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Impact of Introducing an Electric Vehicle Rebate on the Oregon State Economy

PREPARED FOR:
Securing America's Future Energy and
The Electrification Coalition

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April 2, 2015

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EXECUTIVE SUMMARY

The state of Oregon is considering creating an electric vehicle rebate to promote EV sales — $3,000 for battery electric vehicles (BEVs) and $1,500 for plug-in hybrids (PHEVs) with an all-electric drive range of at least 10 miles. Given that the state already has one of the nation's highest electric vehicle (EV) penetration rates — EVs comprised 1.1 percent of all new light duty-vehicle sales in 2014 — a rebate can be expected to boost the penetration rate even higher. This study, commissioned by Securing America's Future Energy (SAFE) in partnership with the Electrification Coalition, and prepared by Keybridge LLC, examines the economic effects of a possible EV rebate on the Oregon state economy.

The study evaluates two scenarios — a "baseline" scenario in which Oregon continues to have no EV rebate and a "policy" scenario in which an EV rebate goes into effect starting in 2015. It quantifies the impact of a rebate on state GDP by comparing the two scenarios. The study starts with an accounting of the household-level response to a rebate and aggregates up to the state-level. The study's micro-level consumer model is based on the Electric Power Research Institute's (EPRI) 2013 and 2014 reports on the economics of EV ownership, which provide detailed estimates of the cost of owning and operating an EV relative to conventional vehicles. The study's macroeconomic modeling of the state-level impacts relies on a 70-sector model of Oregon's economy developed by REMI, Inc., a leading supplier of regional economic models.

The study finds that a tiered EV rebate — $3,000 for BEVs and $1,500 for PHEVs would boost Oregon's real GDP (aggregate state income) each year between 2015 and 2030.

- The cumulative 5-year gain in Oregon's GDP is $38 million, and the cumulative 16-year gain totals $83 million, assuming that consumers respond to the rebate by buying EVs instead of conventional internal combustion engine vehicles. This overall gain in Oregon GDP occurs despite an assumed reduction of state government spending by the same amount as the aggregate EV rebates, in order to keep the state's budget balance unchanged.
- Further, the study finds that with the rebate, Oregon drivers would save $46 million in gasoline bills over the next five years and $212 million through 2030 (only partially offset by $59 million in higher electricity bills).
- Additionally, it finds that an EV rebate would serve as a type of economic insurance policy for Oregon. If the program was implemented and there were more EVs on Oregon roads, and if gasoline prices then spiked by $1.50 a gallon in 2020 due to an oil shock, Oregon EV owners would save an additional $8 million per year for fuel beyond the savings cited above.

Two key factors account for the increase in state GDP. First, with more EVs on the road in the case of an EV rebate, state drivers would pay less for transportation fuel because EVs are cheaper to operate than conventional vehicles. This would cause more spending on other Oregon-produced goods and services—including electricity. Second, the rebate would incentivize more EV purchases, and therefore more inflows of the federal government's EV income tax credit, which represents a form of additional net income to Oregon households.

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I. INTRODUCTION

In an effort to increase electric vehicle sales, the Oregon state government has implemented several programs to incentivize electric vehicle use, including tax credits for installing alternative fueling infrastructure and an alternative fuel vehicle (AFV) loan program for public agencies.[1] Until 2011, Oregon also offered a $750 tax credit for alternative fuel vehicles (AFVs). At least in part due to these programs, Oregon has one of the highest EV penetration rates in the country among states without a current EV tax benefit. Indeed, EVs represented 1.1 percent of all new light-duty vehicle sales in 2014.

In order to further encourage EV ownership, some Oregon lawmakers have proposed a tiered rebate program: a $3,000 income tax rebate for the purchase of new battery electric vehicles (BEVs) and a $1,500 income tax rebate for the purchase of plug-in hybrid electric vehicles (PHEVs) with an electric driving range of at least 10 miles.[2] Proponents of the rebate stress the environmental and household benefits associated with increased EV ownership, while opponents argue that the cost to the state budget would outweigh these benefits. This study, commissioned by Securing America's Future Energy (SAFE) in partnership with the Electrification Coalition, quantifies the economic impact of a possible state rebate for EVs on Oregon's economy. It considers what the likely impact would be on Oregon's economy if, in response to the new rebate, some people currently purchasing conventional vehicles instead purchased electric vehicles.

The study adopts a detailed consumer model of the economics of electric vehicle ownership and operation conducted by the Electric Power Research Institute's (EPRI) in 2013 and 2014. For the macroeconomic modeling component, the study relies on a 70-sector model of Oregon's economy developed by REMI, Inc., a leading supplier of regional economic models.

The report is organized as follows: Section II provides policy context behind the current discussion regarding tax incentives for EVs; Section III outlines the study's technical approach and core assumptions; Section IV describes the study's main findings; and Section V offers key conclusions from the modeling exercise. Four technical appendices present the study's detailed results, a full list of its modeling assumptions, a description of the model used to conduct the study, and references.

II. POLICY CONTEXT

Over the past five years, car manufacturers have introduced several new electric vehicles (EVs) into the American light-duty vehicle market. The potential advantages of increased EV ownership are numerous: electric vehicles provide an opportunity to reduce household spending on transportation over the long-run, insulate consumers from gasoline price

[1] http://www.afdc.energy.gov/laws/11063; http://www.afdc.energy.gov/laws/5315

[2] "Proposed Amendments to HB 2092" also include a $750 rebate for electric motorcycles and small neighborhood electric vehicles. These vehicles are not included is this analysis.

fluctuations, improve U.S. energy diversification, and emit minimal to zero tailpipe pollutants.[3] Despite these benefits, EVs account for only a small segment of U.S. vehicle purchases each year. One likely reason for this is that EVs can still be considered an "infant industry". In other words, EVs represent a relatively new technology that may have difficulty gaining market share in an industry dominated by an older technology (in this case, conventional internal combustion engine vehicles). This may be due to a variety of factors, including entrenched consumer habits, an extensive conventional infrastructure (e.g., fueling infrastructure), and the relatively higher cost of younger technologies, which typically lack the economies of scale in production enjoyed by older technologies.

Given these factors, and in light of the benefits associated with increased EV penetration, the federal government has established an income tax credit of up to $7,500 in order to incentivize the uptake of EVs. Because policymakers expect the EV industry to mature over time and compete with conventional internal combustion engine (ICE) vehicles without government support as economies of scale improve and costs decline, the federal credit is available for the purchase of the first 200,000 EVs sold by each auto manufacturer and is set to phase out once sales quotas are reached.

At the state level, lawmakers can amplify the effect of the federal credit by offering their own incentives, such as a tax credit or a rebate. This can allow states to capture the immediate economic benefits associated with federal funds flowing into the state as well as the long-term, sustained benefits of higher EV penetration. More state residents driving EVs translates into reduced overall spending on transportation fuels and vehicle maintenance. Over the long term, this frees up a larger share of household budgets to be spent on other goods and services, including goods and services that are more likely to be produced within the state of Oregon. In Oregon, some policymakers are proposing to capture these benefits by establishing a state rebate for electric vehicles. While critics of the proposed rebate emphasize its likely cost to the state budget, proponents assert that the benefits of reduced gasoline consumption would create positive ripple effects throughout Oregon's economy.

III. METHODOLOGY

3.1 TECHNICAL APPROACH

This study evaluates two core scenarios — (1) a "baseline" scenario in which Oregon continues to have no EV rebate and (2) a "policy" scenario in which the state offers an EV rebate from 2015 to 2019. The rebate's likely impact on state GDP is quantified by comparing results from the policy scenario to the results from the baseline scenario. The study considers a 16-year time horizon, which spans the five years during which the state rebate is assumed to be in place, and is also intended to coincide with the average lifetime of new vehicles (i.e., vehicles purchased in the fifth and final year of the rebate are assumed to be taken off the road in the last year of the modeling time horizon).

