Transportation 2040 Update

Toward a sustainable transportation system

Appendix L: Climate Change Background

MAY 29, 2014
Appendix L: Climate Change Background

Included in this appendix is a status report on the implementation of PSRC’s Four-Part Greenhouse Gas Strategy since the adoption of Transportation 2040 in 2010, encompassing land use, transportation choices, user fees and technology. Described in greater detail is the background on the vehicle and fuel technology research that was conducted to develop the technology scenarios included in the Strategy, and the methodology to apply the Strategy to the modeled output of Transportation 2040. The results of the Strategy are updated to reflect new information since the adoption of Transportation 2040 in 2010, including the following:

- 2014 Transportation 2040 Update project updates
- New PSRC travel, land use and economic forecasting models
- A change in the motor vehicle emissions software from the Environmental Protection Agency
- New fuel economy and greenhouse gas standards

The plan as adopted in 2010 also included a white paper on adaptation to climate change, specific to the central Puget Sound region’s transportation system. This information is still contained within the original Appendix L, located on PSRC’s website at http://www.psrc.org/assets/4888/Appendix_L_-_Climate_Change_-_FINAL_-_August_2010.pdf.

INTRODUCTION

Transportation 2040 as adopted in 2010 contained a Four-Part Greenhouse Gas Strategy:

- **Land Use**: implement VISION 2040, further the goal of balancing jobs and housing, focus growth in centers and provide for efficient communities;
- **User Fees**: transition the region over time to a user fee/roadway pricing system;
- **Choices**: continue to provide travelers options to the single-occupant vehicle;
- **Technology**: support development of technology to dramatically reduce tailpipe emissions;

PSRC in collaboration with the Washington State Department of Ecology created two scenarios of potential technological improvements by 2040 – a Likely and an Aggressive scenario.

Transportation 2040 includes programs and investments that encompass all four of these strategies, and since plan adoption in 2010 many actions have been taken at the federal, state and regional level to advance implementation of the Strategy. Of most significance is the adoption of new federal fuel economy and greenhouse gas standards for passenger vehicles and trucks, which has exceeded the Likely technology scenario and advanced the Aggressive scenario before 2040. The sections below provide information on these implementation actions, and the updated results of the Four-Part Greenhouse Gas Strategy for the 2014 Transportation 2040 Update.

In addition to minor updates to the plan itself, the suite of modeling tools used by PSRC has been updated. This includes changes to the travel demand model, land use forecast, economic forecast and a transition to the use of EPA’s new emissions software, MOVES (Motor Vehicle Emission Simulator). These changes are described in greater detail in Appendix H. One key impact for the Transportation 2040 Update is that the current version of MOVES – MOVES 2010b – incorporates new Corporate Average Fuel Economy (CAFÉ) and greenhouse gas standards adopted through September 2010. Additional CAFÉ standards were adopted after this date but are not captured in the current version of MOVES; these additional improvements are reflected in the application of the technology assumptions described in Attachment 1 to this document.

**Land Use Implementation**

Since adoption of Transportation 2040 in 2010, many activities related to the land use component of the Strategy are ongoing or have been completed. These include the following:

- Local adoption of growth targets within each county in the region, to begin implementation of VISION 2040’s Regional Growth Strategy;
The Growing Transit Communities Partnership, including the adoption of corridor action strategies, a regional equity network, an affordable housing strategy, and demonstration projects; more information on the Growing Transit Communities program may be found on PSRC’s website at http://www.psrc.org/growth/growing-transit-communities;

PSRC’s Housing Innovations Program, providing resources to promote housing affordability and Smart Growth, such as a housing toolkit and survey;

New regional centers designation procedures approved by the PSRC Board in 2011;

The Transfer of Development Rights Program, including the adoption of Regional TDR Allocations under the Landscape Conservation and Local Infrastructure Program, as well as grant funding awarded to cities for planning and program development;

An analysis of industrial lands will be updated in 2014;

Updates to Countywide Planning Policies as part of the 2015-16 Comprehensive plan update process.

User Fees Implementation

Since adoption of Transportation 2040 in 2010, several studies have been completed or are currently underway by the Washington State Department of Transportation, such as for State Route (SR) 167, SR 509 and Interstate 405. In addition, recommendations from the SR 99 Advisory Committee on Tolling and Traffic Management are expected to be finalized by the end of 2015. Perhaps most significant, the region now has an all-electronic time of day tolling system on the SR 520 bridge, and evaluation of the system will continue.

Transportation Choices Implementation

Since adoption of Transportation 2040 in 2010, the region has continued to work on several new initiatives such as transit service overlay zones and the Growing Transit Communities project mentioned above. In addition, the 2014 Transportation 2040 Update includes a new Active Transportation Plan including a new regional bicycle network, an update to the Coordinated Transit and Human Services Plan, and an update to the Regional TDM Action Plan. The region’s investment in light rail also continues to move forward, with some significant milestones completed or underway. For example, the South 200th Link Light Rail extension has been completed, the University Link Light Rail extension is under construction, and total ridership continues to increase.

