ENVIRONMENTAL ASSESSMENT
SR 520 BRIDGE REPLACEMENT AND HOV PROGRAM

DECEMBER 2009

SR 520, Medina to SR 202: Eastside Transit and HOV Project

Appendix M

Energy Technical Memorandum

Washington State Department of Transportation

U.S. Department of Transportation
Federal Highway Administration

SR 520, Medina to SR 202: Eastside Transit and HOV Project Environmental Assessment

Energy

Technical Memorandum

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Acronyms and Abbreviations

Btu	British thermal unit
CALTRANS	California Department of Transportation
CEVP	Cost Estimating Validation Process
CH_4	methane
CNG	compressed natural gas
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalents
CTED	Washington State Department of Community, Trade and Economic Development
DOE	Department of Energy
EIA	Energy Information Administration
EPA	Environmental Protection Agency
FHWA	Federal Highway Administration
gal	gallon
g	gram
GHG	greenhouse gas
GP	general purpose
HOV	high-occupancy vehicle
IRT	Incident Response Team
kg	kilogram
MBtus	million British thermal units
MOVES	Motor Vehicle Simulation Estimator
mpg	miles per gallon
mph	miles per hour
MT	metric ton
N_2O	nitrous oxide
PSE	Puget Sound Energy

SEPA	State Environmental Policy Act
SR	State Route
SUV	sport utility vehicle
VHT	vehicle hours traveled
VMT	vehicle miles traveled
WSDOT	Washington State Department of Transportation

1. Introduction

Why is energy considered in an environmental assessment?

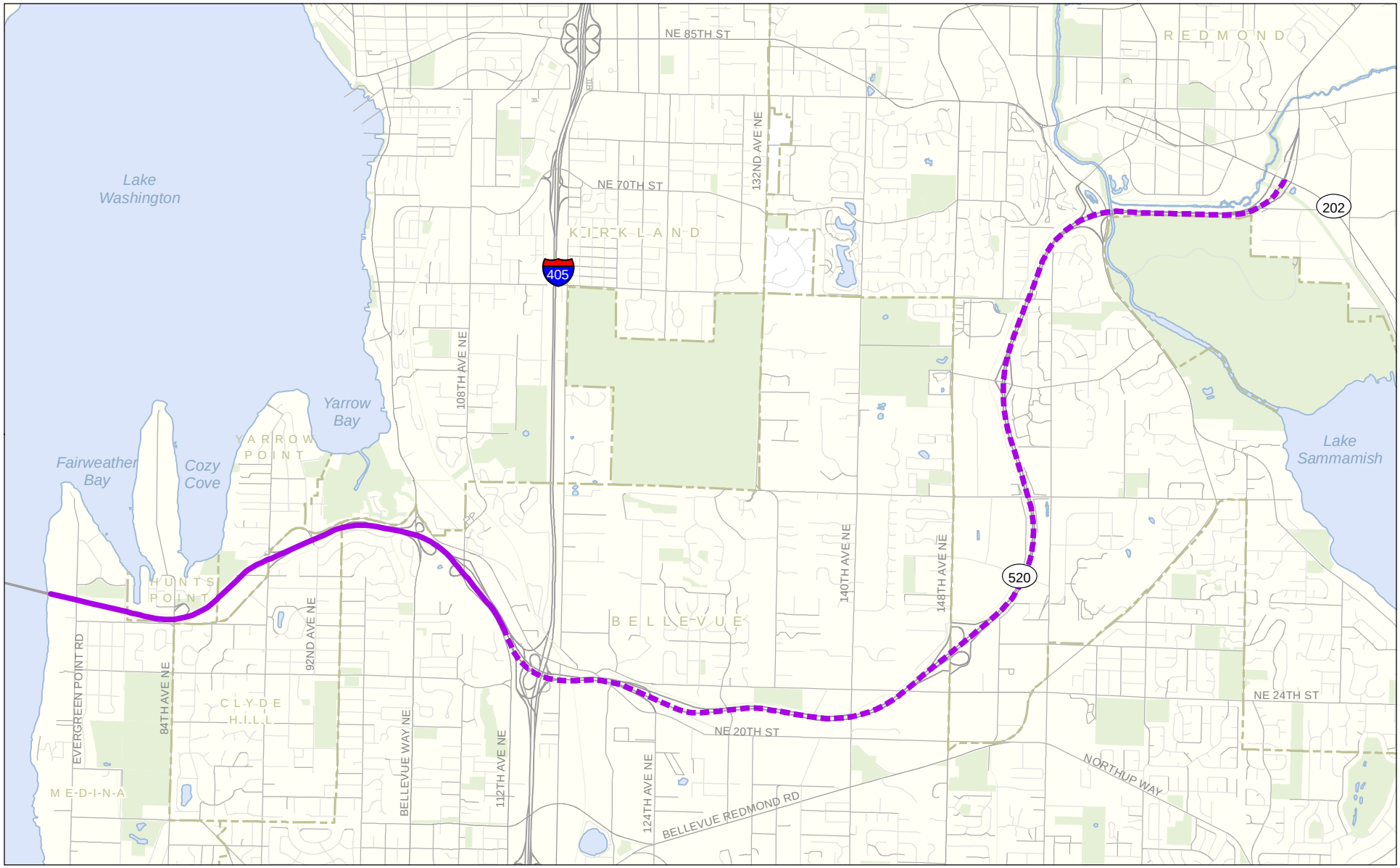
When energy is used to build something or is used to operate a vehicle, it cannot be recovered. Project construction activities and the operation of vehicles on State Route (SR) 520 consume large amounts of energy resources, particularly petroleum. The National Environmental Policy Act (NEPA) requires agencies to consider these environmental effects when making decisions about the SR 520, Medina to SR 202: Eastside Transit and HOV Project. This technical memorandum estimates the amount of energy that would be consumed during construction of the project, and the amount of energy that would be consumed by vehicles operating within the study area under the Build Alternative and No Build Alternative.

