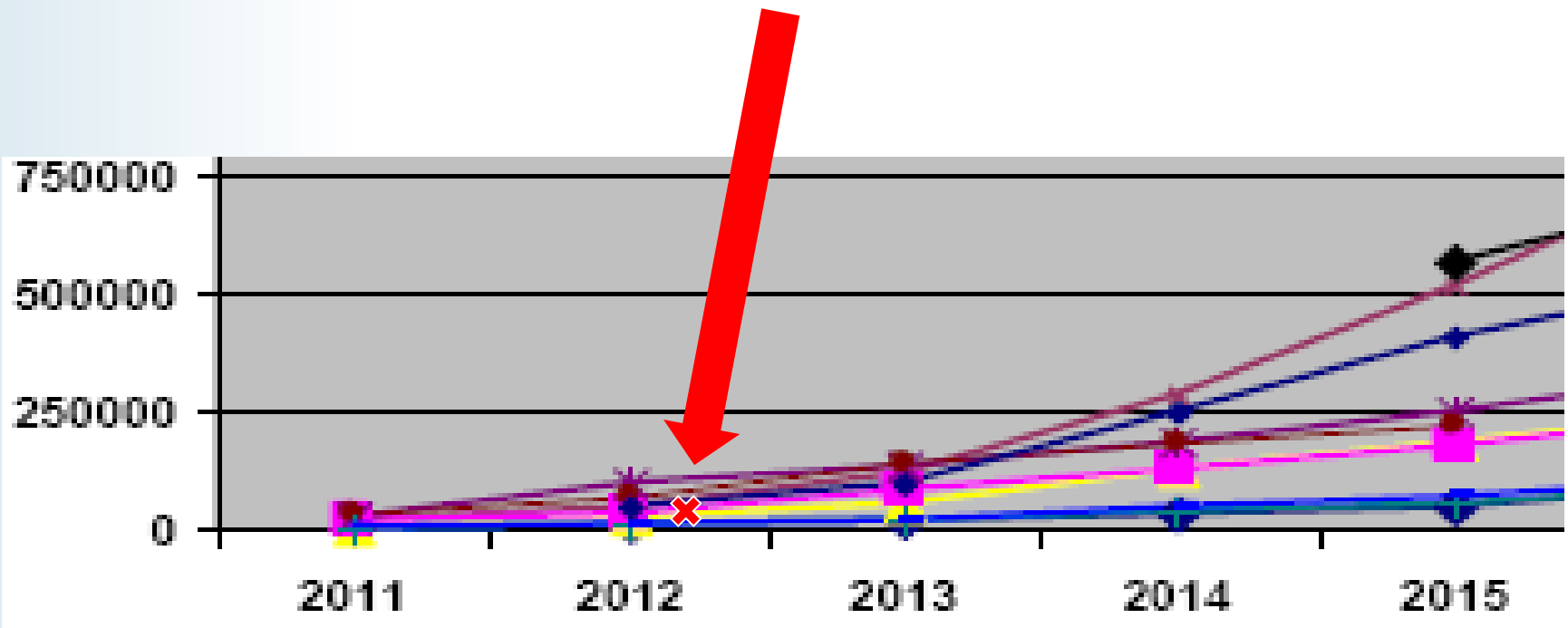
Vehicle Sales Projections

We are Here



Charging Levels

Level	Input Voltage	Typical Charging Times* (miles added per unit of charge)	Breaker Size (A)	Electrical Loads (kW)
1	120 V	12+ hours (4 miles per hour of charge)	15-20	1.65
2	240 V	2 – 4 hours (12 - 24 miles per hour of charge)	40 amp typical	3.3 - 6.6
DC Quick Charge	480v or 208v 3 phase	20 – 40 minutes (4 miles per minute of charge)	Varies	20-60+