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[3] Congressional Budget Office (2012). "Effects of Federal Tax Credits for the Purchase of Electric Vehicles."

The study begins with a "bottom up" approach, starting with an accounting of the household-level response to the introduction of the rebate and aggregating up to the state-level. The study's micro-level consumer cost model is based on the Electric Power Research Institute's (EPRI) 2013 and 2014 reports on the economics of EV ownership, which provide detailed estimates of the cost of owning and operating electric vehicles relative a set of comparison alternate vehicles. To perform the macroeconomic analysis the study relies on a 70-sector model of Oregon's economy developed by REMI, Inc., which is based upon a U.S. Bureau of Economic Analysis input-output database that captures the specific structure of the Oregon state economy and captures the inter-industry flows in activity within the state.

Finally, given the inherent uncertainty in any modeling exercise, this study considers the impacts of introducing a state-level EV rebate under several different scenarios. First, the study includes high and low gasoline price scenarios in addition to a "reference" gasoline price assumption. Second, it adopts the EPRI study's approach to assessing the relative costs of EV ownership by reporting two sets of results: one set assumes that, in the absence of an Oregon EV rebate, all would-be EV-purchasers instead purchase a conventional ICE vehicle, while the other set assumes that they purchase a hybrid ICE vehicle.

3.1.1 Micro-Level Oregon Consumer Model

Introducing a state rebate for EVs in Oregon will cause a number of consumers who would have purchased an ICE vehicle to purchase a BEV or PHEV instead. This behavioral change in response to the change in the incentive structure regarding EVs will decrease the share of consumers' budgets spent on gasoline, leaving more disposable income to be spent on other goods and services throughout the state. It will also increase the number of Oregon households receiving the federal EV tax credit, which can be applied to the cost of a new EV purchase, or toward purchases of additional "other" goods and services.

In order to quantify these changes, this study develops a consumer cost model that represents an individual, "average" Oregon consumer. The consumer model quantifies the impact on the average Oregon consumer's household budget of owning and operating an electric vehicle, instead of a conventional or hybrid ICE vehicle. The development of the consumer model relies heavily on EPRI's 2013 and 2014 reports on the economics of EV ownership. Specifically, the consumer cost model is built around four key cost drivers: vehicle purchase price; electricity cost; gasoline cost; and operating and maintenance costs.

In order to translate the impact of the policy shock on a single consumer's budget into state-level macroeconomic impacts, the results of the consumer are multiplied model by the number of Oregon residents who are expected to be affected by the introduction of the rebate. In order to determine the number of residents affected — in other words, Oregon's "demand response" to rebate — the study compares EV penetration rates in Oregon to penetration rates in a set of comparator states that already have EV tax incentives in place.

Oregon Demand Response

Oregon currently has one of the nation's highest penetration rates for electric vehicles, particularly among states with no EV tax incentive in place. In 2014, 1.1 percent of all vehicle sales were electric vehicles, significantly above the national average of 0.4 percent. Specifically, BEV and qualifying PHEV (i.e., PHEVs with an electric drive range of at least 10 miles) sales totaled 1,841 in 2014. The study's baseline scenario assumes that this rate of annual EV sales continues for the duration of the modeling period. Conversely, the policy scenario assumes that the state rebate would result in 4,418 EVs sold in Oregon per year, an increase of 140% over the baseline scenario. This jump in expected EV purchases quantifies the demand response of Oregon consumers to the introduction of a state rebate, and is based on experience from two of Oregon's neighbors with state-level EV incentives in place: Washington and California. Washington and California were selected as comparator states for Oregon given their regional, cultural, and policy similarities to Oregon. For example, all three states participate in the 'West Coast Green Highway' program, which is working to build out EV charging infrastructure up and down the I-5 interstate corridor. Specifically, this study assumes that if Oregon were to introduce a rebate for EVs, its penetration rate would be generally in line with the penetration rates in Washington and California—scaled for the size of the proposed incentive (see Appendix B – Technical Assumptions for a more detailed description of the demand response calculation).

3.1.2 Macro-Level Oregon State Model

The results of the consumer cost model, scaled up to account for demand response of Oregon consumers to the new rebate, were used as the first of two key input assumptions to the study's macroeconomic model:

(1) **Consumer Spending:** The REMI model uses the aggregate change in the amount and distribution of consumer spending — the output of the micro-level Oregon consumer model — to calculate the impact of the policy on Oregon's economic output. The model assumes that household budgets are fixed. That is, increases or decreases in specific spending categories (e.g., vehicle purchases or gasoline) are offset by reciprocal increases or decreases in other spending categories. An exception to this assumption is the treatment of the federal tax credit and state rebate. Because these incentives are, in effect, additional after-tax income for consumers, they result in spending increases (primarily on motor vehicles) that are not offset by a decrease in other spending. For this reason, the introduction of the Oregon rebate results in a net increase in consumer spending.

(2) **Government Spending:** The second major input to the REMI model is the change in Oregon state government spending as a result of the state rebate. The study assumes that the introduction of the EV rebate causes the state of Oregon to cut its purchases of other goods and services by the same amount that is spent on the rebate. That is, the study explicitly assumes that the net budget position of state of Oregon is unchanged with or without the EV rebate.

Based upon these key input assumptions, the macro model is used to estimate the impact of Oregon's proposed EV rebate on state economic output from 2015 through 2030.

3.2 CORE TECHNICAL ASSUMPTIONS

The results of both the micro-level consumer model and the macro-level state model are dependent upon a set of core assumptions regarding vehicle characteristics, consumer behavior, and economic and price variables.

Most of the study's assumptions regarding vehicle characteristics and the costs of vehicle ownership and operation are taken from the EPRI's 2013 and 2014 studies on the total cost of EV ownership, which provide detailed estimates of the capital, fuel, and maintenance costs for BEVs and PHEVs, as well as a group of comparator conventional and hybrid ICE vehicles. However, this study makes several adjustments to EPRI's assumptions in order to incorporate more recent information regarding the characteristics of vehicle and fuel prices, including more up to date gasoline price assumptions and Oregon-specific electricity price assumptions. A review of the study's core assumptions is included below and a more detailed discussion is presented in Appendix B.

Vehicle Model: As simplifying assumptions, this study takes the price and characteristics of the Nissan Leaf as representative of BEVs sold in Oregon; the Prius Plug-in as representative of "small-battery" PHEVs (i.e., a battery capacity under 10 kWh); and the Chevrolet Volt as representative of "large-battery" PHEVs (i.e., a battery capacity of 10 kWh or greater). The study does not assume a particular model for conventional or hybrid ICE vehicles, but rather relies on EPRI's average vehicle characteristics for comparator conventional and hybrid vehicles.

EV Demand Composition: In both the baseline and policy scenarios, it is assumed that the composition of Oregon EV sales over time is consistent with their composition in 2014 (based on Polk vehicle sales data). Specifically, this study assumes that 71.5 percent of future Oregon EV sales will be BEVs, while 13.4 percent will be small-battery PHEVs, and 15.1 percent will be large-battery PHEVs.

Vehicle Lifetime & Miles Driven: This study assumes that all vehicle types – electric vehicles, hybrids, and conventional vehicles – have a 12-year lifetime. This assumption is based on EPRI's assumption of 150,000 lifetime miles for all vehicle types, and data from the Oak Ridge National Laboratory's 2014 Transportation Energy Data Book suggesting that vehicles travel an average of 12,500 miles per year. Vehicle lifetime is important in the context of the study because it affects the amount of money that consumers must spend to fuel their vehicles over time, and therefore the relative affordability of operating EV versus ICE vehicles.