In addition, many investments identified in Transportation 2040 are completed or under construction. A few examples of these are identified below:

- King County Metro’s RapidRide A, B, C and D lines
- Community Transit’s Swift line
- Seattle’s First Hill Streetcar
- Sound Transit’s South 200th Link Light Rail extension
- an extension of the Centennial Trail
- a missing link for the Interurban Trail
- the Burien Transit Center

Technology Implementation

Since the adoption of Transportation 2040 in 2010, significant federal actions have been taken to improve the fuel economy of vehicles and reduce emissions from fuels. These include new Corporate Average Fuel Economy standards, improving the fuel efficiency of heavy duty vehicles, and further implementation of the national Renewable Fuel Standard. The CAFÉ standards have surpassed the assumptions in the Strategy for improved fuel economy in the Likely scenario and have met the Aggressive scenario assumptions well in advance of 2040. The improvements to fuel efficiency for heavy duty vehicles have surpassed the Likely scenario assumptions, and it is expected that additional improvements will be seen over the next several years which will pass the current Aggressive scenario assumptions.

In addition, actions have been taken in Washington State to advance vehicle electrification through strategies such as the West Coast Green Highway, implementation of public charging stations, PSRC’s work on electric vehicle model guidance, and others. Additional details are provided below:

Federal Activities

- Electric vehicles
ongoing research by US Department of Energy and continuation of the federal tax credit
- New Corporate Average Fuel Economy and greenhouse gas standards
  - Fleet average of 35.5 mpg by 2016, 49.7 mpg by 2025
- Renewable Fuel Standard Program
  - Continued refinements and expansions of the program regarding fuel type and volume/percentage requirements
  - Improvements to medium and heavy duty vehicles
    - 10-20% reduction in fuel consumption by 2018
    - Second phase of regulations for beyond model year 2018 planned

State, Regional, Local Activities
- Electric vehicles
  - Electric vehicle model guidance
  - West Coast Electric Highway
  - the EV project
- Washington State low carbon fuel standard
  - 2011 assessment and recommendation
  - Under consideration by the Governor’s 2013 Climate Legislative and Executive Workgroup
    - CLEV created under ESSB 5802 and charged with recommending a state program of actions and policies to reduce greenhouse gas emissions to ensure achievement of the state’s emissions reductions limits, including an evaluation of the effectiveness, impacts, costs, opportunities and trade-offs of the recommended approaches by the end of 2013
- Western Washington Clean Cities Association
  - Ongoing work on alternative vehicles and fuels for fleets
  - Public/private partnership
- 2012 State Energy Strategy
  - emphasizes a more efficient and coordinated transportation system as one of the greatest potentials to transform energy use to promote both jobs and climate stability
  - encourages more efficient vehicles, improvements to fuels, and reducing vehicle trips and miles traveled

Results
The results of Transportation 2040’s Four-Part Greenhouse Gas Strategy, updated for the 2014 Transportation 2040 Update, are illustrated in the chart below. Transportation 2040 has two components – the Financially Constrained portion of the plan, and projects and programs in the Unprogrammed portion of the plan, the combination of which comprise the full plan. Annual emissions of carbon dioxide equivalents (CO2e) are used to represent greenhouse gas emissions.

As illustrated in the chart, the updated results of the Four-Part Greenhouse Gas Strategy produce a range of emissions reductions between 19% and 36% below 2006 modeled emissions in the year 2040. As a comparison, the state’s greenhouse gas emission reduction limits are to return to 1990 levels by 2020, reduce emissions to 25% below 1990 levels by 2035, and 50% below 1990 levels by 2050; these limits are economy-wide and not sector specific.

As mentioned previously, PSRC is using an updated suite of modeling tools for the 2014 Transportation 2040 Update as compared to the analysis conducted for the adopted plan in 2010. These include revisions to the travel demand model, including an expanded transportation network; new land use assumptions to reflect adopted growth targets; a new economic forecast based on current assumptions; and the use of EPA’s MOVES 2010b model which incorporates new fuel economy and greenhouse gas standards through September 2010. The combination of these updated tools produces different results than were reported for the adopted plan in 2010. However, the 2006 base year and the adopted plan have also been recalibrated to the new modeling framework to ensure consistent comparisons. The results illustrated in the chart below reflect the incorporation of new

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As mentioned previously, PSRC does not have data for the 1990 year referenced in statute that is consistent with our current modeling framework; 2006 is our earliest modeled year and is therefore provided for the purposes of greenhouse gas emissions comparisons.
standards in MOVES 2010b and changes in regional vehicle miles traveled due to the other modeling updates, as well as changes incorporated into the 2014 Transportation 2040 Update as described in the plan document. The model suite changes and their respective impacts are described in greater detail in Appendix H.

As was the case for the plan as adopted in 2010, these results are consistent with national and state data suggesting that multiple strategies across all sectors is necessary to reduce emissions and meet climate goals. PSRC continues to work with federal, state and local partners to advance the investments in Transportation 2040 and continues working towards the implementation of the Four-Part Greenhouse Gas Strategy.