*Typical Charging times vary. They depend on how far the car was driven

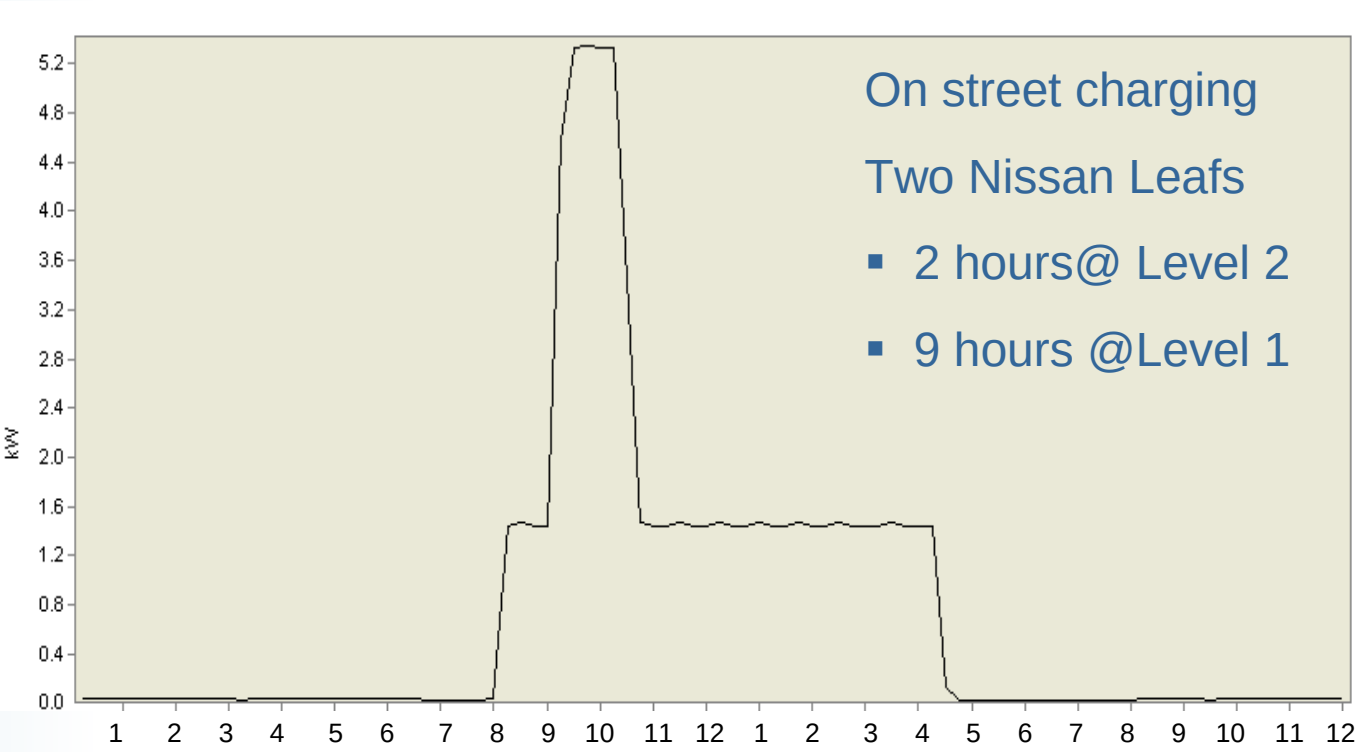
Will all charging locations work with my car??

Level 1	**120 volts** **Dedicated outlet**	 	**Most new vehicles will come with a special cordset**
Level 2	**208 or 240 volts** **Special Connector**		**Most new vehicles will use this standard connector** 
DC Quick Charge	**3 Phase Power**		**Nissan Leaf** **Mitsubishi i-Miev**

4 different Levels charging at once

Tesla	A123	Mitsubishi	Nissan
Roadster	Prius	i MiEV	Leaf
208 volts	120 Volts	208 volts	390 volts
70 amps	12 amps	16 amps	81 amps
Level 2	Level 1	Level 2	DC Quick Charge

