July 6, 2016

MEMORANDUM

TO: **Council members**

FROM: **Massoud Jourabchi, Manager Economic Analysis**

SUBJECT: **Electric Vehicle (EV) and Utilities a Win-Win investment?**

BACKGROUND:

Presenter: Massoud Jourabchi

Summary: Staff prepared an analysis of recent trends in electric transportation. National and regional trends will be discussed. Staff will present on the results of a "What If " analytics that looks at the investment requirements and regional savings in consumer spending on motor fuel and CO2 reductions as a result of switching from gasoline fueled vehicles to electric vehicle.

This analysis finds that:

- Investing in EV infustructure is a cost-effective strategy to reduce CO2 emissions.
- Reduction in CO2 emissions is highly dependent on power system's primary fuel usage.
- Cumulative reduction in CO2 emission between 2015 and 2035 is over 42 million metric tons.
- After 2035, CO2 emissions can be lowered by 4 million metric tons annually.
- Levelized cost CO2 emissions at 5% discount rate is about $31 per metric tons.
- Regional transportation cost can be lowered by $3-5 billion dollars annually.
- Investment of about $3 billion dollars over the next 20 years would be needed, to build the charging infustructure, public Level 1, 2 and DC chargers.

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- Utility investment in more efficient transportation system is a win-win situation for the region and utilities.
- Lowering of cost of transportation has a significant impact on the economy of region, increasing regional income and employment.
- Investment in EV can also serve as an insurance policy against oil price shocks.

Relevance: Understanding this growing load helps Council's ability to forecast future demands for electricity.

Work plan: Maintain Analytical Capability

Background: In the past 6 years, staff has provided updates on this growing load. This presentation is a continuation of past presentation.

Analysis of Impact of Investments in Electric Vehicles in the Northwest- a win-win opportunity?

July 2016

Massoud Jourabchi

Northwest Power and Conservation Council

In this presentation

- Background on national trends
- Update on Electric Vehicle market in the region
- Future of Electric Vehicles (state and utility initiatives)
  - ZEV initiative
- Economic Analysis of Investments in EV
  - Cost Factors considered
    - Charging infustructure for EV
    - Cost of electricity for EV
    - Cost of Gasoline for Internal Combustion Engine (ICE)
    - Cost of CO2 emissions from tail-pipe for ICE
    - Cost of CO2 emission from EV (new natural gas power plants)
    - Incremental cost of purchasing EV
    - Incremental cost of maintenance of EV and battery replacement
- Barriers to EV

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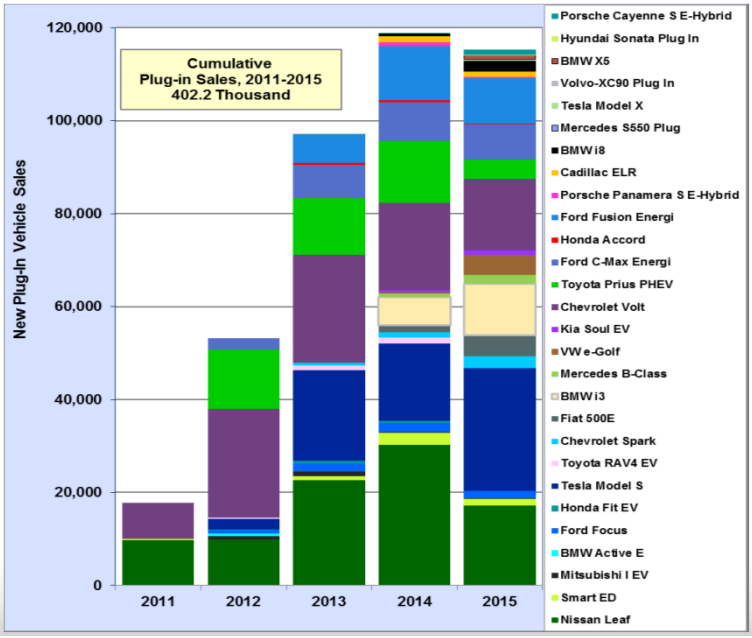
National Background