In addition to the state’s greenhouse gas emissions reduction limits, Washington State has established benchmarks for reducing per capita vehicle miles traveled (VMT). The benchmark is based on a statewide forecast of 75 billion VMT by 2020; trucks over 10,000 pounds gross vehicle weight are exempted. The statutory benchmarks are to decrease annual per capita VMT 18% by 2020, 30% by 2035 and 50% by 2050.

Transportation 2040 as adopted in 2010 demonstrated that VMT per capita in the region was already meeting the state’s 2020 benchmark, and additional reductions were estimated by 2040 in line with the 2035 and 2050 benchmarks. The 2014 Transportation 2040 Update makes further progress towards meeting the state’s VMT benchmark reductions, with a 39% reduction from the state’s baseline by 2040 for the Constrained plan, and 40% for the full plan.
VMT Per Capita

2020 Baseline
18% by 2020
30% by 2035
50% by 2050

2040 Contrained Plan  2040 Full Plan
Attachment 1: Technology Methodology and Background

This paper focuses on the details included in the technology component of the Strategy, which makes some assumptions about the market penetration of electric and other alternative fuel vehicles, less carbon-intensive fuels, and improved fuel efficiency of the overall passenger and freight fleets.

In collaboration with the Washington State Department of Ecology, PSRC developed two technology scenarios: a “likely” scenario and an “aggressive” scenario. The likely scenario was developed based on assumptions about what technology impacts by 2040 would be probable, given current trends at the time the plan was adopted and conservative assumptions about fuel prices and other incentives to change technology. The aggressive scenario assumed a higher degree of concerted effort to transition the vehicle fleet to a more energy efficient approach. These scenarios, based on extensive national research and in consultation with the Environmental Protection Agency, the Washington State Department of Transportation and the Puget Sound Clean Air Agency, are identified in the chart below. The likely scenario as applied to Transportation 2040 as adopted in 2010 resulted in an additional 25% reduction of greenhouse gas emissions from a business as usual alternative. The aggressive scenario resulted in an additional 43% reduction in emissions, beyond the reductions achievable from the transportation and land use strategies contained in Transportation 2040. The application of these likely and aggressive technology improvements in the region, in addition to the investments in Transportation 2040 as adopted in 2010, resulted in a total greenhouse gas emissions reduction between 5% and 28% below 2006 levels.

### Potential Vehicle and Fuel Technological Improvements in the Central Puget Sound Region by 2040

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<th>LIKELY SCENARIO</th>
<th>AGGRESSIVE SCENARIO</th>
</tr>
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<tbody>
<tr>
<td>Percent of Electric Vehicles in Fleet</td>
<td>20%</td>
<td>45%</td>
</tr>
<tr>
<td>Improvements to Fuel Economy</td>
<td>40 mpg</td>
<td>50 mpg</td>
</tr>
<tr>
<td>Reduction of Carbon Intensity of Fuel</td>
<td>10%</td>
<td>25%</td>
</tr>
<tr>
<td>Improvements to Heavy Duty Vehicles</td>
<td>5%</td>
<td>10%</td>
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Each component of the technology assumptions are further described in the following sections, including how the assumptions were applied to the modeled output of the investments and strategies contained in Transportation 2040 as adopted in 2010, and incorporating changes and model updates as part of the 2014 Transportation 2040 Update.

### SECTION 1: BACKGROUND

The following discussion details the research conducted by PSRC and Ecology, and describes how the assumptions related to the vehicle and fuel technological improvements laid out in the table above were reached. The Likely and Aggressive scenarios were developed for the plan as adopted in 2010, and are not being updated for the 2014 Transportation 2040 Update. For the next full plan update scheduled for 2018, PSRC will work with Ecology, EPA and others to review and develop new assumptions as appropriate, given recent and proposed advancements in vehicle and fuel technology.

#### 1A. Percent of Electric Vehicles in the Central Puget Sound Vehicle Fleet

The first supposition regarding the potential for improvements to the vehicle fleet in the Puget Sound region is what portion of the fleet might be converted to electric or hybrid-electric vehicles by 2040. Research conducted on this topic included studies and analyses conducted by the following agencies or institutions (a full bibliography of sources is included at the end of this white paper):

- University of California at Berkeley
- Argonne National Laboratory
- U.S. Environmental Protection Agency (EPA)

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2 PSRC does not have a 1990 base year within the current modeling framework, which is the year on which the state’s greenhouse gas goals are based. 2006 is the earliest year to which plan results can be compared.
There are scenarios within these studies and analyses suggesting the percentage of electric or hybrid-electric vehicles in the national fleet could be anywhere from 9% to 50%. For example, the University of Michigan’s “PHEV marketplace penetration: An agent based simulation” study indicates a fleet penetration by 2030 of 16%, while the UC Berkeley’s “Electric Vehicles in the United States, A New Model with Forecasts to 2030” study reports a possible fleet penetration of 24%. EPA’s “A Wedge Analysis of the U.S. Transportation Sector” study, on the other hand, suggests that vehicle technology combined with alternative fuels can represent a 30% market share by 2050. On the lower end, a 2006 presentation by EPA on “Plug-In Hybrids: Background and Scenario Analysis” cited a modeling scenario resulting in a 9% fleet penetration by 2030.