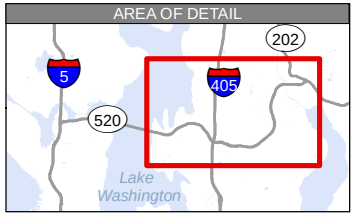
Washington state has adopted greenhouse gas (GHG) reduction goals (Revised Code of Washington [RCW] 70.235.020). As part of its plan to reduce GHG emissions, the State has also adopted vehicle miles traveled (VMT) benchmarks (RCW 147.01.440) as one strategy to reduce transportation sector GHG emissions. Guidance on how to address GHG emissions in environmental documents prepared to meet the State Environmental Policy Act (SEPA) requirements is currently being developed. In the meantime, the Washington State Department of Transportation (WSDOT) is evaluating GHG emissions according to its *Interim Approach to Project-Level GHG and Climate Change Evaluations for Transportation Projects* (2009a). The GHG analysis is included in this technical memorandum following the discussion of energy.

What is the project?

WSDOT is proposing to construct the SR 520, Medina to SR 202: Eastside Transit and HOV Project to reduce transit and high-occupancy vehicle (HOV) travel times and to enhance travel time reliability, mobility, access, and safety for transit and HOVs in rapidly growing areas along the SR 520 corridor east of Lake Washington. Exhibit 1 shows the project vicinity. Some of the improvements included in this project were originally part of the SR 520 Bridge and HOV Project. On June 18, 2008, the Federal Highway Administration (FHWA) authorized WSDOT to develop the SR 520, Medina to SR 202: Eastside Transit and HOV Project as an independent project. The project includes building a complete HOV system between Lake Washington and 108th Avenue NE and restriping the existing HOV lanes from the outside lanes to the inside lanes between the 108th Avenue NE interchange and SR 202 in Redmond.

The portion of the project between Evergreen Point Road and 108th Avenue NE was previously part of the SR 520 Bridge Replacement and HOV Project. The SR 520, Medina to SR 202: Eastside Transit and HOV Project has been an independent project to address needs specific to the portion of SR 520 east of Lake Washington. The project limits extend approximately 8.8 miles along SR 520 from the east shore of Lake Washington (vicinity of Evergreen Point Road) to the interchange with SR 202 in Redmond.





Construction Extent

Restriping Extent

Park

City Limits

N

0 0.5 1 Miles

Source: King County (2005) GIS Data (Streets), King County (2007) GIS Data (Waterbody) and CH2M HILL (2008) GIS Data (Parks and Streams). Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Exhibit 1. **Project Vicinity**

Medina to SR 202: Eastside Transit and HOV Project

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WSDOT is considering two alternatives for the project: the Build Alternative and the No Build Alternative.

Build Alternative

Under the Build Alternative, the proposed project would include the improvements described below.

SR 520 Improvements from Lake Washington to I-405

The proposed project would reconstruct SR 520 from just west of Evergreen Point Road to just east of 108th Avenue NE. Elements constructed as part of this section include the following:

- Construct a new eastbound HOV lane from Lake Washington to the existing eastbound HOV lane west of the I-405 interchange. This improvement would complete the currently discontinuous HOV network on the Eastside and improve travel time reliability for buses and carpools.
- Relocate the existing westbound HOV lane from the outside lane to the inside lane from Lake Washington to I-405. This change would enhance safety by eliminating the need for merging vehicles to weave across the faster-moving HOV lanes to reach the general-purpose lanes.
- Construct a lid with inside transit stop over SR 520 at Evergreen Point Road.
- Construct a new lid and modify the existing half-diamond interchange at 84th Avenue NE.
- Construct a new lid with inside transit stop over SR 520 at 92nd Avenue NE and modify the existing interchange.
- Reconfigure the existing interchange at Bellevue Way NE.
- Construct new HOV direct access ramps at 108th Avenue NE. This improvement would create a more efficient connection for transit and HOV from SR 520 to the South Kirkland Park-and-Ride via local streets.
- Add a bike/pedestrian path from Lake Washington to approximately 108th Avenue NE. This improvement would facilitate nonmotorized use of SR 520, provide transit connections for bikes and pedestrians, and complement the existing nonmotorized transportation network on the Eastside.

SR 520 Improvements from I-405 to SR 202

- Restripe existing eastbound and westbound HOV lanes from the outside to the inside lane. This change would enhance safety by eliminating the need for merging vehicles to weave across the faster-moving HOV lanes to reach the general-purpose lanes.

Other Improvements

- Provide noise walls between Evergreen Point Road and Bellevue Way NE.
- Provide retaining walls and stormwater management system improvements.