- Transportation accounts for about 28% of total U.S. energy consumption.
- In 2014, almost 17% of household expenditures were for transportation.
- Car sharing and leasing rather than purchasing is gaining foothold.
- The average price of a new car was just over $25,000 ($ 2014 dollars).
- Sales-weighted data on new light vehicles sold show a 125% increase in horsepower and a 47% decrease in 0-60 time from 1980 to 2015, with the fuel economy of vehicles improving 29%.
- In 2015, plug-in vehicle sales totaled over 115,000 units.
- At least 24 different models of plug-in vehicles are available or coming soon to the market.
- There are about 30,000 electric vehicle charging units throughout the nation in 2016.



Increasingly more EV / PHEV options are available to the consumers

Alternative fueling infustructure increasing

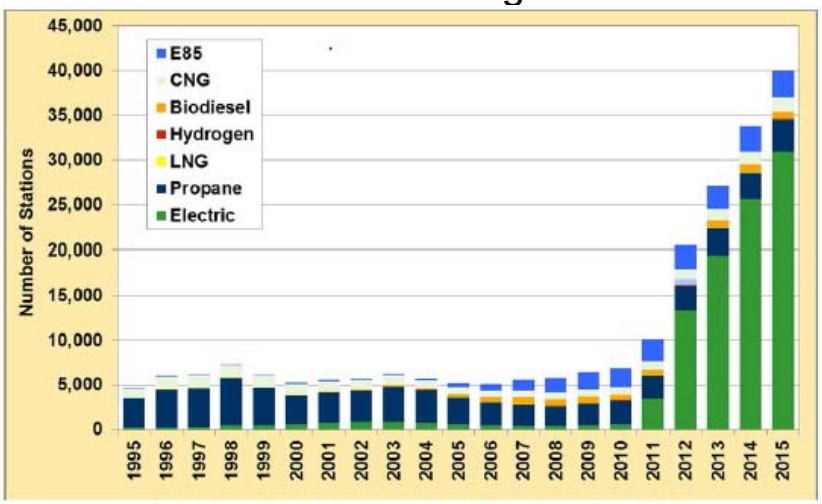
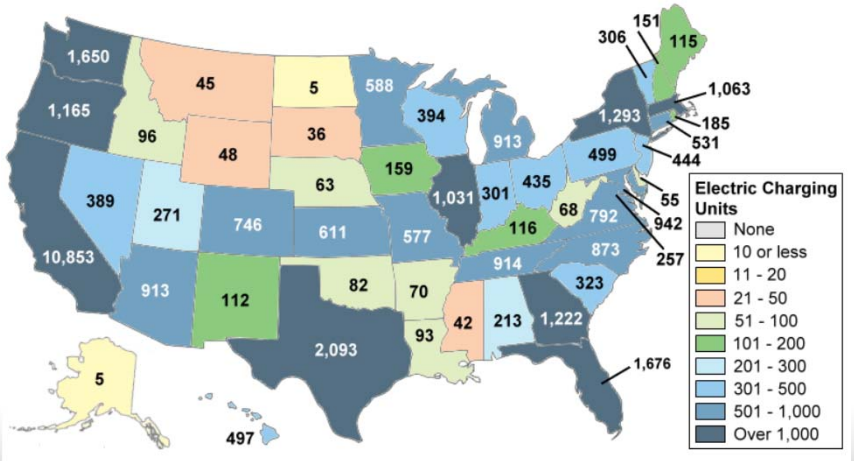