Most of the studies and analyses researched are forecasting to either the year 2020 or 2030 and reporting on national fleet penetration rates, whereas Transportation 2040 is looking at potential vehicle and fuel improvements in the Puget Sound region by the year 2040. One point of consideration in creating our assumptions was that by 2040 the Puget Sound fleet should be as close as possible to a full fleet turnover. Further, Washington State and the Puget Sound region are already looking forward on this issue, with several pieces of state legislation and numerous local actions underway with regards to electric vehicle infrastructure, as described earlier in this document.

Several of the reference documents also point out that it is most likely that the penetration into the fleet of electric vehicles will occur first in the West Coast, since this area has the highest percentage of hybrid vehicle registrations and has the highest demand for these vehicles. In addition, these sources cite the current planning efforts to deploy electric vehicle infrastructure. For example, an analysis conducted by R.L. Polk & Company indicates that registrations nationwide for new hybrid vehicles rose 38% between 2006 and 2007, and that Washington ranked 5th in total hybrid registrations. Growth in Washington State hybrid purchases between 2006 and 2007 was 52% according to this study.

Based on the research summarized above, the movement in Washington State and the region regarding electric vehicle infrastructure, and the timeframe of 2040, we categorized the potential fleet penetration of electric vehicles into the Puget Sound fleet by 2040 into the following two scenarios:

**Likely Scenario: 20%**

This scenario is comprised of a fairly conservative assumption that by 2040, 20% of the Puget Sound fleet would be electric, plug-in hybrid electric or other zero to low emission vehicles. Washington State had approximately 4% of the national share of new hybrid vehicle registrations in 2007; given current issues with reporting at the local level, it is unclear what percentage of the Puget Sound fleet are hybrids or other alternative vehicles, but the Seattle metropolitan region is reported to be second in the nation in per capita hybrid vehicles registrations. It is likely that the share of alternative vehicles in our region will continue to increase over the next 30 years. Given the growth rate of hybrid vehicle sales nationally over the past several years, and the interest nationally and regionally in more efficient vehicle technology, we feel that 20% is a conservative assumption for the region’s 2040 fleet.

**Aggressive Scenario: 45%**

This scenario is comprised of a more aggressive assumption that by 2040, should the region, the state and the federal government more actively pursue the transition to alternative vehicles, 45% of the Puget Sound fleet could be electric, plug-in hybrid electric or other zero to low emission vehicles. Many of the studies and analyses researched indicate the possibility of a greater penetration into the national fleet of alternative vehicles than our conservative scenario. The conservative, or likely, scenario is based on the current conditions in our region and the expected growth in the market. Given all the other factors mentioned – the

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3 The phrase “zero emission vehicles” refers only to the tailpipe emissions; for a discussion of possible “upstream” emissions from these types of vehicles, refer to Section 2.
impetus in Washington State and the Puget Sound region, the expected full fleet turnover by 2040, and the expected national agenda on clean technology – a more aggressive fleet penetration of 45% seems reasonable should a more focused pursuit of this transition occur at all levels.

1B. Improvements to Vehicle Fuel Economy

The second supposition regarding the potential for improvements to the vehicle fleet in the Puget Sound region is what additional improvements in fuel economy might be possible by 2040. Research conducted on this topic included studies and analyses conducted by the following agencies or institutions (a full bibliography of sources is included at the end of this white paper):

- National Highway Traffic Safety Administration (NHTSA)
- Cambridge Systematics
- U.S. EPA
- California Air Resources Board
- Energy Information Administration (EIA)
- Congressional Budget Office
- U.S. Department of Energy

In September 2009, NHTSA and EPA released a joint proposed rule to update the current Corporate Average Fuel Economy (CAFÉ) standards for the light-duty passenger vehicle fleet. Previously, the CAFÉ standards were 27.5 miles per gallon (mpg) for passenger vehicles and 20.7 mpg for light trucks; the light truck standards were updated in 2006 to 23.5 mpg by model year 2010. In March 2009, as a precursor to the subsequent rulemaking, NHTSA set a new standard for model year 2011 vehicles of 30.2 mpg for passenger cars and 24.1 mpg for light trucks, for a combined fleet average of 27.5 mpg. The new CAFÉ standards were finalized in May 2010 and will apply to both passenger cars and light trucks manufactured in model years 2012 through 2016; the joint rulemaking with EPA’s proposed greenhouse gas emissions standards for light duty vehicles will achieve a combined average of 35.5 mpg by model year 2016.

Given the movement nationally to improve the fuel economy of the future vehicle fleet, activity in California related to fuel economy improvements, as well as legislation in Washington State related to clean vehicles and alternative fuels, we categorized the potential for future fuel economy improvements to the Puget Sound vehicle fleet by 2040 into the following two scenarios:

- **Likely Scenario: 40 mpg**
  This scenario is comprised of a fairly conservative assumption that by 2040, further strengthening of the CAFÉ standards for the passenger vehicle fleet is likely. This scenario assumes that the average fuel economy of the Puget Sound passenger vehicle fleet in 2040 will be 40 mpg, compared to the new standards finalized in 2010 which would achieve a fleet average nationally of 35.5 mpg by model year 2016.