- Improve stream habitat by realigning portions of the Yarrow Creek channel and shortening some culverts.
- Improve fish passage culvert crossings to restore fish passage and open up habitat that was previously inaccessible to salmon and other fish species.
- Mitigate the project's effects on wetlands and streams at a site or sites as determined through future negotiations with permitting agencies.

No Build Alternative

Under the No Build Alternative, the project would not be built. Only routine maintenance, repair, and minor safety improvements would take place on SR 520 in the study area over the next 20 years. The No Build Alternative would not improve transit reliability and transit and HOV travel times on SR 520. Also included in the No Build Alternative for traffic modeling purposes is the assumption that the SR 520, Bridge Replacement and HOV Project would not be built until this project is complete.

WSDOT is evaluating the No Build Alternative to provide a reference point for comparing the effects, both positive and negative, associated with the proposed project.

2. Methodology

This technical memorandum discusses the existing energy use characteristics at both the state level and the project level. Where detailed information about energy use in the project vicinity is not available, the project team used state-level trends to help describe energy consumption at the local level. The analysis focuses on energy use associated with the proposed project and study area and does not consider energy-related effects to refineries or utilities.

The energy analyst used the guidance in Chapter 440 of the WSDOT *Environmental Procedures Manual* (WSDOT 2008) to estimate the likely energy-related effects of the alternatives. The analyst also used information provided in *Energy and Transportation Systems*, a report by the California Department of Transportation (CALTRANS) (CALTRANS 1983).

Construction Analysis

During construction of the proposed project, energy would be consumed by site preparation and construction activities, including equipment operation and construction lighting. The amount of energy used during project construction would be roughly proportional to the size and cost of the project. Therefore, the project team used construction cost estimates provided by WSDOT to calculate energy consumption during the construction period. The analysis focuses on energy use associated with the proposed project and project site.

CALTRANS established energy consumption factors for different transportation facilities in *Energy and Transportation Systems* (CALTRANS 1983). The energy consumption factors developed by CALTRANS are still widely used today and are designed to provide a way to compare one alternative to another. For this project, the project team estimated energy consumption during construction by

applying a construction energy consumption factor to total project costs. The energy consumption factor for urban freeway structures, developed by CALTRANS, was used to estimate energy consumed during project construction and is presented in Exhibit 2.

Exhibit 2. Primary Facility Type by Project Section

Project Section	Primary Facility Type	Energy Consumption Factor (Btu/$)
Eastside Project Area	Urban Freeway	27,500

Source: CALTRANS (1983)

The consumption factors were reported in British thermal unit (Btu) per dollars of construction spending. Because the CALTRANS report was developed using 1977 construction dollars, the energy consumption factors had to be adjusted to account for inflation. The California Construction Cost Index was used to adjust the construction costs from 2012 dollars (mid-point of year of expenditure) to 1977 dollars.

The analysts used cost estimates developed during WSDOT's Cost Estimating Validation Process (CEVP) to calculate energy consumption during the construction period. The cost estimates are in 2012 dollars and represent the mid-point of expenditure for the project. Costs associated with right of way purchase and construction engineering were excluded from the energy consumption estimate.

Operational Analysis

The project team identified energy effects during project operation at a level of detail that allows comparison of the Build Alternative and No Build Alternative. Energy consumption estimates were based on travel forecasts generated by the traffic analysis. The effects analysis includes energy consumption calculations using vehicle miles traveled (VMT) as an indicator of volume and energy consumption rates and as an indicator of energy use. The analysis does not include the variables of traffic operations at interchanges, arterials, or local intersections.

The project team obtained the energy consumption rates (Btu per mile) for passenger vehicles, buses, and heavy-duty trucks from the Department of Energy's (DOE) *Transportation Energy Data Book, Edition 27* (DOE 2008). The energy consumption factor for passenger vehicles includes cars, motorcycles, and light trucks. Exhibit 3 presents consumption factors by mode (DOE 2008).

What is a VMT?

VMT stands for vehicle miles traveled and is the number of miles vehicles travel each year. For transportation projects with set boundaries, VMT can refer to the aggregate number of miles that all the vehicles travel using the specified roadways. Per person (or per capita) VMT in Washington has been stable at 9,000 miles per person since the 1980s, meaning the statewide VMT has grown at roughly the same pace as population. Methods of reducing VMT typically target transferring trips from single-occupant vehicles to multiple-person vehicles like carpools, vanpools, and transit. VMT can also be lowered by reducing the distance of travel through changes in land use.

Exhibit 3. Energy Consumption Factors by Mode

Vehicle Mode	Btus/Mile
Passenger Vehicle	5,942
Heavy Duty Truck	23,260
Transit Bus	37,310

Note: Passenger vehicles include cars, motorcycles, and light trucks.
Source: DOE (2008)

The project team estimated operational effects by calculating the total energy consumed under each alternative. The project team estimated the energy consumption by applying the energy consumption rates by mode presented in Exhibit 2 to the VMT data reported in the Transportation Discipline Report (WSDOT 2009b). To convert MBtu to gallons of gasoline, the total MBtu values for passenger vehicles were divided by 124,000 (EIA 2007). To convert MBtu to gallons of diesel, the total MBtu values for heavy trucks and transit buses were divided by 139,000 (EIA 2009c). See Attachment 1 for detailed calculations of energy consumed during operations.