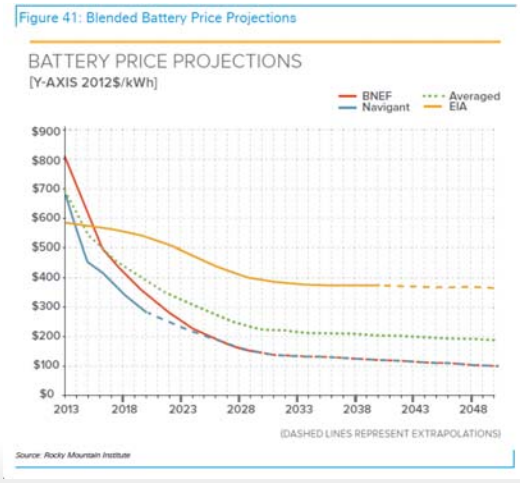
FIGURE 112. Alternative Fueling Stations by Fuel Type, 1995-2015

Number of Electric Charging Units by State, 2016

Note: Includes public and private stations and units. About 84% of stations and units are public.



It is All about the Batteries



Cost of battery in 2010 $/KWH	$1000
2010-2014	15%
2015-2020	9%
2020-2035	5%

Batteries make up a third of the cost of an EV.

Future batteries may be more of fast charging Lithium Capacitors.

General Motors says the cost the battery cells in its 2016 EV Volt to be an *"industry-leading"* **$145 per kWh**.

A Price point that was expected to be reached by 2027.

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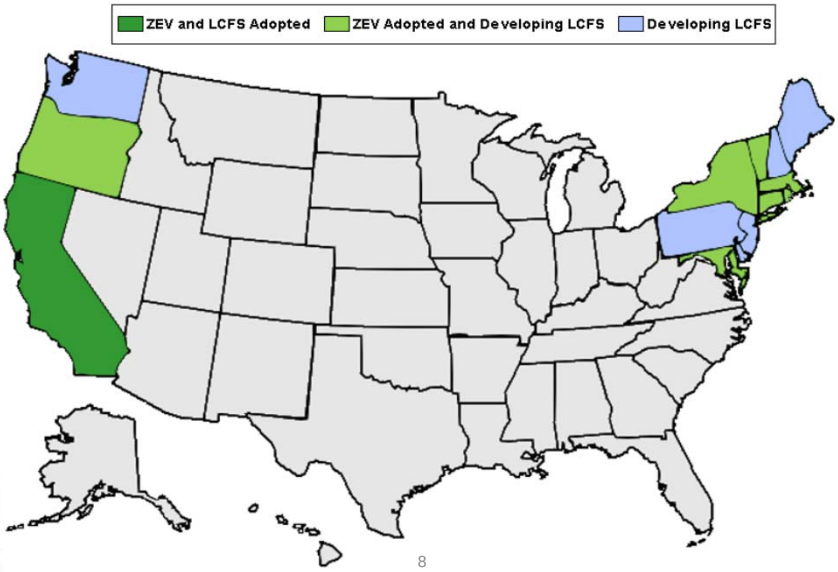
Drive toward Zero Emission Vehicles

(in 2015 Low Carbon Fuel Standards in state of Washington was defeated.)



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NW Transportation Background

- As of 2013 there were about 5.3 million automobiles in the four states.
- There were about 6 million light duty trucks, for a total of about 11.3 million vehicles.
- These automobiles and trucks traveled over 115 million miles (highway travel).
- As of 2014, region spent $14 billion dollars in purchasing gasoline
- Region has spent over $223 billion dollars in purchasing gasoline over the past 20 years.
- Over the next 20 years, the current stock of vehicles is expected to be totally replaced.
- Transportation sector produces about 80 million metric tons of CO2 per year, 63 millions of metric tons of which is from motor gasoline use.