Gasoline Prices: Gasoline price assumptions are based on regional historical prices reported in the Energy Information Administration's (EIA) January 2015 Short-Term Energy Outlook (STEO), and regional price forecasts reported in the EIA's 2014 Annual Energy Outlook (AEO). This approach grounds the model in recent gasoline price trends while allowing prices to move over time in line with the EIA's latest forecasts. The study assumes a gasoline price in Oregon of $2.62 per gallon in 2015, $3.21 in 2020, $3.74 in 2025, and $4.26 in 2030.

Acknowledging the uncertainty and volatility inherent in predicting gasoline prices, the study also conducts sensitivity analysis around the gasoline price assumption. A high gasoline price scenario adds $1 to the reference case gasoline price assumption for each year, while the low price scenario subtracts $1 each year. Under the low gasoline price scenario, prices are $1.62 a gallon in 2015 and peak at $3.26 per gallon in 2030, while under the high price scenario gasoline prices are $3.62 in 2015 and reach $5.26 in 2030.

Electricity Prices: Electricity price assumptions are based on state-specific historical prices reported in the EIA's December 2014 Monthly Electricity Review (MER) and regional price forecasts reported in the EIA's 2015 Short-Term Energy Outlook (STEO) and 2014 Annual Energy Outlook (AEO). The Oregon electricity price for 2014 from the MER was used as the jumping-off point and this price was increased gradually over time according the regional forecast growth rates in the STEO and AEO. This approach accounts for the significant variation in electricity prices across states, due to different generation sources, while allowing prices to fluctuate over time. Oregon's electricity price is assumed to remain significantly below the national average throughout the forecast period.

Federal Tax Credit "Capture": The size of the federal EV tax credit is based on vehicles' battery capacity; BEVs and large-battery PHEVs receive a larger federal tax credit than small-battery PHEVs.[4] As a simplifying assumption, this study assumes that BEVs and all large-battery PHEVs receive the maximum $7,500 credit amount, while small-battery PHEVs are assumed to receive $2,500 (the amount for which the study's small-battery PHEV representative vehicle, Toyota's Plug-in Prius, is eligible).[5]

The study assumes that Oregon consumers who purchase an EV capture 100% of the amount of the federal credit for which the vehicle is eligible. Survey data indicate that the vast majority of national EV purchasers have household incomes that result in federal tax liabilities above $7,500 — the threshold needed to capture the full federal tax credit.[6] In cases when an EV is leased instead of purchased, it is assumed that leasing companies pass on the full amount of any tax credit in order to provide a more competitive lease rate.[7]

State Rebate "Capture": The study also assumes that Oregon EV purchasers capture 100% of the state rebate. De-linking the process of filing tax returns from receiving the rebate increases the odds that EV purchasers will be able to navigate the required paper work and receive the full rebate amount. Also, tax considerations (e.g., income tax liability) do not interfere with receiving the full amount of the rebate. Further, under the proposed Oregon rebate program, EV lessees will also be eligible to claim the rebate.

Consumer Behavior: Given the cost differential between the average EV and the average conventional vehicle, it is assumed that all EV purchasers make up some of the cost difference by putting the full amount of the federal tax credit received toward the EV purchase. However, the same assumption is not applied to consumer behavior vis-à-vis the Oregon rebate. Instead, the study assumes that one group of EV purchasers treats the state rebate as a necessary

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[4] http://www.irs.gov/Businesses/Plug-In-Electric-Vehicle-Credit-IRC-30-and-IRC-30D
[5] http://www.fueleconomy.gov/feg/taxphevb.shtml
[6] The EV Project (August 2013). "Who are the Participants in the EV Project?" http://www.theevproject.com/cms-assets/documents/128842-80098.devproj.pdf
[7] Jordan Golson (August 2014). "Why It's Cheaper to Lease a New Electric Car than to Buy One Used" *Wired.* http://www.wired.com/2014/08/why-its-cheaper-to-lease-a-new-electric-car-than-to-buy-one-used/

incentive to purchase an EV (i.e., the "treatment group"), and that this group applies the full amount of the rebate toward the cost of the EV. The study assumes that a second group of EV purchasers would have purchased the EV even without the state rebate (i.e., the "control group"), and that this group spends a portion of the state rebate on non-vehicle goods and services, and saves the remainder. The "control group" in Oregon is approximately 40% of total EV purchasers.

IV. RESULTS

The study finds that a $3,000 BEV and $1,500 PHEV rebate would increase Oregon's real GDP each year between 2015 and 2030. Specifically, it finds that the cumulative 5-year GDP boost to the state economy is $38 million, and the cumulative 16-year gain is $83 million, assuming that consumers respond to the rebate by purchasing electric vehicles instead of conventional internal combustion engine vehicles. This overall increase in Oregon GDP occurs despite a general reduction in state government spending by an amount equivalent to the aggregate EV rebates. It also holds under all gasoline price scenarios, and regardless of whether consumers choose to purchase an EV instead of a conventional ICE vehicle, or instead of a hybrid ICE vehicle.

Two key factors account for this increase in real state GDP. First, with significantly more EVs on the road after the introduction of the state rebate, Oregon drivers would pay less for transportation fuel over the coming years, given that EVs cost less to operate than conventional vehicles. Second, the rebate would cause a substantial increase in the number of EVs sold in Oregon, which would boost cash inflows to state households from the federal income tax credit.

The sections below report these results in more detail. Section 4.1 describes the results of the consumer model (i.e., the impact of a new state rebate on consumer and government spending) and Section 4.2 describes the results of the macro model (i.e., the impact on state GDP). Note that all results reported below are consistent with a scenario in which all new EV purchasers would have otherwise purchased a conventional ICE vehicle; Appendix A provides complete results tables that report results for both conventional and the hybrid alternate vehicle scenarios.

4.1 CONSUMER MODEL RESULTS: IMPACTS ON SPENDING

4.1.1 Changes in Consumer Spending

Shifts in Oregon consumer spending in response to the state rebate and the costs of operating an EV versus a conventional vehicle affect several major spending categories:

- **Motor Vehicles:** Spending on motor vehicles increases by roughly $22 million each year from 2015 to 2019, resulting in a cumulative $109 million increase in motor vehicle spending. This shift accounts for the "new" EV purchasers who would have purchased a conventional ICE vehicle in the absence of the state rebate, but chose to pay a higher sticker price for a BEV or PHEV instead.

- **Motor Fuel:** With the EV rebate, spending on electricity increases by a total of $59 million over the modeling period, while gasoline spending falls by $212 million. These spending shifts reflect lower fuel costs for EVs than for conventional vehicles. With the introduction of Oregon's EV rebate, consumers would spend less on motor fuel and more on other goods and services, given the study's fixed household budget assumption (see Figure 1 for the effects of reduced spending on gasoline and increased spending on electricity on "other" spending). Importantly, if the state rebate goes into effect, Oregon households would spend less on motor fuel regardless of the future trajectory of gas prices. According to the study's low gasoline price scenario, total spending on gasoline declines by $151 million by 2030; under the high price scenario, spending falls by $272 million by 2030.

The Impact of an Oil Price Shock

In addition to the low and high gasoline price scenarios, the study also examined the impact of an oil price shock on gasoline spending. In the event that unforeseen economic or political events prompt a severe and sustained oil supply shock – simulated in this study as a sudden $1.50 spike in gas prices in 2020 and 2021 – Oregon consumers would save an additional $7.6 million per year on fuel. This $7.6 million is *on top of* the roughly $16 million in gasoline savings as a result of the state rebate under more typical gas prices. In essence, introducing the rebate would add nearly 12,900 EVs to Oregon roads by 2019, thereby serving as a type of future economic insurance policy against oil price spikes for state consumers.