Charging Profiles- Level 1 and 2 Charge



On street charging

Two Nissan Leafs

- 2 hours@ Level 2
- 9 hours @Level 1

Level 1= 1.44 kW

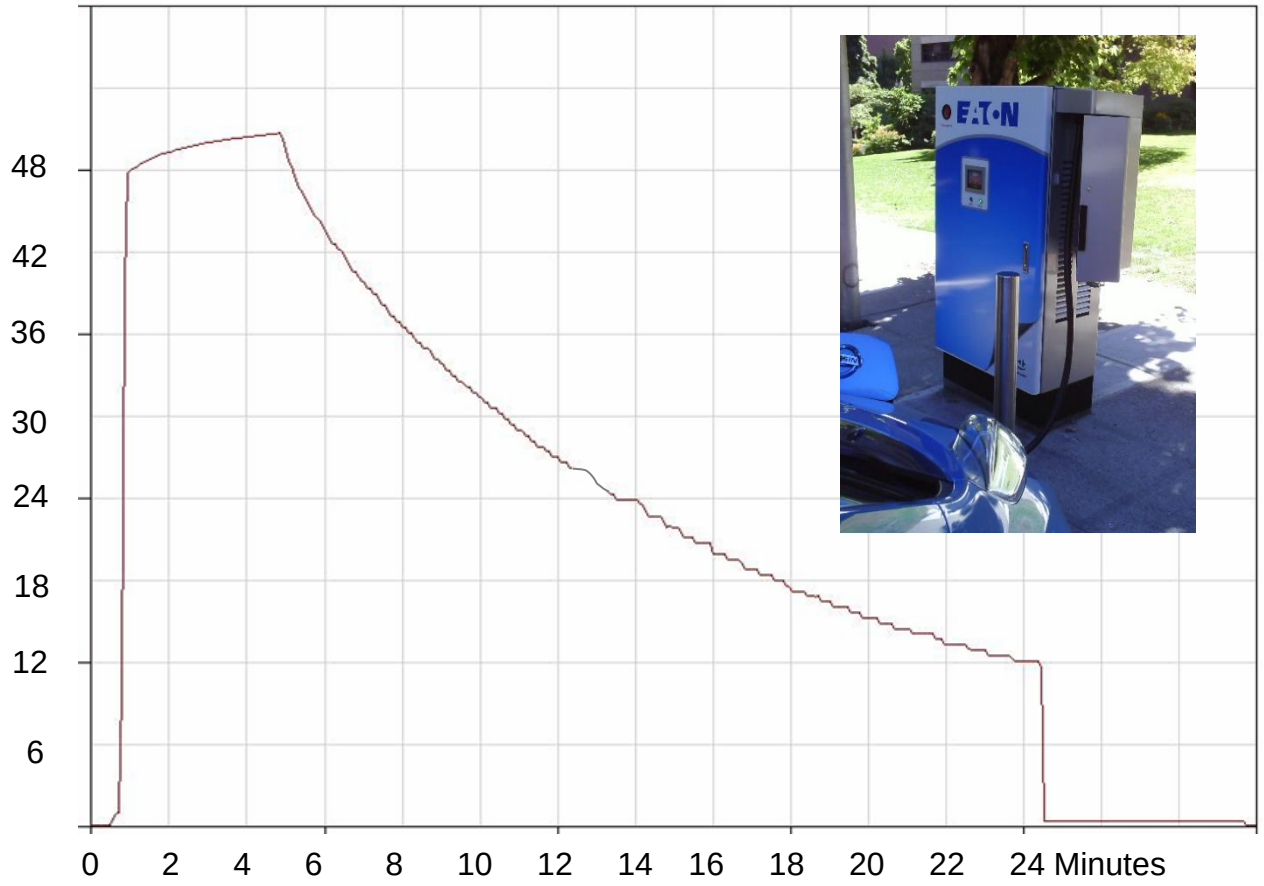
Level 2= 3.8 kW

Total Charge was 17.2 kWh

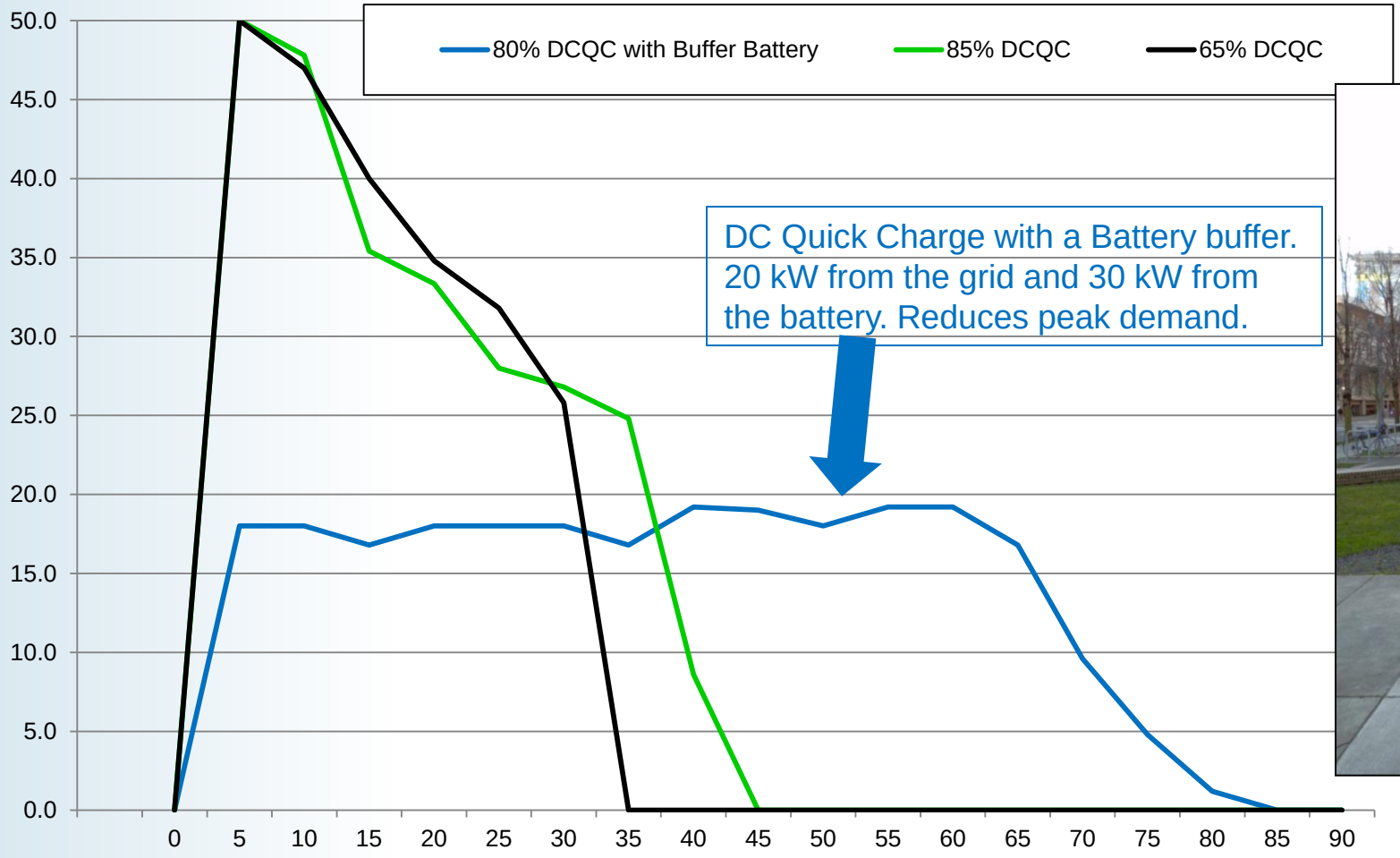
Charging Profiles- DC Quick Charge

DC Quick Charger

- 50 kW
- 11 kWh in 23 minutes
- ~ 4 miles per minute of charge in the first 10 minutes



Charging Profiles- DC Quick Charge



How much load is added for a residential customer with an EV?

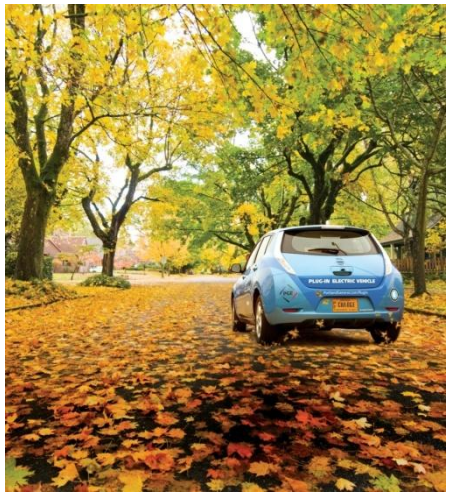
Assumptions:

- 10,000 miles driven per year (some say 12-15k)
- All charging done at home (Probably not true)
- Approx 3-5 miles per every kWh used

Answer:

10,000 miles/4 miles per kWh = 2500 kWh/year

How much load is added for all residential customer EVs by 2015?



Assumptions:

- 10,000 miles driven per year
- All charging done at home (worst case)
- Approx 4-5 miles per every kWh used
- 25,000 EVs in Oregon (Oregon 1% of US Population but with 2.5 times the adoption rate of other areas.)

•Answer:

10,000miles/year x 25,000 vehicles / 4 miles/kWh / 8760000 kwh/MWa=**7 MWa**

What will be the peak demand when EVs are charging?