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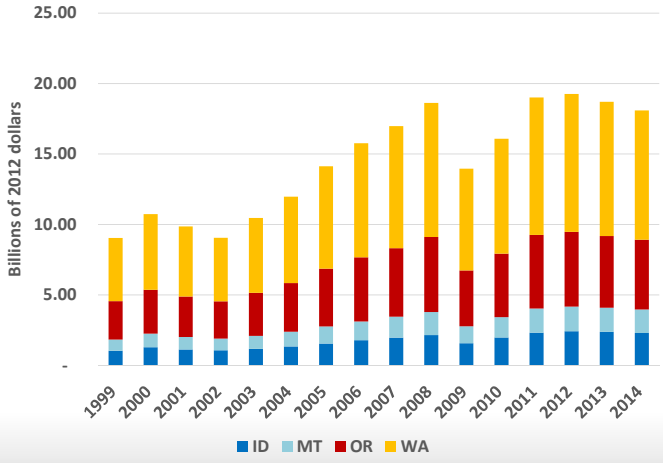
On Average Region spends $14.5 billion dollars a yea in Gasoline Expenditure

(Billions of 2012 dollars)



Billions 2012$	Since 2010	since 1999
ID	$ 11	$ 27
MT	$ 8	$ 21
OR	$ 25	$66
WA	$ 46	$118
4 states	91	$223

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As of June 2015 there were about 22,000 Electric Vehicles registered and about 2,400 Public chargers installed in the NW

As of June 2015	Electric Vehicle Count	Public Level 1 Chargers	Public Level 2 Chargers	Public DC fast Chargers
ID	444		35	15
MT	492		15	28
OR	7,104	122	705	137
WA*	14,610	249	981	110
Regional Total	22,650	371	1736	290
US		2992	22,565	2920
Region as % of US		12%	8%	10%

*As of December 2015 there are over 16,500 EVs in state of Washington

Source: For EV Count- IHS global Insight data as of June 2015
For Public EV charging, US DOE Alternative fueling stations.

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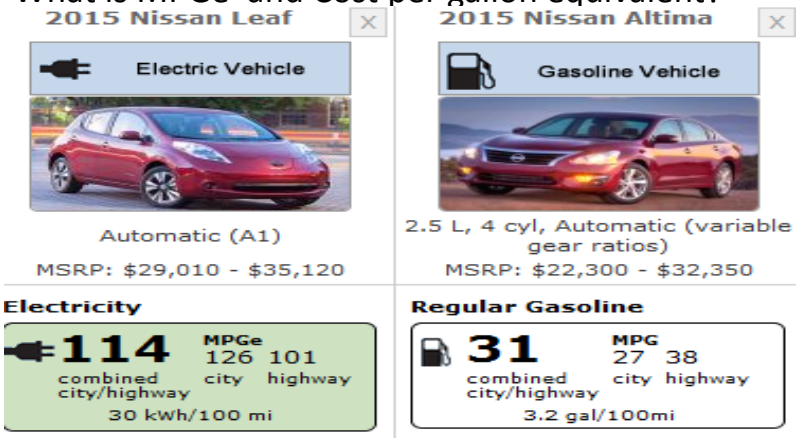
Some terminology background

What is MPGe and Cost per gallon equivalent?



	for the NW
FE : Average Miles per gallon for New ICE	27.9
EC : Average kWh/mile for EV	0.26
EP : Average Residential Rate $/kWh	0.08
eGallons Cents/Gallon equivalent	58

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Comparison of CO2 emission ICE and EV

	MPG	Gallons/mile	Lb of CO2/gallon	CO2 lb/mile
ICE - 2015	25	0.040	19.6	0.8
ICE - 2035	75	0.013	19.6	0.3
2035 scenario B1	KW/Mile	lb/kwh		CO2 lb/mile
EV with Mix	0.260	0.428		0.1
EV with Coal	0.260	2.4		0.6
EV with Existing gas	0.260	1.1		0.3
EV with New gas	0.260	0.8		0.2

Note: with renewables powering EVs no CO2 is emitted.

Regional Economic Impact of EV

- On average, a dollar saved at the gas pump and spent on the other goods and services that households want creates 16 times more jobs.
- Unlike the fossil fuel supply chain, the majority of new demand financed by EV fuel cost savings goes to in-state services
- Both those driving EV and those who do not benefit from vehicle electrification, either directly or indirectly through job creation.