The project team based its analysis of the direct effects on energy on projected year 2030 corridor traffic volumes and total VMT. Traffic volumes for each alternative were obtained from the Transportation Discipline Report (WSDOT 2009b). Annual VMT was calculated by multiplying a factor of 340 days per year by daily VMT for the study area.

3. Affected Environment

The study area for the energy analysis is the same as the study area for the traffic operations analysis—the SR 520 highway and local interchanges from the eastern side of the Lake Washington shoreline to the SR 520/SR 202 interchange. Exhibit 1 presents a map of the project alignment and the project limits. The study area includes the entire SR 520 corridor because the traffic model included all vehicle trips across Lake Washington via SR 520 from the beginning of the trip to the end. For example, if a passenger vehicle was driving from Redmond to Seattle via SR 520, the entire trip along the corridor would be included in the traffic data.

According to the Washington State Department of Community, Trade and Economic Development (CTED), Washington's per capita energy consumption was approximately 200 million Btu (MBtu) in 2005 after averaging close to 250 MBtu from 1970 through 1999. The drop in per capita energy consumption was due to decreased energy use in some energy-intensive industries (i.e., aluminum) and to higher energy prices (CTED 2009). Washington's economy is also becoming less energy intensive because of improved technology, productivity increases, and a shift from natural resource manufacturing to less energy-intensive industries such as software and biotech. Washington's per capita average energy consumption in 2005 was below the national average of 232 MBtu.

Because most of the energy consumed during project construction and operation will result from transporting site materials, construction products, and other items to and from the site, WSDOT included a discussion of fuel consumption. Detailed fuel consumption data are not available at the

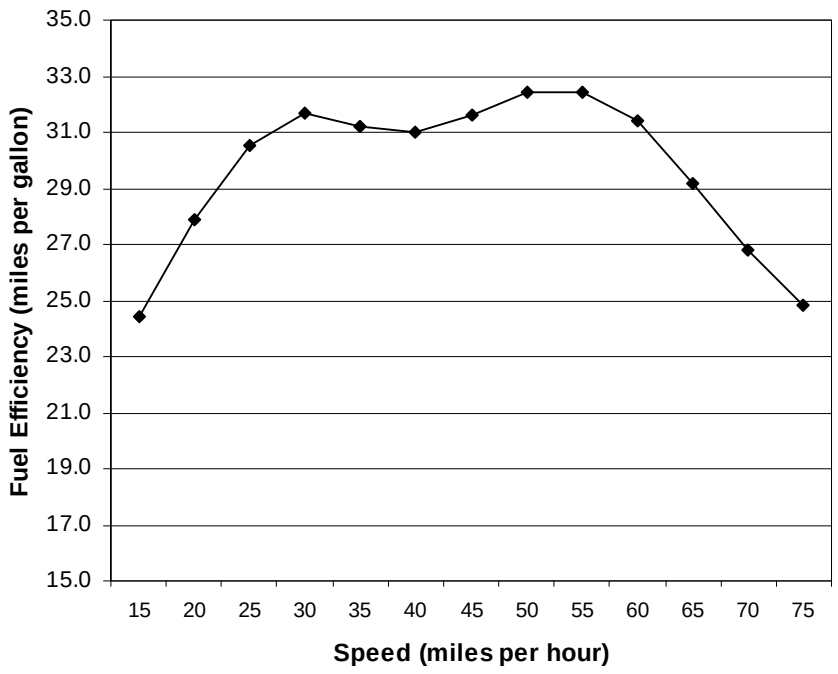
local level, thus WSDOT included a discussion on statewide fuel consumption. In 2007, the transportation sector in the state of Washington consumed approximately 338.0 trillion Btus of gasoline and approximately 143.2 trillion Btus of distallate fuel (EIA 2009a, 2009b). Distillate fuel includes diesel fuel and fuel oils, including on-highway diesel engines for trucks and cars as well as off-highway diesel engines such as railroad locomotives.

In recent years, the fuel efficiency of new vehicles has declined because of the popularity of larger engine vehicles such as pickups, vans, and sport utility vehicles (SUVs). The passage of the national Energy Independence and Security Act of 2007 (Public Law [Pub.L.] 110-140), which revised fuel efficiency standards, is expected to lead to higher new vehicle fuel efficiency in the future. The Energy Independence and Security Act of 2007 mandates that, by 2020, the fuel economy of all new cars, trucks, and SUVs will be 35 miles per gallon (mpg). On May 19, 2009, President Barack Obama announced a national auto fuel efficiency program that will require an average fuel economy standard of 35.5 mpg by 2016 (The White House 2009).

The SR 520 corridor is heavily used and frequently congested with traffic because it is one of only two crossings that serve residents, commuters, and other travelers across Lake Washington. The corridor is home to some large organizations, such as Microsoft and the University of Washington, whose employees travel SR 520 to get to and from their places of work. Currently, congestion occurs for more than 2 hours in both the morning and evening commutes. The congestion level indicates that the available roadway capacity is fully used and traffic is being forced to operate at lower speeds and with limited maneuverability. The Transportation Discipline Report (WSDOT 2009b) provides a more detailed explanation of current traffic congestion.