- **Vehicle Maintenance & Operation:** With an EV rebate, spending on motor vehicle maintenance decreases by $55 million over the modeling period, which frees up $55 million for spending on "other" goods and services, reflecting lower maintenance costs for EVs compared to conventional vehicles. However, based on the EPRI assumption that BEV owners must pay to rent a replacement vehicle on days that require a greater driving range than the BEV is able to provide, the EV rebate increases this "replacement" cost to BEV purchasers by a total of $45 million, reducing general consumer spending by a reciprocal $45 million.[8]

- **Other Consumer Spending:** Finally, because the consumer model assumes that Oregon household budgets are fixed, shifts in motor-vehicle related spending necessarily affect a household's ability to spend on "other" items. Introducing a state EV rebate would have the effect of increasing "other" household spending by Oregon consumers by $191 million over the modeling period, predominantly (although not exclusively) through savings from significantly reduced spending on gasoline. (See Figure 2 for the net change in consumer spending predicted by the consumer cost model).

[8] According to the EPRI studies, PHEV drivers do not pay any vehicle replacement costs, given that PHEVs possess the ability to drive using gasoline when their electric charges run out.

Figure 1. Shifts in Oregon Motor Fuel Spending

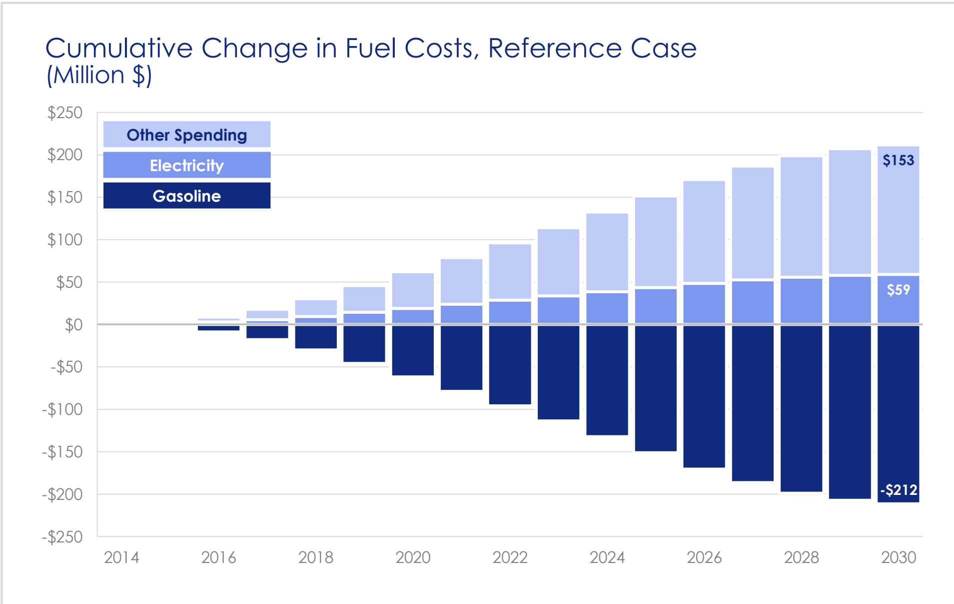
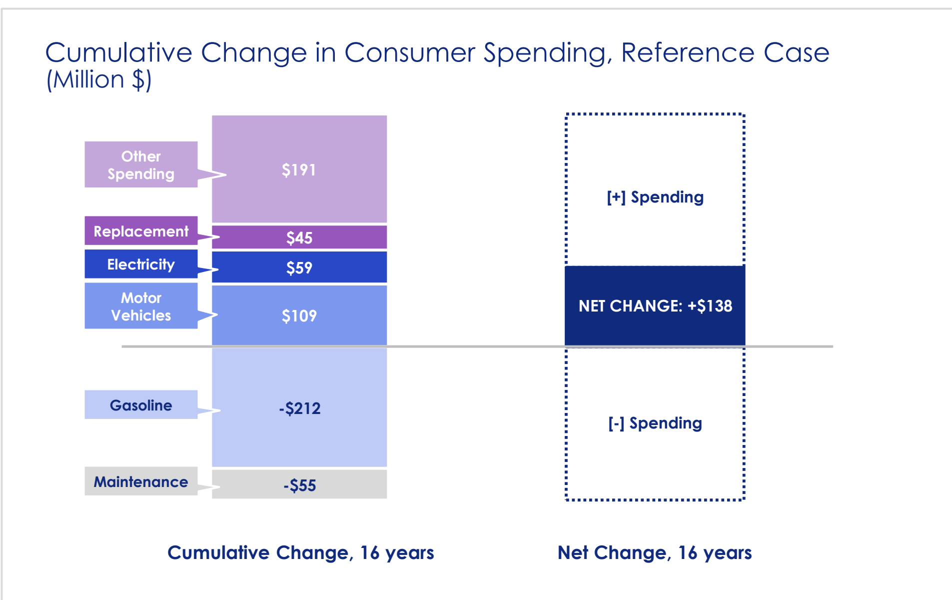


Figure 2. Shifts in Household-Level Consumer Spending



4.1.2 Changes in Government Spending

The introduction of the EV rebate would of course represent a new cost for the Oregon state government. Given this study's "balanced budget" assumption regarding state spending, this is assumed to require reduced government spending in other areas by an amount equivalent to the aggregate EV rebates. Accordingly, the study finds that — based on the number of Oregon consumers that is estimated to purchase an EV in the "policy" scenario — government purchases fall by $11 million in each year from 2015 to 2019, totaling $57 million over the 5-year policy period.

Table 1. Impact on Consumer & Government Spending, Reference Case (Million $)

Impact on Spending	1 Year	5 Years	16 Years
Household-Level			
Motor Vehicle Spending	$21	$109	$109
Electricity Spending	$1	$14	$59
Gasoline Spending	-$3	-$46	-$212
Maintenance Spending	$0	-$9	-$55
Replacement Spending	$1	$10	$45
Other Consumer Spending	$8	$59	$191
State-Level			
Government Spending	-$11	-$57	-$57

4.2 MACRO MODEL RESULTS: IMPACT ON THE STATE ECONOMY

Overall, the study finds that the Oregon EV rebate program would increase the state's real GDP each year between 2015 and 2030. Note that real GDP is equal to aggregate state income and also equal to total state economic output, adjusted for inflation. The cumulative 5-year GDP gain is $38 million, and the cumulative 16-year gain totals $83 million.

The Oregon EV rebates would also increase aggregate consumer spending; in fact, the rebate's effect on aggregate consumer spending is larger than its impact on GDP impact. Specifically, if Oregon were to introduce the rebates in 2015, aggregate consumer spending would increase by $156 million over the 5-year policy period and by $236 million over the full 16-year modeling period. The reason for the larger impact on aggregate spending than on GDP is that motor-vehicles and related goods (including their multiplier effects) are often produced outside of the state of Oregon. This is because Oregon is not a hub of vehicle manufacturing, and goods and services produced outside of the state do not count toward Oregon's GDP.