Opportunities for Investment in Transportation infustructure

- According to National Academy of Sciences, 2013 report on transitions to Alternative vehicles and fuels, "The US light-duty vehicle fleet is responsible for about half of the petroleum consumed in this nation and about 17 percent of its greenhouse gas emissions".
- Finding alternative vehicles to transport nation with the goal of reducing greenhouse emissions would be worthwhile. One such alternative is electric vehicles.
- We have prepared an analytical tool to estimate regional impact of growth in EVs.

Incremental Cost of Choosing EV over ICE (Billions of 2012$)

7th Power Plan scenario	1B	3C	2B
Including CO2 (social cost of carbon 2.5% discount)	(5,391)	(5,680)	(5,668)
Excluding CO2 value	(2,184)	(2,184)	(2,184)

Not incorporated in these benefits are:

1) Indirect employment impact of keeping more of transportation energy bill in the region.
2) Tax revenue impact of reduced gasoline sales
3) Value of retired batteries at the end of life.
4) Value of potential use of EV in DR.

In the future as number of EV increases number of Public charging stations need to increase by a factor of 8-10

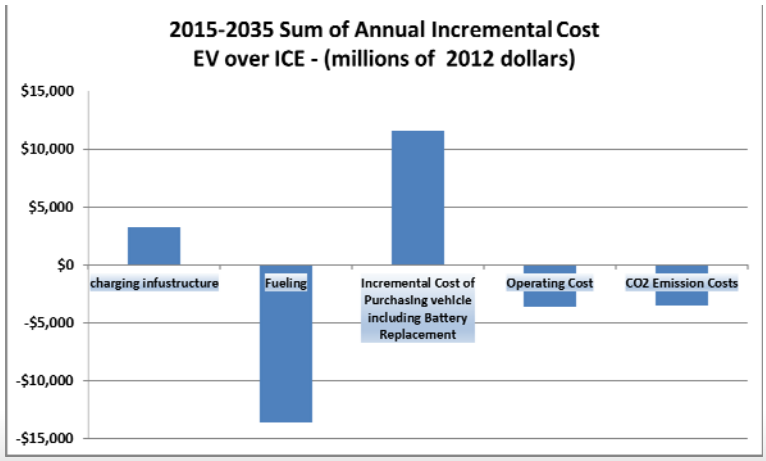
Future needs	Level 1	Level 2	DC fast Chargers
2015	371	1736	290
2020	823	3,852	644
2025	1,479	6,918	1,156
2030	2,260	10,573	1,766
2035	3,020	14,133	2,361

Incremental Costs Comparing EV and ICE

(All costs shown are in millions of 2012 dollars)

	EV charging infustructure Cost	Incremental Cost of Purchasing vehicle including Battery Replacement	Incremental Fuel cost	Incremental Operating Cost
2015	43	88	(46)	(6)
2020	121	385	(303)	(54)
2025	168	633	(642)	(146)
2030	199	746	(974)	(276)
2035	205	790	(1,300)	(428)
2015-2035	3,215	11,623	(13,560)	(3,630)

Incremental cost under Scenario 2B - Carbon Reduction - Social Cost of Carbon - Mid-Range