Assumptions:

- 25,000 cars in 2015
- All plugged in at the same time and charging at full rate
- Vehicle types and charge levels:
  - 20% PHEV at 1.6 kW = 25,000 x (.2 x 1.6kW) = 8,000 kW
  - 30.8% charging at 3.3 kW = 25,000 x (.308 x 3.3kW) = 25,410 kW
  - 39% charging at 6.6 kW = 25,000 x (.39 x 6.6kW) = 64,350 kW
  - 10% on the road = 25,000 x (.1 x 0 kW) = 0 kW
  - .2% charging at 50kW = 25,000 x (.002 x 50kW)= 2,500 kW

Answer:

= (8,000+25,410+64350+0+2,500)/1000 = 100 MW

What will be the peak demand when EVs are charging during the day? (Let's be more realistic !!)

Assumptions:

- 25,000 cars in 2015 (2.5 times the adoption rate of other areas)
- Daytime 70 % of the people are at work or shopping not charging, more using quick charge stations but are only at 30 kW after 10 min
  - 4% PHEV at 1.6 kW = 1,620 kW
  - 6.8% charging at 3.3 kW = 5,610 kW
  - 9% charging at 6.6 kW = 14,850 kW
  - 10% on the road = 0 kW
  - 70% at work or shopping = 0 kW
  - .2% charging at 30kW = 1,500 kW Total = 24 MW

- Only 1/2 of the people charging at level 1 or 2 overlap their full charge time, since they have only driven 30 miles in the day and their charge time is over or their charge rate is lower when others plug in.

Answer: 13 MW

What will be the peak demand when EVs are charging during the night? (Let's be more realistic !!)

Assumptions:

- 25,000 cars in 2015
- Nightime 20 % of the people are at work or shopping not charging, very few using quick charge stations but are only at 30 kW after 10 min
  - 16% PHEV at 1.6 kW = 6,400 kW
  - 24% charging at 3.3 kW = 19,800 kW
  - 29.95% charging at 6.6 kW = 49,418 kW
  - 10% on the road = 0 kW
  - 20% at work or shopping = 0 kW
  - .05% charging at 30kW = 375 kW Total = 76 MW
- Only 1/2 of the people charging at level 1 or 2 overlap their full charge time, since they have only driven 30 miles in the day and their charge time is over or their charge rate is lower when others plug in.

Answer: 38 MW

Assumptions that will change

Adoption rate

- Fuel Prices, Media reports, Incentives, vehicle pricing

How far people drive

- 3 months after ownership users are more range aware

When they charge

- TOU rates, Critical Peak Pricing, customer habits

Where they charge

- Costs at public charging stations, availability of charging

Charging rates

- Types of vehicle availability

Research in the works

The EV Project

- Ecotality
- 60+ Project Partners (Idaho National Lab, Nissan, GM, Utilities)

Questions they will answer:

- When do people charge
- Where do people charge (home, work, public charging)
- Length of Charge

Other Things we would like to know

- How far do they drive (per trip, monthly annually)
- How do these vary (length of ownership, fuel pricing, other???)

The EV Project 4th Qtr 2011 Report

Data collected so far on approximately

- **4,000 Vehicles**
- **160,000 charging Events**
- **1.3 GWh energy consumed**
- **14 Million miles driven**

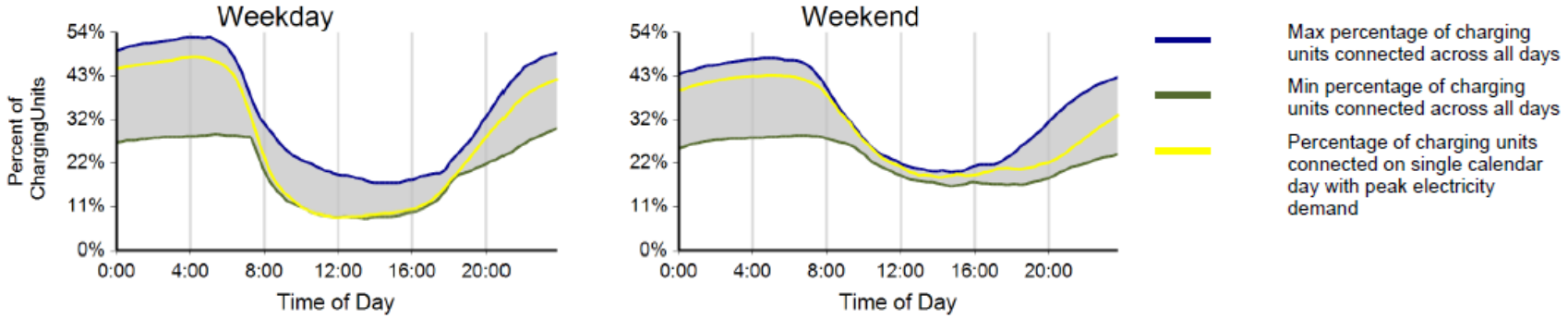
Questions they will answer:

- **When do people charge**
- **Where do people charge (home, work, public charging)**
- **How far do they drive (per trip, monthly annually)**
- **How do these vary (length of ownership, fuel pricing, other???)**

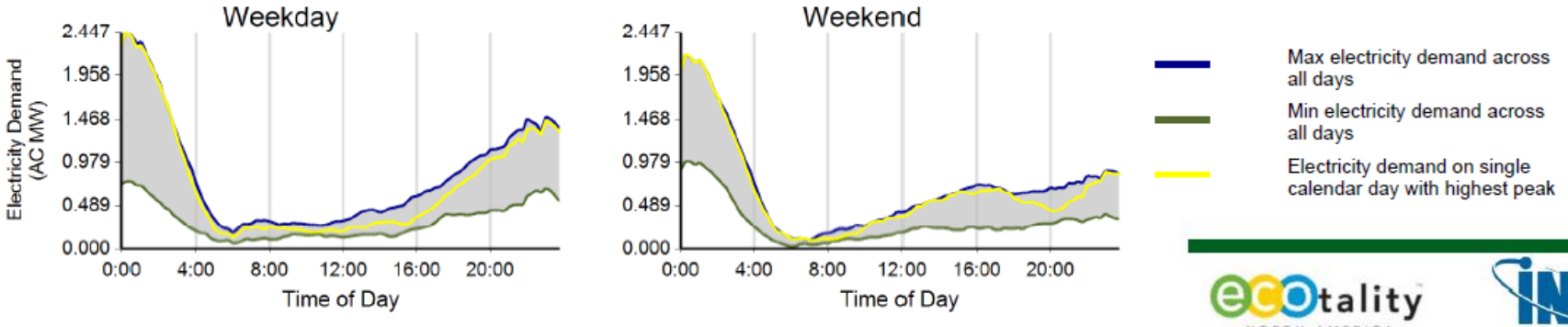
http://www.theevproject.com/documents.php

The EV Project 4th Qtr 2011 Report

Charging Availability: Range of Percent of Charging Units with a Vehicle Connected versus Time of Day[3]



Charging Demand: Range of Aggregate Electricity Demand versus Time of Day[4]



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INL Idaho National Laboratory

[1] Includes all charging units that were in use by the end of the reporting period

[2] A charging event is defined as the period when a vehicle is connected to a charging unit, during which period some power is transferred

[3] Considers the connection status of all charging units every minute

[4] Based on 15 minute rolling average power output from all charging units

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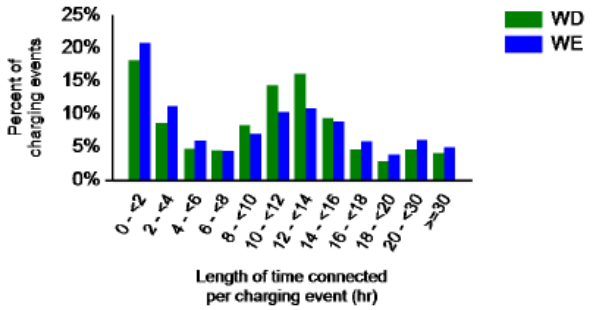
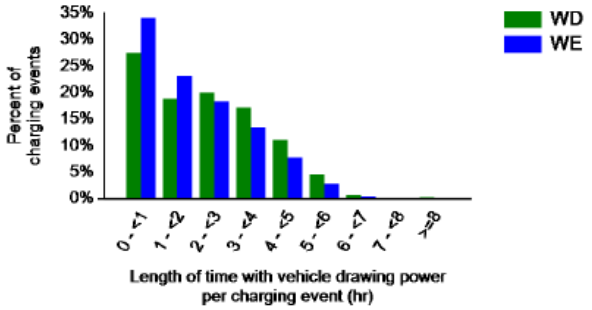
The EV Project 4th Qtr 2011 Report