Table 2. Impact on the State Economy, Reference Case (Million $)

Impact on State Economy	1 Year	5 Years	16 Years
Aggregate Consumer Spending (2009 $)	$29	$156	$236
Real GDP (2009 $)	$6	$38	$83

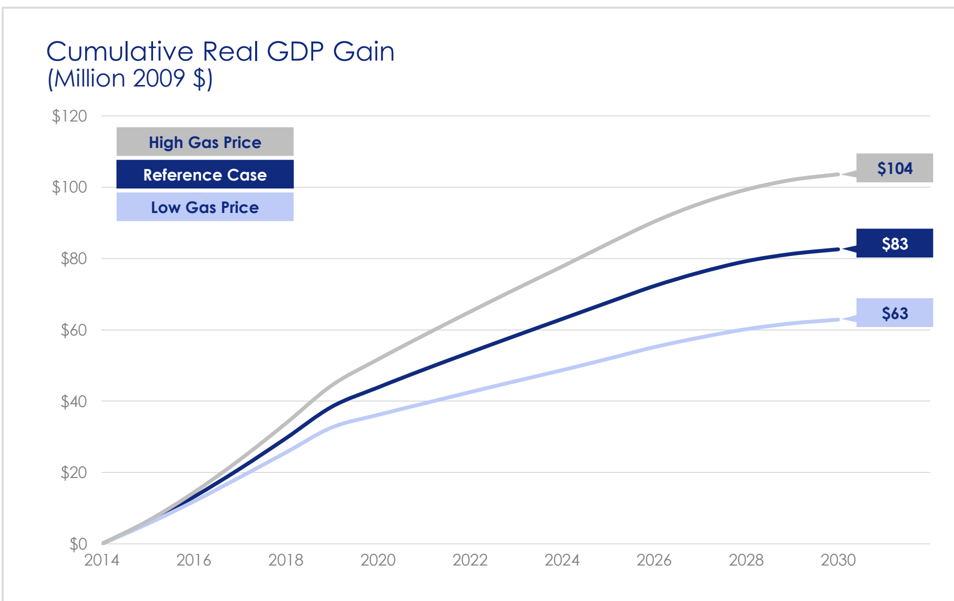
The two most important drivers of changes in aggregate consumer spending, in terms of their GDP impact, are (1) transportation fuel savings, and (2) additional after-tax income from the federal tax credit and state rebate. First, new EV purchasers will spend significantly less on motor fuel as a result of the rebate, which frees up more of their disposable income to be spent on other goods and services. Given that much of the motor fuel-related savings is spent on goods and services produced within the state of Oregon, while petroleum is predominately imported from outside Oregon, this shift in spending positively affects state GDP. Second, with the rebate in effect, new EV purchasers gain additional income from the federal tax credit and rebate.

Most of this additional income is spent on motor vehicles, but some of it is spent on other goods and services. This additional spending has ripple effects throughout the state economy. Again, the overall increase in Oregon GDP occurs despite a decrease in state government spending to offset the cost of the state rebate.

The study's core finding — that Oregon's proposed EV rebate results in a GDP gain in each of the 16 years — remains intact under all gasoline price scenarios and regardless of whether Oregon consumers purchase EVs instead of conventional or hybrid ICE vehicles. In the low gasoline price scenario, GDP increases by a cumulative $33 million in the first five years and by $63 million over the 16-year horizon. In the high gasoline price scenario, GDP increases by $44 million over five years and by $104 million over 16 years.

While consistently positive, the economic impact of the rebate is relatively modest, compared to Oregon's roughly $220 billion economy. This finding is expected, given that EVs are a new technology and that they play a modest role in the overall state economy.

Figure 3. Impact on Oregon Real GDP



V. CONCLUSION

Introducing a $3,000 rebate for BEVs and a $1,500 rebate for PHEVs with an electric driving range of at least 10 miles would boost Oregon's GDP by $83 million over the period from 2015 to 2030. This gain in GDP would be moderately larger if gasoline prices were to increase substantially over the next 16 years, and moderately smaller if gasoline prices were to decline further. However, state GDP would steadily increase each year over the next 16 years for any plausible gasoline price profile.

There are two key channels through which the state rebate would benefit the economy. First, with the presence of the rebate there would be substantially more EVs on Oregon roads, and Oregon households would spend substantially less each year for their transportation fuel. This is because electric vehicles cost less to operate per mile driven than conventional gasoline vehicles. Second, the rebate would incentivize more Oregon households to purchase EVs, which would mean significantly greater inflows of the federal EV tax credit to state residents.

Given the state of play in Oregon and the likely impacts of significantly increasing the number of electric vehicles sold in the state over the next five years, policymakers must weigh a number of factors as they seek to craft an effective policy concerning EVs. These include the degree to which the electric vehicle industry has traditional "infant industry" qualities; the degree to which the state will benefit from leveraging existing federal incentive programs; the degree to which electric vehicles provide an opportunity to reduce household spending on gasoline, and the degree to which they might view the attractiveness of insulating consumers from potential future oil price volatility.

APPENDIX A: DETAILED MODELING RESULTS

Reference Gasoline Price Case (Million $)

EV vs. Conventional ICE	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16
Model Inputs																
Motor Vehicle Spending	$20.5	$21.1	$21.8	$22.4	$23.1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Electricity	$0.9	$1.9	$2.8	$3.8	$4.8	$4.8	$4.8	$4.8	$4.9	$4.9	$5.0	$5.0	$4.1	$3.1	$2.1	$1.1
Gasoline	-$2.6	-$6.1	-$9.1	-$12.3	-$15.7	-$16.2	-$16.7	-$17.3	-$17.9	-$18.4	-$18.9	-$19.4	-$16.0	-$12.2	-$8.4	-$4.3
Maintenance	$0.0	-$0.8	-$1.7	-$2.6	-$3.5	-$4.5	-$4.7	-$4.8	-$5.0	-$5.1	-$5.3	-$5.4	-$4.5	-$3.5	-$2.4	-$1.2
Replacement	$0.6	$1.2	$1.9	$2.6	$3.4	$3.5	$3.6	$3.7	$3.8	$3.9	$4.0	$4.1	$3.4	$2.6	$1.8	$0.9
Government Spending	-$11.4	-$11.4	-$11.4	-$11.4	-$11.4	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Other Consumer Spending	$8.2	$10.2	$11.8	$13.6	$15.6	$12.5	$13.1	$13.6	$14.2	$14.7	$15.2	$15.6	$12.9	$9.9	$6.8	$3.5
Macro Results																
Total Employment (Individuals)	85	94	97	100	99	53	48	45	45	42	43	41	35	27	18	11
Aggregate Consumer Spending (2009 $)	$28.8	$30.4	$31.5	$32.5	$33.0	$9.0	$8.7	$8.5	$8.7	$8.5	$8.6	$8.4	$7.1	$5.6	$3.9	$2.5
Real GDP (2009 $)	$6.1	$7.1	$7.9	$8.5	$8.9	$5.4	$5.0	$4.8	$4.7	$4.6	$4.7	$4.6	$3.8	$3.1	$2.1	$1.3

EV vs. Hybrid ICE	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16
Model Inputs																
Motor Vehicle Spending	$5.9	$6.1	$6.3	$6.5	$6.7	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Electricity	$0.9	$1.9	$2.8	$3.8	$4.8	$4.8	$4.8	$4.8	$4.9	$4.9	$5.0	$5.0	$4.1	$3.1	$2.1	$1.1
Gasoline	-$1.7	-$3.9	-$5.8	-$7.9	-$10.1	-$10.4	-$10.8	-$11.1	-$11.5	-$11.8	-$12.2	-$12.5	-$10.3	-$7.9	-$5.4	-$2.8
Maintenance	$0.0	-$0.2	-$0.4	-$0.6	-$0.9	-$1.1	-$1.2	-$1.2	-$1.2	-$1.3	-$1.3	-$1.4	-$1.1	-$0.9	-$0.6	-$0.3
Replacement	$0.6	$1.2	$1.9	$2.6	$3.4	$3.5	$3.6	$3.7	$3.8	$3.9	$4.0	$4.1	$3.4	$2.6	$1.8	$0.9
Government Spending	-$11.4	-$11.4	-$11.4	-$11.4	-$11.4	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Other Consumer Spending	$21.8	$22.4	$22.8	$23.2	$23.7	$3.3	$3.6	$3.8	$4.1	$4.3	$4.5	$4.6	$3.9	$2.9	$2.0	$1.0
Macro Results																
Total Employment (Individuals)	170	175	175	172	168	39	30	25	24	24	26	27	22	19	15	9
Aggregate Consumer Spending (2009 $)	$33.9	$34.5	$35.0	$35.1	$35.0	$5.7	$5.2	$4.9	$4.9	$4.9	$5.1	$5.0	$4.1	$3.5	$2.8	$1.9
Real GDP (2009 $)	$11.8	$12.7	$13.3	$13.6	$13.7	$4.3	$3.5	$3.2	$3.0	$3.0	$3.2	$3.3	$2.8	$2.4	$1.7	$1.2