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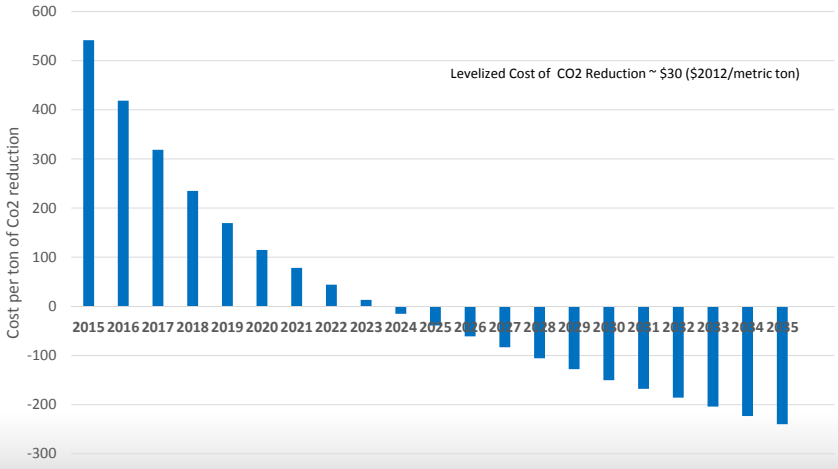
Per ton cost of CO2 emission reduction and goes negative as more EVs are added and as costs of decline (2012 dollars/Metric ton)



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Barriers and potential solutions to implementation of EVs

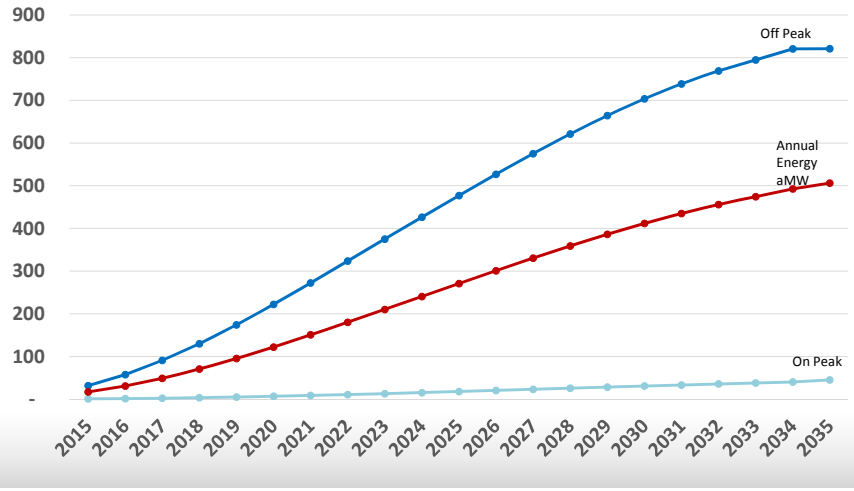
- Perceived high cost of EVs.
  - EV specific dealer incentives.
  - Bulk purchasing can lower the cost of EVs.
- Range anxiety
  - Range on single-charge increasing
  - More reliable fast DC chargers
  - Encourage standardization of fast chargers
- Limited availability of charging infustructure, where and when needed.

Why utilities should care?

- Growing load with good load shape
- Cost-effective CO2 reduction
- Return on investment on charging stations
- Opportunity for GTV and VTG (DR)
- Reuse of EV batteries for storage and DR.

Load Impact of EVs

Energy (aMW) Peak and Off-Peak (MW)



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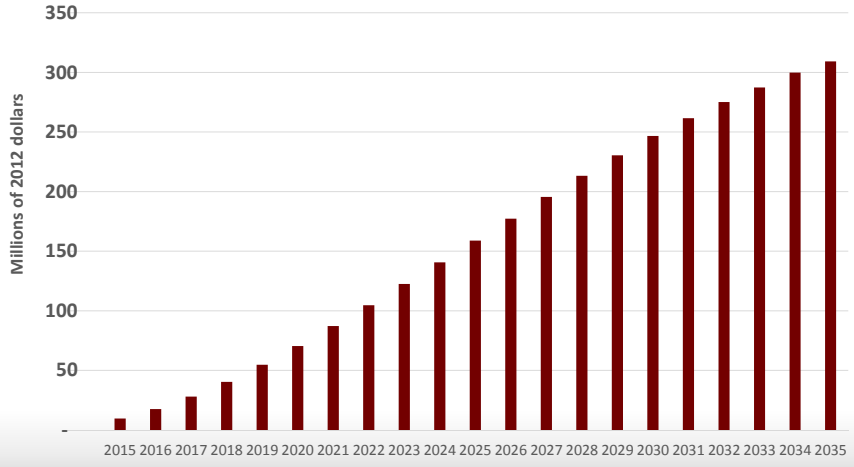
Increase in Electric Utilities Revenue due to charging EV (millions of 2012 dollars)