Individual Charging Event Statistics	Weekday (WD)	Weekend (WE)	Overall
Average length of time with vehicle connected per charging event (hr)	11.6	11.4	11.5
Average length of time with vehicle drawing power per charging event (hr)	2.3	1.9	2.2
Average electricity consumed per charging event (AC kWh)	8.3	6.9	7.9

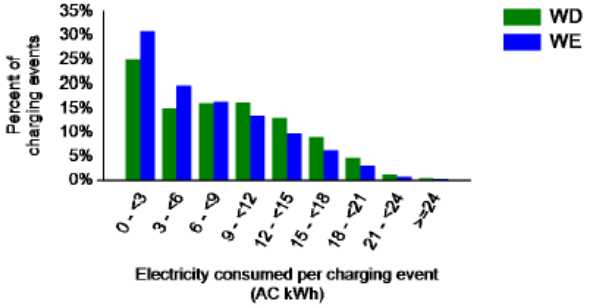
Distribution of Length of Time with a Vehicle Connected per Charging Event



Distribution of Length of Time with a Vehicle Drawing Power per Charging Event



Distribution of Electricity Consumed per Charging Event



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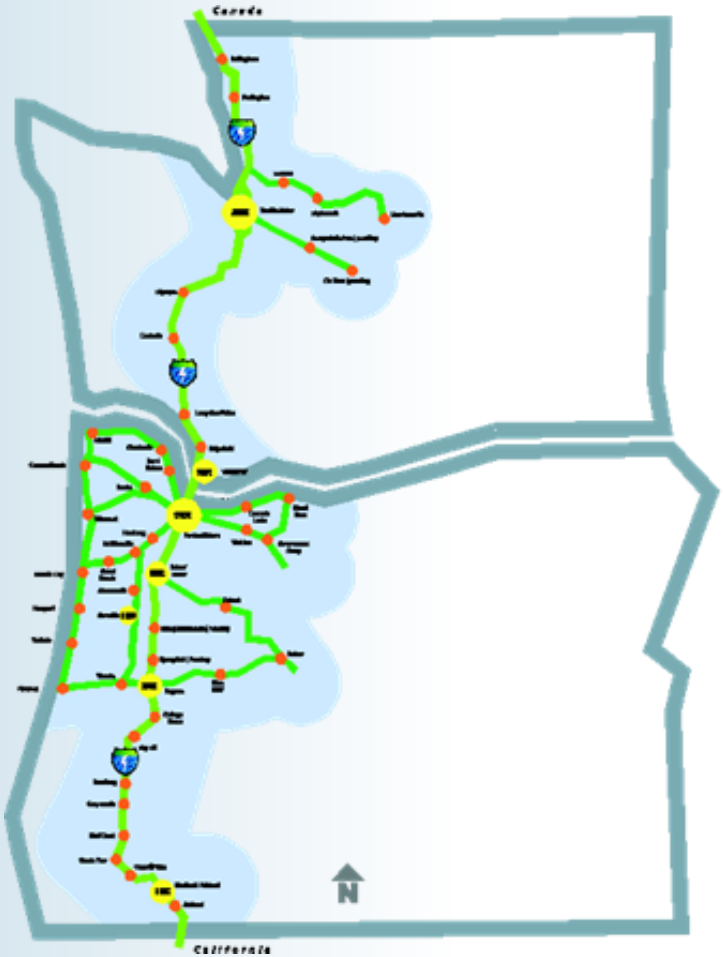
Infrastructure Projects

WEST COAST ELECTRIC HIGHWAY

West Coast Electric Highway Initiative

- The West Coast Electric Highway is the nation's most extensive, multi-state network of electric vehicle DC fast charge stations under development.
- Provide travelers with electric vehicle charging from "BC to Baja"
- The first part of the network, will span the 585 miles through Washington and Oregon along Interstate-5 from Canada to California with DC quick charge stations every 40 to 60 miles.
- Unique west coast driving experience with consistent infrastructure, branding and signage.