Low Gasoline Price Case (Million $)

EV vs. Conventional ICE	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16
Model Inputs																
Motor Vehicle Spending	$20.5	$21.1	$21.8	$22.4	$23.1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Electricity	$0.9	$1.9	$2.8	$3.8	$4.8	$4.8	$4.8	$4.8	$4.9	$4.9	$5.0	$5.0	$4.1	$3.1	$2.1	$1.1
Gasoline	-$1.6	-$4.0	-$6.0	-$8.2	-$10.6	-$11.2	-$11.7	-$12.2	-$12.8	-$13.3	-$13.9	-$14.4	-$11.9	-$9.2	-$6.4	-$3.3
Maintenance	$0.0	-$0.8	-$1.7	-$2.6	-$3.5	-$4.5	-$4.7	-$4.8	-$5.0	-$5.1	-$5.3	-$5.4	-$4.5	-$3.5	-$2.4	-$1.2
Replacement	$0.6	$1.2	$1.9	$2.6	$3.4	$3.5	$3.6	$3.7	$3.8	$3.9	$4.0	$4.1	$3.4	$2.6	$1.8	$0.9
Government Spending	-$11.4	-$11.4	-$11.4	-$11.4	-$11.4	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Other Consumer Spending	$7.2	$8.2	$8.8	$9.6	$10.5	$7.5	$8.0	$8.5	$9.1	$9.6	$10.1	$10.6	$8.9	$6.9	$4.8	$2.5
Macro Results																
Total Employment (Individuals)	78	81	82	79	75	28	26	24	25	23	25	26	21	18	13	8
Aggregate Consumer Spending (2009 $)	$28.2	$28.9	$29.6	$29.8	$29.8	$5.7	$5.6	$5.7	$5.7	$5.6	$5.8	$6.0	$4.8	$4.0	$2.9	$1.7
Real GDP (2009 $)	$5.6	$6.3	$6.8	$6.9	$7.0	$3.5	$3.2	$3.2	$3.1	$3.0	$3.2	$3.3	$2.7	$2.3	$1.7	$1.0

EV vs. Hybrid ICE	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16
Model Inputs																
Motor Vehicle Spending	$5.9	$6.1	$6.3	$6.5	$6.7	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Electricity	$0.9	$1.9	$2.8	$3.8	$4.8	$4.8	$4.8	$4.8	$4.9	$4.9	$5.0	$5.0	$4.1	$3.1	$2.1	$1.1
Gasoline	-$1.0	-$2.6	-$3.9	-$5.3	-$6.8	-$7.2	-$7.5	-$7.9	-$8.2	-$8.6	-$8.9	-$9.2	-$7.7	-$5.9	-$4.1	-$2.1
Maintenance	$0.0	-$0.2	-$0.4	-$0.6	-$0.9	-$1.1	-$1.2	-$1.2	-$1.2	-$1.3	-$1.3	-$1.4	-$1.1	-$0.9	-$0.6	-$0.3
Replacement	$0.6	$1.2	$1.9	$2.6	$3.4	$3.5	$3.6	$3.7	$3.8	$3.9	$4.0	$4.1	$3.4	$2.6	$1.8	$0.9
Government Spending	-$11.4	-$11.4	-$11.4	-$11.4	-$11.4	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Other Consumer Spending	$21.2	$21.1	$20.8	$20.6	$20.5	$0.1	$0.3	$0.5	$0.8	$1.0	$1.2	$1.4	$1.3	$1.0	$0.7	$0.4
Macro Results																
Total Employment (Individuals)	164	168	164	160	153	24	16	12	12	12	14	17	13	12	9	8
Aggregate Consumer Spending (2009 $)	$33.2	$33.6	$33.5	$33.5	$33.1	$3.6	$3.3	$3.1	$3.0	$3.1	$3.2	$3.4	$2.8	$2.4	$1.9	$1.5
Real GDP (2009 $)	$11.4	$12.2	$12.5	$12.7	$12.6	$3.2	$2.4	$2.2	$2.0	$2.1	$2.2	$2.4	$2.1	$1.8	$1.3	$1.0

High Gasoline Price Case (Million $)

EV vs. Conventional ICE	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16
Model Inputs																
Motor Vehicle Spending	$20.5	$21.1	$21.8	$22.4	$23.1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Electricity	$0.9	$1.9	$2.8	$3.8	$4.8	$4.8	$4.8	$4.8	$4.9	$4.9	$5.0	$5.0	$4.1	$3.1	$2.1	$1.1
Gasoline	-$3.7	-$8.1	-$12.1	-$16.3	-$20.8	-$21.3	-$21.8	-$22.3	-$22.9	-$23.5	-$24.0	-$24.5	-$20.0	-$15.3	-$10.4	-$5.3
Maintenance	$0.0	-$0.8	-$1.7	-$2.6	-$3.5	-$4.5	-$4.7	-$4.8	-$5.0	-$5.1	-$5.3	-$5.4	-$4.5	-$3.5	-$2.4	-$1.2
Replacement	$0.6	$1.2	$1.9	$2.6	$3.4	$3.5	$3.6	$3.7	$3.8	$3.9	$4.0	$4.1	$3.4	$2.6	$1.8	$0.9
Government Spending	-$11.4	-$11.4	-$11.4	-$11.4	-$11.4	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Other Consumer Spending	$9.2	$12.2	$14.8	$17.6	$20.6	$17.6	$18.1	$18.6	$19.2	$19.8	$20.2	$20.7	$17.0	$12.9	$8.8	$4.5
Macro Results																
Total Employment (Individuals)	90	105	114	121	124	76	70	67	66	62	63	61	49	36	25	14
Aggregate Consumer Spending (2009 $)	$29.5	$31.8	$33.6	$35.2	$36.1	$12.1	$11.7	$11.7	$11.6	$11.3	$11.6	$11.3	$9.4	$7.3	$5.2	$3.2
Real GDP (2009 $)	$6.4	$8.0	$9.2	$10.2	$10.7	$7.3	$6.8	$6.6	$6.4	$6.3	$6.4	$6.2	$5.1	$3.9	$2.8	$1.5

EV vs. Hybrid ICE	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16
Model Inputs																
Motor Vehicle Spending	$5.9	$6.1	$6.3	$6.5	$6.7	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Electricity	$0.9	$1.9	$2.8	$3.8	$4.8	$4.8	$4.8	$4.8	$4.9	$4.9	$5.0	$5.0	$4.1	$3.1	$2.1	$1.1
Gasoline	-$2.3	-$5.2	-$7.8	-$10.5	-$13.3	-$13.7	-$14.0	-$14.3	-$14.7	-$15.1	-$15.4	-$15.7	-$12.9	-$9.8	-$6.7	-$3.4
Maintenance	$0.0	-$0.2	-$0.4	-$0.6	-$0.9	-$1.1	-$1.2	-$1.2	-$1.2	-$1.3	-$1.3	-$1.4	-$1.1	-$0.9	-$0.6	-$0.3
Replacement	$0.6	$1.2	$1.9	$2.6	$3.4	$3.5	$3.6	$3.7	$3.8	$3.9	$4.0	$4.1	$3.4	$2.6	$1.8	$0.9
Government Spending	-$11.4	-$11.4	-$11.4	-$11.4	-$11.4	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Other Consumer Spending	$22.5	$23.7	$24.7	$25.8	$27.0	$6.6	$6.8	$7.0	$7.3	$7.5	$7.7	$7.9	$6.5	$4.9	$3.3	$1.7
Macro Results																
Total Employment (Individuals)	172	183	185	187	183	53	44	39	38	36	37	38	31	24	17	12
Aggregate Consumer Spending (2009 $)	$34.1	$35.5	$36.1	$36.9	$37.0	$7.8	$7.2	$6.9	$6.9	$6.8	$6.8	$6.8	$5.6	$4.7	$3.5	$2.3
Real GDP (2009 $)	$12.0	$13.3	$14.1	$14.8	$14.8	$5.5	$4.7	$4.3	$4.1	$4.0	$4.1	$4.2	$3.5	$2.9	$2.1	$1.3