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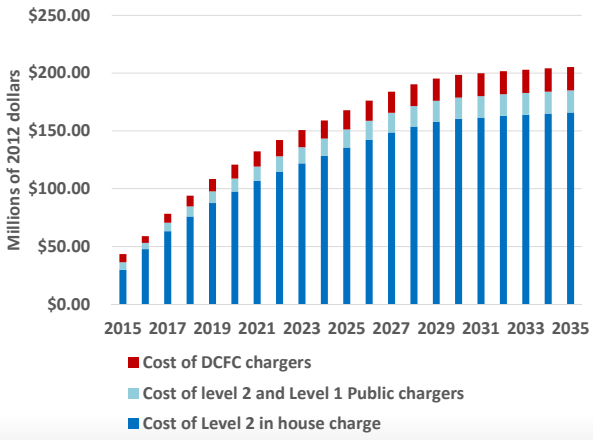
Annual Cost of Charging Infustructure



Estimated investment over the next 20 years
~ 3.2 billion dollars ($2012)

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Comparison of CO2 reduction strategies

Scenario	System Cost w/o Carbon Dioxide Revenues (billion 2012$)	Reduction in 2035 PNW CO2 Emissions (MMT) compared to Existing Policy
Existing Policy	$82	0
Lower Conservation	$97	5
Increased Market Reliance	$76	1
No Demand Response	$86	1
Regional RPS at 35%	$128	(10)
SCC - Mid-Range	$78	(15)
Retire Coal w/SCC_MidRange	$91	(18)
Max. CO2 Reduction - Exist. Tech.	$117	(20)
Retire Coal	$98	(20)
Electric Vehicles	($2)	(4)

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Comparison of Co2 Emissions
(2016-2035 Cumulative)

CO2 Emissions - PNW System 2016 - 2035 (MMTE)	Cumulative Emission Reduction Over Existing Policy - Scenario (MMTE)
Carbon Cost Risk	196
SCC - Medium	360
SCC - High	438
Maximum Carbon Reduction – Existing Technology	217
Maximum Carbon Reduction – Emerging Technology	262
RPS at 35%	87
Electric Vehicles	45

Examples of actions states could take?

- Amend building and electrical codes to require EV readiness across all residential and commercial buildings.
- Offer incentives for installation of level 2 and DC fast chargers in commercial and industrial facilities (private, state and federal facilities).

Summary of Key findings
with the goal of 100% EV by 2050

- Investing in EV infustructure is a cost-effective strategy to reduce CO2 emissions.
- Reduction in CO2 emissions is highly dependent on power system's primary fuel usage.
- Cumulative reduction in CO2 emission between 2015 and 2035 is over 42 million metric tons.
- After 2035, CO2 emissions can be lowered by 4 million metric tons annually.
- As more EVs are added to the transportation mix and as power generation system becomes less CO2 intensive and as fuel and operating savings increase, the average cost of CO2 reduction per ton becomes smaller and smaller.
- Levelized cost CO2 emissions at 5% discount rate is about $30 per metric tons.

Summary of Key findings
with the goal of 100% EV by 2050

- Regional transportation cost can be lowered by $3-5 billion dollars.
- Invest of about $3 billion dollars over the next 20 years would be needed, to build the charging infustructure, public Level 1,2 and DC chargers.
- Utility investment in more efficient transportation system is a win-win situation for the region and utilities.
- Lowering of cost of transportation has a significant impact on the economy of region, increasing regional income and employment.
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Questions ?