Teaming up with other projects underway



Washington DOT EV charging network:

- 11 DCQCs along I-5, US 2 and I-90

Oregon DOT I-5 Highway Project

- 10 DCQCs along I-5 station USDOE, ODOE ~ $1m

Electric Vehicle Corridor Connectivity Project

- 22+ DCQCs- Western Oregon, USDOT, TIGER II (Transportation Investment Generating Economic Recovery) $3.4m

The EV Project

- ECOtality $40M to install cahrging in 6 regions of the country including Oregon and Washington
- ~2,000 public and fleet charging stations, including 40-60 Quick Chargers and 1800 residential stations for Nissan LEAF and GM Volt owners

Charge America

- Coulomb awarded $37M to install 5,000 charging stations in 37 regions, including eastern King County (Bellevue).

Hope to see you down the road on the Electric Highway

Rick Durst

Portland General Electric

Transportation Electrification

Project Manager

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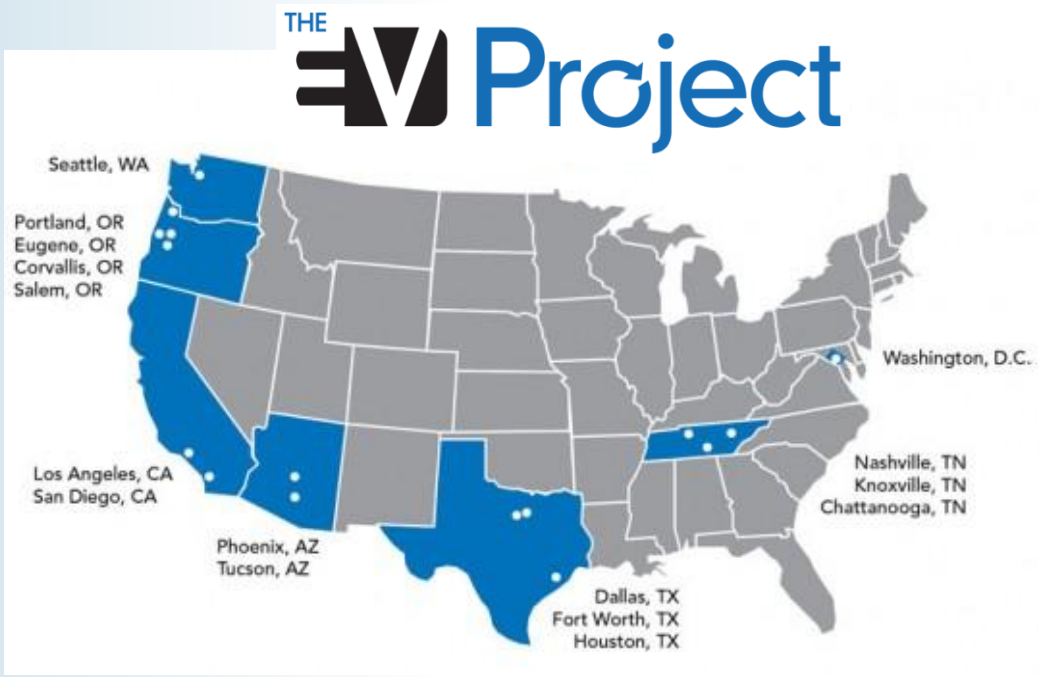
US Dept of Energy's Transportation Electrification Project:

$200+ million for EV Infrastructure



- **Nation-wide:**
- **14,000** Level 2 (240V) chargers
- **300 - 400** DC Fast Charger (480V) ports
- **5,700** Nissan LEAF cars
- **2,600** Chevrolet Volt cars
- **60+** project partners
- **1,200** new jobs by 2012 and
- **5,500** new jobs by 2017
- **18** major cities and metropolitan areas

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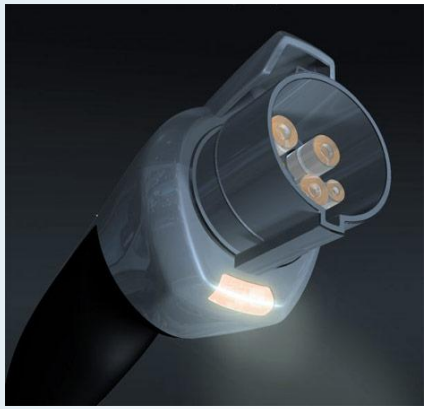
AC Level II Charging Station

- 208/240VAC, SAE J-1772 connector
- Typically 6.6 kW maximum
- Tesla could be 14 kW charger, but requires a special connector



SAE J1772 Connector

Shorepower

Blink - Ecotality

GE

Aerovironment

Eaton

Coulomb

Evr-Green/ Leviton