Excessive idling and stop-and-go traffic conditions substantially reduce fuel economy compared with free-flow conditions. Because of the current conditions in the study area, there are many times throughout the day when the study area is congested and vehicles operate at inefficient speeds. Exhibit 4 presents the average mpg for cars and pickups traveling at speeds between 15 and 75 miles per hour (mph) from a test of vehicles by FHWA.

The data in Exhibit 4, which are based on the results of an FHWA test of vehicles (DOE 2008), are presented for illustrative purposes to show the effect vehicle speed has on fuel efficiency. As shown, fuel efficiency is greatest when passenger vehicles are traveling between 30 and 55 mph.



Source: DOE (2008)

Exhibit 4. Average Automobile Fuel Consumption Rate

Because of traffic congestion, the existing average travel speed of all vehicles driving in the study area is 29 mph. According to the Transportation Discipline Report (WSDOT 2009b), vehicles drive approximately 1.7 million VMT daily along the SR 520 corridor. To convert the daily number to an annual number, a conversion factor of 340 days per year was applied to the daily VMT number, resulting in an annualized estimate of 562 million VMT (Tresia Bass, Traffic Operations Lead, Parametrix, Bellevue, Washington, Annualization Factor to Convert Daily VMT to Annual VMT. March 16, 2009. Personal communication).

The analysts obtained energy consumption rates (expressed in Btu per mile) for passenger vehicles, buses, and heavy-duty trucks from the DOE's *Transportation Energy Data Book, Edition 27* (DOE 2008) and applied these factors to the VMT estimates by mode. Nearly 4.0 million MBtu of energy is consumed by vehicles in the study area each year. To convert MBtu to gallons of gasoline, the total MBtu values for passenger vehicles were divided by 124,000 (EIA 2007). To convert MBtu to gallons of diesel, the total MBtu values for heavy trucks and transit buses were divided by 139,000 (EIA 2007). The results indicate that approximately 31.2 million gallons of fuel are consumed each year in the study area (see Attachment 1 for detailed calculations).

4. Potential Effects of the Project

How would construction of the project affect energy use?

During construction of the proposed project, energy would be consumed by site preparation and construction activities, including equipment operation and by providing construction lighting. The amount of energy used during the construction of the project would be roughly proportional to the size and cost of the project.

The project team used construction cost estimates provided by WSDOT to calculate energy consumption during the construction period. Construction cost estimates were estimated to be $581 million, excluding right of way cost and construction engineering. Construction cost estimates are in 2012 dollars and represent the mid-point of expenditure for the project.

Exhibit 5 presents total energy consumption for construction of the Build Alternative. The energy consumed during construction would be spread out over the entire construction period of approximately four years. The project would consume approximately 2.8 million MBtus.

Exhibit 5. Total Energy Consumption During Construction

Alternative	Construction Cost (2012 Dollars)	MBtus
Eastside Transit and HOV Project	$581,000,000	2,825,000

Notes: Construction costs reflect the estimated mid-point of expenditure for the project and exclude right of way cost and construction engineering.

How would operation of the project affect energy consumption?

Operational affects occur when vehicles utilize the roadway. During operation, annual VMT in the study area under the Build Alternative would be 805 million. By comparison, the VMT under the No Build scenario would be 806 million, or 0.1 percent more than the Build Alternative.

Exhibit 6 presents estimates of annual energy consumption during operation for each alternative. The energy consumption difference between the Build and No Build Alternatives is not considered to be significant.

Exhibit 6. Fuel Consumption Estimates in the Study Area by Alternative

Alternative	Annual VMT (millions)[a]	MBtus	Million Gallons of Fuel/Year[b]	Percent Change versus No Build 2030
Existing Conditions	562	3,949,000	31.21	
No Build – 2030	806	5,661,000	44.74	NA
Build – 2030	805	5,654,000	44.68	-0.1%

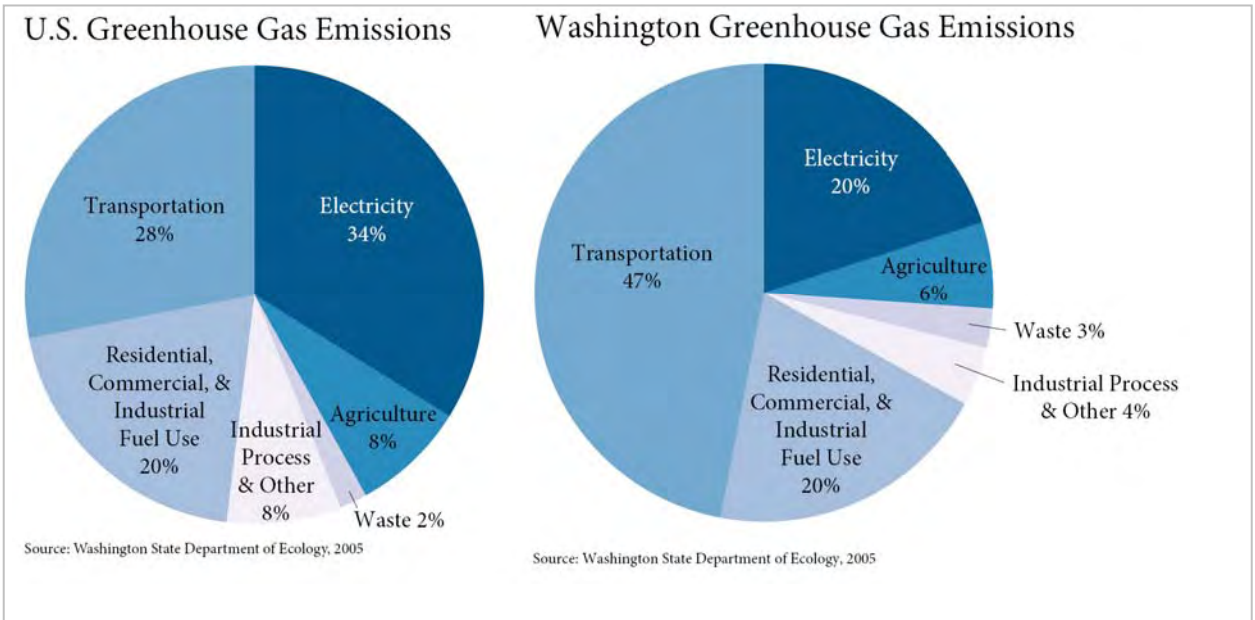
[a] An annualization factor of 340 was used to convert daily VMT to annual VMT.
[b] One gallon of gasoline = 124,000 Btu.