APPENDIX B: TECHNICAL ASSUMPTIONS

Vehicle-Specific Assumptions			
INPUT	**VALUE**	**SOURCE**	**NOTES**
Battery Electric Vehicle (Nissan Leaf)			
Purchase Price	$32,927	Nissan MSRP	Average of 3 Leaf Model MSRP
Vehicle Sales Tax	N/A	Tax Foundation	Oregon does not impose a general sales or transaction tax.
Miles Per Gallon	N/A	EPRI (2014)	
kWh per Mile	0.30	DOE	Fueleconomy.gov reported for 2015 Leaf
Share of Miles Using Gasoline	0%	EPRI (2014)	
Annual Maintenance Cost	$88	EPRI (2014)	
Annual Replacement Cost	$325	EPRI (2014)	The costs incurred by EV owners when they have transportation needs beyond the range of an EV and must procure a "replacement" vehicle.
Annual Battery Costs	$0	EPRI (2014)	All EV's experience some battery decline after 8-12 years. However, the EPRI study concludes that there is not yet enough evidence to support a specific cost assumption, and so assumes $0 battery replacement costs. (Note: depending upon the state, vehicle manufacturers have committed to a 100-150,000 mile battery pack warranty)
Plug-in Electric Vehicle, >10 kWh Battery Capacity (Chevrolet Volt)			
Purchase Price	$34,995	Chevrolet MSRP	
Vehicle Sales Tax	N/A	Tax Foundation	Oregon does not impose a general sales or transaction tax.
Miles Per Gallon	37	EPRI (2014)	
kWh per Mile	0.35	DOE	Fueleconomy.gov reported for 2015 Volt
Share of Miles Using Gasoline	38%	Chevrolet	Calculated from direct data on Volt miles driven
Annual Maintenance Cost	$240	EPRI (2014)	
Annual Battery Costs	$0	EPRI (2014)	See Note above.
Plug-in Electric Vehicle, <10 kWh Battery Capacity (Prius Plug-in)			
Purchase Price	$30,815	Toyota MSRP	
Vehicle Sales Tax	N/A	Tax Foundation	Oregon does not impose a general sales or transaction tax.
Miles Per Gallon	50	EPRI (2014)	
kWh per Mile	0.29	DOE	Fueleconomy.gov reported for 2015 Prius Plug-in
Share of Miles Using Gasoline	59%	KBR calc	Calculated using EPRI (2014) total gasoline costs for Prius Hybrid and Prius Plug-in Hybrid
Annual Maintenance Cost	$204	EPRI (2014)	
Annual Battery Costs	$0	EPRI (2014)	See Note above.
Conventional ICE Vehicle			
Purchase Price	$25,000	EPRI (2014)	Subtracted EPRI's 7.2% sales tax to reflect no sales tax in Oregon
Miles Per Gallon	29	EPRI (2014)	Reflects a "blended" conventional model
kWh per Mile	N/A	EPRI (2014)	
Share of Miles Using Gasoline	100%	EPRI (2014)	
Annual Maintenance Cost	$440	EPRI (2014)	
Hybrid ICE Vehicle			
Purchase Price	$30,659	EPRI (2014)	Subtracted EPRI's 7.2% sales tax to reflect no sales tax in Oregon
Miles Per Gallon	43	EPRI (2014)	Reflects a "blended" hybrid model
kWh per Mile	N/A	EPRI (2014)	
Share of Miles Using Gasoline	100%	EPRI (2014)	
Annual Maintenance Cost	$205	EPRI (2014)	

General Assumptions			
INPUT	**VALUE**	**SOURCE**	**NOTES**
Gasoline Price (per gallon)	--	EIA STEO, AEO	No single value; varies by year
Electricity Price (per kWh)	--	EIA MER & AEO	No single value; varies by year
Inflation Rate	3.0%	EPRI (2013, 2014)	
Interest Rate	2.0%	EPRI (2013, 2014)	
Discount Rate (1-5 yr)	2.0%	EPRI (2013, 2014)	
Discount Rate (>5 yr)	5.0%	EPRI (2013, 2014)	
Vehicle Miles	150,000	EPRI (2013, 2014)	EPRI cites NHTSA (2006) Vehicle Survivability and Travel Mileage Schedules
Vehicle Miles Per Year	12,500	ORNL	ORNL 2014 Transporation Energy Data Book estimates annual VMT for light-duty vehicles at 12,928. This number has been rounded down, acknowledging that EV's may be driven slightly less on average than comparative conventional vehicles.
Life of Vehicle (yrs)	12	KBR calc	= Lifetime Miles / Miles per Year; Rounded up to nearest whole year
Baseline EV Sales	1,841	Polk Database	2014 sales (Jan-Oct actual sales*12/10)
Federal Tax Credit, BEV & PHEV (battery capacity >10 kWh)	$7,500	DOE	The study uses the Chevrolet Volt as the representative large-battery PHEV
Federal Tax Credit, PHEV (battery capacity <10 kWh)	$2,500	DOE	The study uses the Toyota Plug-in Prius as the representative small-battery PHEV
State Rebate on BEV	$3,000	--	
State Rebate on PHEV	$1,500	--	Excludes PHEVs with an electric driving range under 10 miles
EV Sales After Policy Shock	4,418	Keybridge calc	See description below for more detail
Demand Response (EV Sales)	+2,577	Keybridge calc	See description below for more detail
Marginal Propensity to Consume	70.0%	Keybridge calc	See description below for more detail
Length of EV Program	5 years	--	

Marginal Propensity to Consume (MPC) – Detailed Methodology

According to economic theory, households tend to save a portion of temporary income, such as a tax credit or rebate. The proportion of income spent depends on several factors, including income, wealth, and financial liquidity.[9] This study's assumption regarding the marginal propensity to consume of Oregon households affects the size of the policy shock's GDP impact. However, the MPC assumption only affects a subset of Oregon EV-owners.[10]

- The "treatment group" of Oregon EV purchasers includes those consumers who are assumed to require the state incentive in order to purchase an EV. The MPC assumption does not apply to them, given that they are assumed to apply the full value of the state rebate to the vehicle purchase.

- The "control group" of Oregon EV purchasers includes consumers who would have purchased an EV without the state incentive. Because Oregon does not currently offer an EV rebate, the size of the control group is based directly on actual 2014 vehicle sales data. The MPC assumption does apply to this group, given that they treat the rebate as "extra" money and do not apply it to the vehicle purchase.

This study adopts a three-step income-based approach in order to calculate the MPC of the "control group" of Oregon EV purchasers:

(1) The U.S. 2013 Census Bureau's Consumer Expenditure Survey (CEX) reports average propensity to consume by income quintile. These data were used to calculate the MPC for each quintile: *change in consumption between quintiles / change in after-tax income between quintiles*

(2) 2013 survey data from The EV Project, funded by the Department of Energy, indicate that the majority of EV owners tend to have income in the top fourth and fifth quintiles. These data were applied to the CEX-based MPCs by quintile to develop a weighted average MPC: 65%.

(3) Finally, it is important to note that some EV owners lease rather than purchase their vehicles, and consumers who lease vehicles are assumed to have somewhat lower income than consumers who purchase vehicles. It is also assumed that household income levels of EV purchasers will tend to decline somewhat over the next 5 years as these vehicles are increasingly viewed as more mainstream purchases. For these reasons, this study rounds up the calculated 65% MPC assumption to 70%.