- **Aggressive Scenario: 50 mpg**
  This scenario is comprised of a more aggressive assumption that by 2040, there is the potential that even greater improvements to vehicle fuel economy can be achieved. This scenario assumes a continued interest at the national level in pursuing cleaner and more efficient vehicles, from a 34.1 mpg national fleet average in 2016 to a 50 mpg fleet average in the Puget Sound region by 2040.

Since the adoption of Transportation 2040 in 2010, additional rulemaking has occurred to improve fuel economy and greenhouse gas emissions from motor vehicles beyond model year 2016. New CAFÉ and greenhouse gas standards for model years 2017-2025 were finalized in August 2012, which will result in a combined fleet average of 49.7 mpg by 2025. As mentioned above, the Likely and Aggressive scenarios are not being updated at this time, but will be reviewed and revised as appropriate as part of the 2018 plan update process.

It is important to note here that the categories of technology improvements outlined in this report are not mutually exclusive. For example, one way to improve the average fuel economy of the fleet is to include electric vehicles and/or reduce the carbon content of fuels. As such, while the assumptions for each category are fully described separately in Section 1, the methodology used to apply each assumption takes into account the overlapping nature of the improvements and modifies accordingly so as to avoid double counting of benefits. This is more fully described in Section 2.
1C. Reduction of Carbon Intensity of Fuels (i.e., Alternative Fuels)

The third supposition regarding the potential for improvements to the vehicle fleet in the Puget Sound region was what opportunities to reduce the carbon content of fuel might be possible by 2040. Research conducted on this topic included studies and analyses conducted by the following agencies or institutions (a full bibliography of sources is included at the end of this white paper):

- Washington State Department of Ecology
- California Air Resources Board
- University of California at Berkeley
- University of California at Davis
- U.S. EPA
- Western States Petroleum Association
- U.S. Department of Energy
- Pew Center on Global Climate Change

Several states around the country are researching the benefits and costs of implementing a low carbon fuel standard, and many states have also adopted legislation related to alternative and renewable fuels. Most notably, the three West Coast states of California, Oregon and Washington are each pursuing these strategies to varying degrees. California, for example, adopted a low carbon fuel standard in 2010 that would reduce the carbon intensity of passenger vehicle fuels by at least 10% by 2020. As mentioned previously, Washington State has passed legislation requiring the use of alternative fuels in state fleets, as well as legislation related to renewable fuel standards. Washington State is also currently in the process of researching a low carbon fuel standard, assessing options and their applicability for Washington State.

Perhaps more so than with any of the other categories of technological improvements, the potential to reduce the carbon intensity of fuel relies on many other strategies that are already captured within the other categories, particularly those of improved vehicle fuel economy and an influx of electric or hybrid vehicles into the fleet. However, our research suggests that there are additional benefits that could be achieved through further pursuit of alternative fuels such as ethanol, biodiesel, hydrogen fuel cells, etc. For example, EPA finalized a renewable fuels standard that will increase the required volumes of renewable fuel to 36 billion gallons by 2022.

Given the national, regional and state interest in pursuing alternative and renewable fuels, we categorized the potential for advances in reducing the carbon intensity of fuel in the Puget Sound region by 2040 into the two scenarios below. It is important to note that the scenarios are based on the total assumed reduction of carbon intensity in the fuel supply, inclusive of all possible strategies for achieving these targets. Issues related to overlapping strategies are addressed in Section 2, which modifies the application of these estimates accordingly so as to avoid double counting of benefits.

- **Likely Scenario: 10%**
  This scenario is comprised of a fairly conservative assumption that by 2040, a 10% reduction in the carbon intensity of fuel can be achieved in the Puget Sound region. Given the actions already taken by Washington State related to fuels, and the passage of a national program on renewable fuels, it is likely that a 10% additional reduction over the next 30 years will be possible.

- **Aggressive Scenario: 25%**
  This scenario is comprised of a more aggressive assumption that by 2040, a 25% reduction in the carbon intensity of fuel can be achieved in the Puget Sound region. This scenario assumes that an even more aggressive pursuit of alternative and renewable fuels, including the possibility of new technologies such as hydrogen fuel cells, is possible over the next 30 years. As an example, EPA’s “A Wedge Analysis of the U.S. Transportation Sector” study looked at varying levels of both corn and cellulosic ethanol in the market by 2050, up to 90 billion gallons compared to 9 billion gallons produced in 2008. The U.S. Department of Energy is also pursuing research into hydrogen fuel cells. Their Fuel Cell Technologies Program coordinates research with national laboratories, universities and industry partners to overcome technical barriers to the reliability, cost and performance of fuel cell systems. Fuel cells are currently being developed for passenger vehicles, buildings and small applications such as computers.
1D. Improvements to Heavy Duty Vehicles

The fourth supposition regarding the potential for improvements to the vehicle fleet in the Puget Sound region is what improvements in the fuel economy of heavy duty vehicles might be possible by 2040. This area is less robust in terms of the research and data available, but also has perhaps the most potential in significant improvements due to the relatively large share of carbon emissions per vehicle and the overall increase in freight truck emissions in the last 20 years. Research conducted on this topic included studies and analyses conducted by the following agencies or institutions (a full bibliography of sources is included at the end of this white paper):

- U.S. EPA
- Federal Highway Administration
- Air and Waste Management Association
- David Suzuki Foundation
- Levelton Consultants, Ltd.
- U.S. Department of Energy
- Washington State Department of Ecology
- California Air Resources Board

There are a variety of factors in play when discussing heavy duty, or freight, truck emissions. These include not just the efficiency of the vehicles, but also details with the movement of freight such as the number of small shipments, an increase in the number of “empty” miles, increased idling due to traffic congestion, etc. This analysis focuses only on the technological improvements possible to heavy duty vehicles and engines.