Sources: Bass (2009, personal communication); Transportation Discipline Report (WSDOT 2009b); DOE 2008.

How would the project affect greenhouse gas emissions?

Vehicles emit a variety of gases during their operation; some of these are greenhouse gases (GHGs). The GHGs associated with transportation are water vapor, carbon dioxide (CO_2), methane (also known as "marsh gas"), and nitrous oxide (used in dentists' offices as "laughing gas"). Any process that burns fossil fuel releases CO_2 into the air. Carbon dioxide makes up the bulk of the emissions from transportation.

Vehicles are a significant source of greenhouse gas emissions and contribute to global warming primarily through the burning of gasoline and diesel fuels. National estimates show that the transportation sector (including onroad vehicles, construction activities, airplanes, and boats) accounts for almost 30 percent of total domestic CO_2 emissions. However, in Washington state, transportation accounts for nearly half of GHG emissions because our state relies heavily on hydropower for electricity generation. Most other states rely on fossil fuels such as coal, petroleum, and natural gas to generate electricity. The next largest contributors to total GHG emissions in Washington are fossil fuel combustion in the residential, commercial, and industrial sectors at 20 percent; and in electricity consumption, also 20 percent. Exhibit 7 shows the gross GHG emissions by sector, nationally and Washington state.



Ecology and CTED 2007

Exhibit 7. GHG Emissions by Sector, 2005, US and Washington State

Efforts to Reduce Greenhouse Gas Emissions in Washington State

In 2007, Governor Gregoire and the legislature set greenhouse gas reduction goals for Washington state:

- 1990 greenhouse gas levels by 2020
- 25 percent reduction below 1990 levels by 2035
- 50 percent by 2050

Also in 2007, the Climate Advisory Team was formed by Governor's Executive Order 0702 to find ways to reduce greenhouse gas emissions. The final report included 13 broad recommendations of actions.

The Washington legislature passed and the Governor signed House Bill 2815 in the spring of 2008. This bill includes, among other elements, statewide per capita VMT reduction goals as part of the state's GHG emission reduction strategy.

This bill also established the Climate Action Team, a group similar to 2007's Climate Advisory Team. This group refined 2007's broad recommendations into specific actions the state can take to reduce emissions. WSDOT worked as a member of this group on strategies to reduce VMT and on how to include climate change in State Environmental Policy Act evaluations. The final report and other information on the process are available at: http://www.ecy.wa.gov/climatechange/2008CAT_overview.htm.

In addition to work with others in our state, WSDOT is leading the development of effective, measurable, and balanced emission reduction strategies. Current WSDOT activities that reduce GHG emissions include:

- **Transportation Options –** For 30 years, WSDOT has supported carpooling, vanpooling, and public transportation through the funding, building, and maintenance of the freeway HOV system, ferries, rail, and other programs. WSDOT's Commute Trip Reduction program has been partnering with employers to offer alternatives to drive-alone commuting for 17 years, and WSDOT has the nation's largest public vanpool program. These programs continue to expand, and with recent high gas prices demand for these programs has surged.

  These investments help to reduce the number of vehicles on the roadway during peak congestion and help reduce VMT.

- **Incident Response Team (IRT) –** WSDOT has 55 vehicles that patrol 500 miles of highway to clear blocking incidents quickly and safely. IRT clears 98.6 percent of all incidents in less than 90 minutes, reducing the amount of time motorists spend sitting and idling in traffic.

- **Using Biodiesel in Ferries –** Each year, the state ferry system burns approximately 17 million gallons of diesel fuel in its ferries, making the agency a significant fuel consumer in Puget Sound. In March 2008, Washington State Ferries began testing the use of biodiesel in the marine environment. Using biodiesel instead of traditional petroleum-based fuels reduces emissions of particulate matter and greenhouse gases, improving both local air quality and the Earth's climate.

In addition to working to reduce emissions on the transportation network, WSDOT is also taking action to reduce the agency's emissions. Steps include:

- **No Idle Policy –** In 2006, WSDOT adopted a no-idle policy to reduce fuel use and vehicle emissions. We estimate by reducing vehicle idling by 50 percent, we can save as much as $500,000 annually in fuel costs.