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[9] In general, recent literature puts the U.S. MPC in the range of 40-90%. See Parker (2014).

[10] The division of Oregon EV-purchasers is based on Polk vehicle sales data. The share of consumers in the "control group" is based on 2014 EV sales in Oregon, while the share of consumers in the "treatment group" is based on data from neighboring states (see "Demand Response" discussion on page B-4).

Demand Response – Detailed Methodology

Due to the limited economic literature on the relationship between electric vehicle incentives and sales, this study estimates Oregon consumers' response to the proposed rebate using historical vehicle sales data from two comparison states – Washington and California – both of which currently have an EV tax incentive in place. Washington and California were selected as comparison states due to their regional proximity to Oregon, and general cultural and policy similarities. For example, all three states share very similar charging infrastructure, the scale of which is high relative to the rest of the country.

Specifically, if Oregon were to institute a state rebate for EVs, the study assumes that state demand for BEVs and PHEVs with an electric driving range of more than 10 miles will be equivalent to the average penetration rate between Washington and California, scaled to reflect the slightly larger size of the proposed Oregon incentive.

- **California:** Offers a $2,500 rebate for BEVs and a $1,500 rebate for PHEVs; the sales-weighted average rebate is $2,041. The EV penetration rate in California was 2.9 percent of all new light-duty vehicles sold in 2014.
- **Washington:** Offers a state sales tax exemption for BEVs, which is worth an average of approximately $2,200 per vehicle. The EV penetration rate in Washington was 1.6 percent of all new light-duty vehicles sold in 2014.
- **Oregon Demand Response:** The proposed Oregon rebate is $3,000 for BEVs and $1,500 for PHEVs with an electric driving range over 10 miles. The current combined EV penetration rate in the state is 1.1 percent of all new light-duty vehicle sales. Oregon's demand response is calculated using the average of the California and Washington EV penetration rates, 2.2%, which is then scaled to reflect the larger size of the Oregon rebate relative to incentives in Washington and California. Specifically, the demand response to a new state rebate is assumed to push the EV penetration rate up to 2.7 percent of all new light-duty vehicles sold in 2015 through 2019 (when the policy is assumed to expire).

Based upon these assumptions, EV sales in Oregon would equal 4,418 each year of the policy period, a 140% increase in EV sales from 2014 levels. The breakdown between sales of BEVs and PHEVs is assumed to remain consistent with the relative shares of new EVs sold in 2014: 71.5 percent of all new EVs sold during the policy period are assumed to be BEVs, 13.4 percent are assumed to be PHEVs with a battery capacity under 10 kWh, and the remaining 15.1 percent are assumed to be PHEVs with a battery capacity of at least 10 kWh.[11]

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[11] Polk Vehicle Database

APPENDIX C: REMI MODEL DESCRIPTION

To perform this analysis, Keybridge relied upon an economic model of Oregon produced by Regional Economic Modeling Inc. (REMI). The REMI PI+ model is a structural economic forecasting and policy analysis model. It integrates input-output, computable general equilibrium, econometric and economic geography methodologies. The model is dynamic, with forecasts and simulations generated on an annual basis and behavioral responses to compensation, price, and other economic factors. The model consists of thousands of simultaneous equations with a structure that is relatively straightforward. The exact number of equations used varies depending on the extent of industry, demographic, demand, and other detail in the specific model being used. The overall structure of the model can be summarized in five major blocks: (1) Output and Demand, (2) Labor and Capital Demand, (3) Population and Labor Supply, (4) Compensation, Prices, and Costs, and (5) Market Shares.

The Output and Demand block consists of output, demand, consumption, investment, government spending, exports, and imports, as well as feedback from output change due to the change in the productivity of intermediate inputs. The Labor and Capital Demand block includes labor intensity and productivity as well as demand for labor and capital. Labor force participation rate and migration equations are in the Population and Labor Supply block. The Compensation, Prices, and Costs block includes composite prices, determinants of production costs, the consumption price deflator, housing prices, and the compensation equations. The proportion of local, inter-regional, and export markets captured by each region is included in the Market Shares block.

Models can be built as single region, multi-region, or multi-region national models. A region is defined broadly as a sub-national area, and could consist of a state, province, county, or city, or any combination of sub-national areas. Single-region models consist of an individual region, called the home region. The rest of the nation is also represented in the model. However, since the home region is only a small part of the total nation, the changes in the region do not have an endogenous effect on the variables in the rest of the nation.

Block 1. Output and Demand

This block includes output, demand, consumption, investment, government spending, import, commodity access, and export concepts. Output for each industry in the home region is determined by industry demand in all regions in the nation, the home region's share of each market, and international exports from the region.

For each industry, demand is determined by the amount of output, consumption, investment, and capital demand on that industry. Consumption depends on real disposable income per capita, relative prices, differential income elasticities, and population. Input productivity depends on access to inputs because a larger choice set of inputs means it is more likely that the input with the specific characteristics required for the job will be found. In the capital stock adjustment process, investment occurs to fill the difference between optimal and actual capital stock for residential, non-residential, and equipment investment. Government spending changes are determined by changes in the population.

Block 2. Labor and Capital Demand

The Labor and Capital Demand block includes the determination of labor productivity, labor intensity, and the optimal capital stocks. Industry-specific labor productivity depends on the availability of workers with differentiated skills for the occupations used in each industry. The occupational labor supply and commuting costs determine firms' access to a specialized labor force.

Labor intensity is determined by the cost of labor relative to the other factor inputs, capital and fuel. Demand for capital is driven by the optimal capital stock equation for both non-residential capital and equipment. Optimal capital stock for each industry depends on the relative cost of labor and capital, and the employment weighted by capital use for each industry. Employment in private industries is determined by the value added and employment per unit of value added in each industry.

Block 3. Population and Labor Supply

The Population and Labor Supply block includes detailed demographic information about the region. Population data is given for age, gender, and race, with birth and survival rates for each group. The size and labor force participation rate of each group determines the labor supply.

These participation rates respond to changes in employment relative to the potential labor force and to changes in the real after-tax compensation rate. Migration includes retirement, military, international, and economic migration. Economic migration is determined by the relative real after-tax compensation rate, relative employment opportunity, and consumer access to variety.

Block 4. Compensation, Prices and Costs

This block includes delivered prices, production costs, equipment cost, the consumption deflator, consumer prices, the price of housing, and the compensation equation. Economic geography concepts account for the productivity and price effects of access to specialized labor, goods, and services.

These prices measure the price of the industry output, taking into account the access to production locations. This access is important due to the specialization of production that takes place within each industry, and because transportation and transaction costs of distance are significant. Composite prices for each industry are then calculated based on the production costs of supplying regions, the effective distance to these regions, and the index of access to the variety of outputs in the industry relative to the access by other uses of the product.

The cost of production for each industry is determined by the cost of labor, capital, fuel, and intermediate inputs. Labor costs reflect a productivity adjustment to account for access to specialized labor, as well as underlying compensation rates. Capital costs include costs of nonresidential structures and equipment, while fuel costs incorporate electricity, natural gas, and residual fuels.

The consumption deflator converts industry prices to prices for consumption commodities. For potential migrants, the consumer price is additionally calculated to include housing prices.

Housing prices change from their initial level depending on changes in income and population density.

Compensation changes are due to changes in labor demand and supply conditions and changes in the national compensation rate. Changes in employment opportunities relative to the labor force and occupational demand change determine compensation rates by industry.

Block 5. Market Shares

The market shares equations measure the proportion of local and export markets that are captured by each industry. These depend on relative production costs, the estimated price elasticity of demand, and the effective distance between the home region and each of the other regions. The change in share of a specific area in any region depends on changes in its delivered price and the quantity it produces compared with the same factors for competitors in that market. The share of local and external markets then drives the exports from and imports to the home economy.

APPENDIX D: REFERENCES

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