There are numerous regulatory and voluntary mechanisms currently being pursued to reduce emissions from heavy duty trucks. For example, EPA has established rules related to both diesel fuel and heavy duty engines, as has the California Air Resources Board. The Washington State Department of Ecology is pursuing several strategies to reduce diesel emissions, including retrofitting older diesel vehicles and an idle reduction campaign. Thus far, these programs and regulations have focused primarily on the reduction of particulate matter and nitrogen oxide emissions from heavy duty vehicles, although it is expected there will be corollary reductions in greenhouse gas emissions.

At the time these scenarios were developed for the adoption of Transportation 2040 in 2010, there was limited research available on the potential to reduce greenhouse gas emissions from technological improvements to heavy duty vehicles, but what research was available suggested reductions in the range of 25-50%. These improvements include hybrid vehicle systems, aerodynamic and rolling resistance improvements, and engine and fuel improvements, among other strategies.

While it is expected for this area to yield significant benefits in the future, the assumptions in 2010 of these benefits were conservative until further research became available supporting a larger reduction potential:

- **Likely Scenario: 5%**
  This scenario is comprised of a fairly conservative assumption that an additional 5% reduction in greenhouse gas emissions from technological improvements to heavy duty vehicles can be achieved in the Puget Sound region by 2040. Given the aggressive strategies currently being pursued in Washington State and the Puget Sound region related to diesel emissions, as well as activities being undertaken at the national level to reduce emissions from heavy duty vehicles and diesel fuel, it is likely that a 5% additional reduction over the next 30 years will be possible.

- **Aggressive Scenario: 10%**
  This scenario is comprised of a more aggressive assumption that an additional 10% reduction in greenhouse gas emissions from technological improvements to heavy duty vehicles can be achieved in the Puget Sound region by 2040. Given all the reasons identified above we feel that 10% is an achievable target, but with the lack of available research on the benefits of existing strategies to reduce greenhouse gas emissions, we remain conservative on the range of emissions reductions assumed.

Since the adoption of Transportation 2040 in 2010, new rulemaking has occurred to improve fuel economy and greenhouse gas emissions from medium and heavy duty vehicles. The standards for model years 2014-2018 are expected to reduce greenhouse gas emissions 10-20%. As mentioned above,
the Likely and Aggressive scenarios are not being updated at this time, but will be reviewed and revised as appropriate as part of the 2018 plan update process.

SECTION 2: METHODOLOGY

This section describes how the assumptions for the two technology scenarios – likely and aggressive – were applied to the output of the Transportation 2040 alternatives analysis. EPA’s draft Motor Vehicle Emission Simulator (MOVES) Demo model was utilized to estimate greenhouse gas emissions for Transportation 2040 as adopted in 2010. This version of the draft model did not have the capability to adjust for advanced vehicles or fuel scenarios, so our approach involved post-processing each assumption to the emissions results produced by the integration of PSRC’s modeling framework. Each assumption under both scenarios was carefully applied to only the appropriate output, and the adjustments described above were made so as to avoid double counting of benefits.

For the 2014 Transportation 2040 Update, EPA’s updated version of MOVES2010b was used. This update to MOVES incorporates the national fuel economy and greenhouse gas standards for passenger vehicles and light trucks adopted as of September 2010, which MOVES Demo did not. As such, the methodology to apply those assumptions for fuel economy improvements in the Likely and Aggressive scenarios is adjusted to avoid double counting of benefits.

2A. Percent of Electric Vehicles in the Central Puget Sound Vehicle Fleet

- Likely Scenario: 20%
- Aggressive Scenario: 45%

The assumptions for the percentage of electric, plug-in hybrid electric or other zero to low emission vehicles in the fleet were applied only to the emissions output from passenger cars and light-duty trucks\(^4\). For the purposes of this analysis as applied to Transportation 2040, these vehicles were assumed to have zero tailpipe emissions (see below for a discussion of other emissions implications from these vehicles).

- Likely Scenario (20%): a 20% reduction was applied to the greenhouse gas emissions results from Transportation 2040 for passenger cars and light trucks.
- Aggressive Scenario (45%): a 45% reduction was applied to the greenhouse gas emissions results from Transportation 2040 for passenger cars and light trucks.