- **Reducing diesel emissions –** In 2005, WSDOT started using five percent biodiesel (B5) mixed with regular diesel in maintenance vehicles operating in the Central Puget Sound area. Currently, 25 WSDOT fueling stations have 10 percent biodiesel (B10) available, and WSDOT is working towards using 20 percent biodiesel (B20), depending on availability.

WSDOT and its partners are also actively implementing the 2005 Transportation Partnership Act, a 16-year plan to meet Washington state's most critical transportation needs. Many of these local, regional, and statewide transportation system improvements, in conjunction with ongoing programs, help to reduce the number of miles that vehicles need to travel each year. Together, these efforts combine to create more efficient driving conditions, offer mode choices, and help move WSDOT toward state GHG reduction goals.

Calculation of Greenhouse Gas Emissions for Project Construction

During construction, the primary source of greenhouse gas emission will be the energy used to build the facility. Emissions will be proportional to the amount of energy used and are the basis of this analysis. Small amounts of GHG emissions could also come from fugitive gases unintentionally released, such as coolant leaking from air conditioners. Fugitive emissions are not included in this analysis.

For this analysis, site construction energy needs were assumed to be met with diesel fuel only (no electricity or gasoline). All materials transport to and from the site is included. The construction emissions quantity is an estimate; actual use could be different based on specific equipment and construction methods determined in final design. Exhibit 8 shows the energy use anticipated for each alternative.

Exhibit 8. Onsite Energy Use

Alternative	Energy
2030 No Build	No construction energy use
2030 Build	2,825,000 MBtus

The results of the energy analysis were converted to gallons of diesel fuel electricity using the conversion factor 139,000 Btu per gallon diesel (EIA 2007).

Carbon dioxide, nitrous oxide (N_2O), and methane (CH_4) emissions were calculated by applying the appropriate emission factor (Exhibit 9). Because N_2O and CH_4 are more potent greenhouse gases than CO_2, the quantities of N_2O and CH_4 were multiplied by their global warming potentials to convert to carbon dioxide equivalents. Global warming potentials express the ability of different compounds to warm the atmosphere compared to CO_2. Carbon dioxide equivalents (CO_2e) represent the warming potential of gases in terms of the amount of CO_2 that would cause the same level of warming. For example, N_2O is 310 times more potent than CO_2 at warming the earth's atmosphere. One kilogram of N_2O has the same warming power as 310 kilograms CO_2e.

Exhibit 9. Carbon Dioxide Equivalents Emissions Factors

	Diesel[a]	Global Warming Potential
CO_2	10.15 kg/gal	1
N_2O	0.26 g/gal	310
CH_4	0.58 g/gal	21

[a] The Climate Registry, *General Reporting Protocol*, May 2008, page 93.
kg/gal = kilograms per gallon
g/gal = grams per gallon

Calculation of Greenhouse Gas Emissions for Project Operation

Operational greenhouse gas emissions will come from the vehicles that use the facility once it is complete and depend of the number of vehicles, vehicle speed, distance traveled, and vehicle fuel efficiency.

Traffic analysts provided distance, volume, and speed data in 15-minute increments for two time periods (5:30 a.m. to 10:15 a.m. and 3:00 p.m. to 7:45 p.m.) for SR 520 from the interchange with I-5 to one mile past SR 202. HOV and general purpose lanes were reported separately, and heavy trucks are estimated to be 3 percent of overall traffic. This information was evaluated for three scenarios:

- Existing conditions
- 2030 No Build
- 2030 Build

The U.S. Environmental Protection Agency's Motor Vehicle Simulation Estimator (MOVES) modeling tool was used to calculate emission factors based on vehicle type and speed. The 2004 demo version of the model with the corrected speed curve for light duty vehicles was used for this analysis. Three emission factors were modeled:

- HOV lanes (passenger cars, passenger trucks, transit buses)
- General-purpose (GP) lanes (passenger cars, passenger trucks, motorcycles, motorhomes)
- Trucks (single and combination unit, long- and short-haul trucks; light commercial trucks; refuse trucks)

MOVES models emission factors by month and time of day because weather can affect vehicle efficiency. Because the purpose of this analysis is to show differences in alternatives, not predict absolute total emissions, one month, March, was chosen to represent the average weather in the area. Although weather does affect emission factors, a review of the emission factors showed that the emission factors were almost identical across the time periods being analyzed. Therefore, the emission factors for 7:00 a.m. to 8:00 a.m. were used for all hours analyzed. Detailed model inputs are provided in Attachment 2.

From the traffic data supplied, VMT were calculated for each 15-minute period for each link. To determine greenhouse gas emissions, VMT for each link was multiplied by the relevant speed-based emission factor. Alternatives are compared by summing the emissions from all vehicle types by time period and by link.

Effect of Project Construction on Greenhouse Gas Emissions

Project construction is estimated to produce 209,000 metric tons (MT) CO_2e emissions. These emissions would be spread over the duration of construction.

The emissions estimate is based on the results of the energy analysis. Since the energy analysis is based on applying an energy conversion factor to project costs, greenhouse gas emissions are directly proportional to project costs. This methodology does not rely on an in-depth analysis of construction techniques and equipment. Actual emissions will depend on the type of equipment used and construction methods chosen.