Significant discussion was held regarding whether it was appropriate to describe these vehicles as having “zero emissions.” There was some concern expressed that this description does not adequately convey that there are, in fact, “upstream” emissions that may be created from the generation of the electricity used for these vehicles. At this point in time, all emissions results analyzed at PSRC – whether for Transportation 2040, the Regional Transportation Improvement Program or other analyses – only report on on-road vehicle tailpipe emissions. It is this category for which PSRC has state and federal requirements through transportation conformity. The analysis of “upstream” or “lifecycle” emissions is an area for which there is no standard methodology or guidance currently available. We do not conduct such an analysis for any other component of our plan – for example, upstream emissions impacts from gasoline production, materials production for concrete/cement/steel for building infrastructure, emissions impacts from the construction and operation of buildings, vehicle production, etc.

We do, however, want to stress that the results as described in Transportation 2040’s Four-Part Greenhouse Gas Strategy reflect only on-road vehicle emissions, and we recognize that the source of fuel used for any future vehicle fleet may have additional greenhouse gas emissions not reflected in our reporting. There has been some movement in Washington State and the Puget Sound region, however, to ensure that the electricity for vehicles will come from alternative sources and utilize the grid off-peak. These strategies, if adopted, will mitigate any “upstream” emissions from these vehicles.

For the 2014 Transportation 2040 Update, there are no changes to the methodology as described above.

\(^4\) PSRC’s modeling output can be segregated into passenger vehicles, light trucks, medium trucks and heavy trucks.
2B. Improvements to Vehicle Fuel Economy

- **Likely Scenario: 40 mpg**
- **Aggressive Scenario: 50 mpg**

In order to avoid double counting of benefits, the assumptions for improved vehicle fuel economy were applied to the remainder of the passenger vehicle fleet, after the reductions under 2A were applied. For the purposes of this analysis we assumed that any increases in the number of “traditional” hybrid electric vehicles (not plug-in hybrid electric vehicles) would be captured with the overall improvements to the average fuel economy of the fleet.

As mentioned above, we were not able to adjust for these improvements within the emissions model, and there is no methodology available to apply an adjustment to the emissions output or to individual emission factors. From the NHTSA Draft Environmental Impact Statement (DEIS) for the proposed CAFÉ standards, these standards are expected to reduce grams CO$_2$e per mile from 295 in the base year fleet to 250 grams CO$_2$e per mile, a 15.3% improvement. Data on the other alternatives analyzed in the NHTSA DEIS suggest that a combined fleet average of 38.7 mpg, which is the alternative closest to our Likely Scenario assumption, would result in an 18.3% reduction from the existing fleet. As a comparison, the alternative closest to the proposed CAFÉ standards of 35.5 mpg resulted in a reduction of 14.5%. Data was not readily available for a 50 mpg fleet average, which is our Aggressive Scenario. While Growing Cooler does report on a 50 mpg fleet average, their calculations have built-in assumptions regarding national VMT growth, and are not easily transferable for a post-processing application to Transportation 2040.

Based on the research conducted, we chose the following application of our Likely and Aggressive Scenarios for the plan as adopted in 2010:

- **Likely Scenario (40 mpg):** an 18% reduction was applied to the greenhouse gas emissions results from Transportation 2040 for the remainder of the passenger cars and light trucks. This is based on the analysis of the alternative in the NHTSA DEIS which is closest to this scenario, at a combined fleet average of 38.7 mpg.

  *MOVES2010b incorporates the fuel economy standards adopted through September 2010, which results in a fleet average of 35.5 mpg for model years 2012-2016. Per the Final NHTSA EIS for these standards, this is expected to conservatively result in a 12.5% reduction in emissions in 2040. For the 2014 Transportation 2040 Update, the methodology for the Likely scenario of a 40 mpg fleet average was therefore reduced to a 5.5% reduction of the modeled Transportation 2040 output.*

- **Aggressive Scenario (50 mpg):** a 25% reduction was applied to the greenhouse gas emissions results from Transportation 2040 for the remainder of the passenger cars and light trucks. In the absence of specific data that can be applied to our results, we compared the varying reduction of emissions from the NHTSA DEIS alternatives and used this as a factor for our Aggressive Scenario assumptions. For example, the difference in greenhouse gas emissions between a combined fleet average of 35.5 mpg and a fleet average of 38.7 mpg standard in the NHTSA DEIS is approximately 4%. As such, to maintain consistency and reasonableness in the application of our assumptions, we forecasted an additional 8% reduction between a combined fleet average of 40 mpg and 50 mpg. We believe this is a fairly conservative application of our assumptions. For example, EPA’s “A Wedge Analysis of the U.S. Transportation Sector” study indicates that hybrid electric vehicles achieve a 29% reduction in greenhouse gas emissions over traditional gasoline vehicles; as a comparison, we are applying only a 25% reduction factor for a combined fleet average of 50 mpg.

  *Per the information above, for the 2014 Transportation 2040 Update, the methodology for the Aggressive scenario of a 50 mpg fleet average was therefore reduced to a 12.5% reduction of the modeled Transportation 2040 output.*

2C. Reduction of Carbon Intensity of Fuels (i.e., Alternative Fuels)

- **Likely Scenario: 10%**
- **Aggressive Scenario: 25%**

As discussed in Section 1, the scenarios for reducing the carbon intensity of the fuel supply have the most potential for overlap with the other components of the technology assumptions. As such, for the application of these scenarios to Transportation 2040, we wanted to ensure that we did not overestimate, or double count, the benefits from this strategy. Based on the research conducted, however, it does seem likely that at least some portion of the implementation strategy will be achieved through alternative fuels such as ethanol, biodiesel, etc., and therefore additional reductions may be achieved above and beyond the reductions assumed from improved fuel economy and electric vehicles.

To remain as conservative and reasonable as possible, therefore, the following adjustments were applied to the greenhouse gas emission results from Transportation 2040 for the remainder of the passenger vehicle fleet, after the reductions from 2A and 2B were applied:

- **Likely Scenario (10%)**: a 5% reduction was applied to the greenhouse gas emission results from Transportation 2040 for the remainder of the passenger cars and light trucks. This is an adjustment of 50% from the scenario assumption of a 10% benefit from this strategy.

- **Aggressive Scenario (25%)**: a 12% reduction was applied to the greenhouse gas emission results from Transportation 2040 for the remainder of the passenger cars and light trucks. This is an adjustment of 50% from the scenario assumption of a 25% benefit from this strategy.

*For the 2014 Transportation 2040 Update, there are no changes to the methodology as described above.*

2D. Improvements to Heavy Duty Vehicles

- **Likely Scenario: 5%**
- **Aggressive Scenario: 10%**

As discussed in Section 1, the potential for improvements to heavy duty vehicles providing reductions in greenhouse gas emissions was still an emerging area of research during the adoption of Transportation in 2010. Although quite a bit of work has been done towards reducing emissions of the heavy duty fleet, most of the results were expressed in terms of reducing emissions of particulate matter or nitrogen oxides. As such, we remained as conservative as possible in applying benefits to this portion of the Puget Sound vehicle fleet.

- **Likely Scenario (5%)**: a 5% reduction was applied to the greenhouse gas emission results from Transportation 2040 for medium and heavy duty trucks. While our assumptions have been focused on heavy duty trucks, we believe it is likely that improvements to the medium truck category (e.g., commercial vans and trucks) will also be achieved by 2040.

- **Aggressive Scenario (10%)**: a 10% reduction was applied to the greenhouse gas emission results from Transportation 2040 for medium and heavy duty trucks.

Since the adoption of Transportation 2040 in 2010, new rulemaking has occurred to improve fuel economy and greenhouse gas emissions from medium and heavy duty vehicles. The standards for model years 2014-2018 are expected to reduce greenhouse gas emissions 10-20%, depending on the vehicle classification. Per the NHTSA FEIS for this standard, an estimated 10% reduction of emissions is expected on average for the heavy duty fleet by 2040. Therefore, the methodology to apply the Likely scenario is increased to 10% to reflect the new standards currently in place. To be conservative, while further improvements are expected in the future, no additional reduction was assumed for the Aggressive scenario.

**SUMMARY**

Based on PSRC’s analyses and research, as well as data and research conducted at the national level, Transportation 2040 includes a Four-Part Greenhouse Gas Strategy. Recognizing that it will require multiple strategies and tools to effectively reduce emissions from the transportation sector, the Strategy therefore contains the following elements:
• **Land Use**: building upon the VISION 2040 Regional Growth Strategy to further the goal of providing a jobs vs. housing balance, and to pursue additional refinements through strategies such as transit-oriented development facilities;

• **User Fees**: recognizing its critical role in reducing VMT and emissions, transition the region over time to a user fee/roadway pricing system;

• **Choices**: continue to provide travelers options to the single-occupant vehicle, and continue research into the costs and benefits of various strategies;

• **Technology**: recognizing that improvements to vehicles and fuels will play a crucial role in reducing emissions, PSRC has undertaken research with the Department of Ecology on the potential technological advances that may be likely in our region by the year 2040.

The Transportation 2040 emissions results produced from the land use and transportation investments adopted by the PSRC Boards were based on current fleet assumptions and disaggregated into vehicle types – passenger cars, light duty trucks, medium trucks and heavy trucks. Based on the vehicle and fuel technology assumptions and methodologies laid out in this report, the following adjustments to those disaggregated emissions results were made to reflect an alternative 2040 vehicle fleet, representing what might be likely and what might be achieved with more aggressive pursuit of improvements.

1. A portion of the passenger car/light duty truck fleet was assumed to be electric and have zero tailpipe emissions;\(^5\)

2. After the above calculation was applied, an adjustment was applied to the remaining emissions from the passenger car/light duty truck fleet to reflect improvements in fuel economy for these vehicles;

3. After both of the above calculations were applied, an adjustment was then applied to the remaining emissions from the passenger car/light duty truck fleet to reflect additional benefits from alternative fuels;

4. Finally, an adjustment was made to the emissions from heavy duty and medium duty trucks, to reflect conservative assumptions regarding future improvements to this portion of the fleet.

\(^5\) As noted above, this refers only to zero tailpipe emissions and does not necessarily mean zero emissions; a discussion of potential upstream impacts from the energy production is referenced in Section 2.
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