Effect of Project Operation on Greenhouse Gas Emissions

Exhibit 10 shows the total estimated CO_2e emissions produced during the peak periods on weekdays (5:30 am to 10:15 am and 3:00 pm to 7:45 pm). These periods were compared because they are the most congested times of day. Congestion decreases fuel economy and increases GHG emissions.

Changes in the roadway configuration will most greatly affect traffic during these time periods because of the large number of vehicles on the road and greater likelihood for congested conditions.

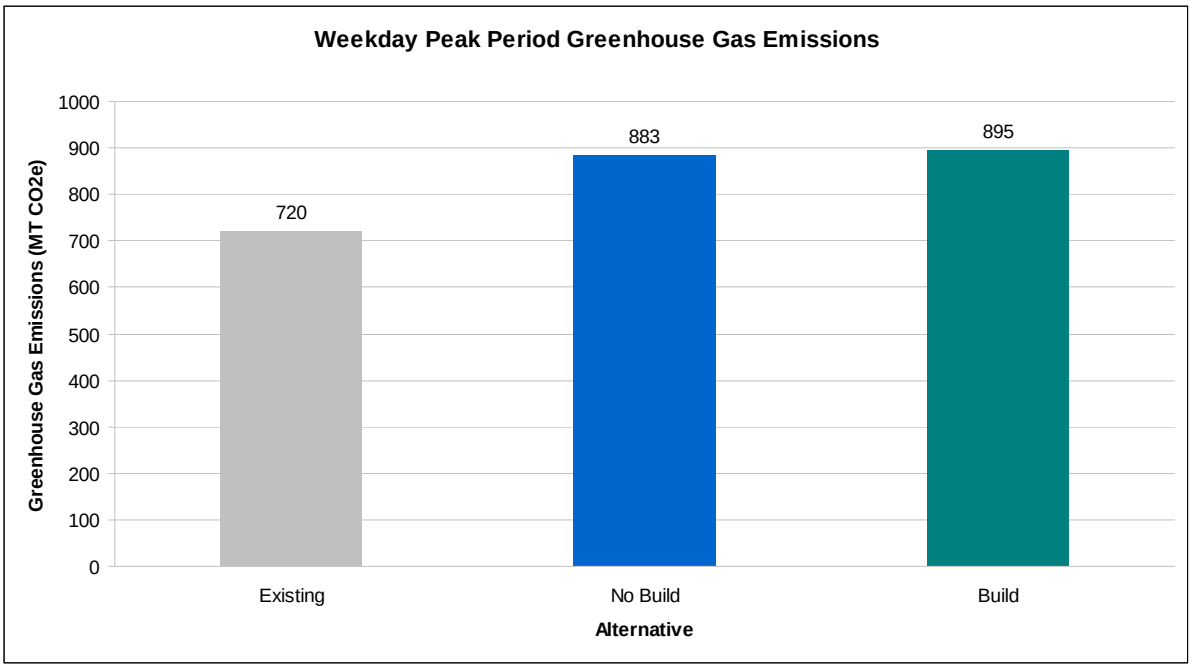


Exhibit 10. Daily Peak Period GHG Emissions – Metric Tons Carbon Dioxide Equivalents

The operational emissions values represent only those emissions during the peak periods on weekdays. Additional emissions are released during non-peak hours and on the weekends. Because traffic data was not available for these periods, this analysis does not include these emissions. This data limitation also precludes the calculation of annual greenhouse gas emissions for this project. However, since the weekday peak travel hours are the highest CO_2e emitting periods, the daily comparison is expected to reflect annual trends.

Although this analysis does not include any project effects to roadways other than SR 520, it is important to note that conditions on SR 520 influence, and are influenced by, traffic on other roadways in the region. The overall effect of the project on greenhouse gas emissions in the region could be lower or higher than the figures reported.

These values should not be compared to the construction emissions. Construction emission can be clearly delineated in time and space. Operational emissions are much less clearly defined because they are heavily influenced by conditions outside the study area.

Exhibit 11 compares the alternatives and presents percent change from the No Build Alternative. These values represent average days. On some days, emissions will be higher due to special events, weather, or incidents on the roadway. On other days, traffic conditions will allow traffic to flow at more efficient speeds and emissions may be lower.

Exhibit 11. Daily Peak Period GHG Emissions Comparisons – Metric Tons Carbon Dioxide Equivalents

	AM Hours			PM Hours			Total		
Alternative	AM Emissions (MT CO_2e)	Compared to No Build (MT CO_2e)	Percent Difference (MT CO_2e)	PM Emissions (MT CO_2e)	Compared to No Build (MT CO_2e)	Percent Difference (MT CO_2e)	Total Emissions (MT CO_2e)	Compared to No Build (MT CO_2e)	Percent Difference (MT CO_2e)
Existing	379	-32	-8%	341	-131	-27%	720	-74	-18%
No Build	411			472			833		
Build	413	2	1%	482	10	2%	895	12	1%

Note: Numbers may not add due to rounding.

Current conditions produce about 720 MT of CO_2e each weekday from 5:30 a.m. to 10:15 a.m. and 3:00 p.m. to 7:45 p.m. In 2030 the No Build Alternative would produce about 833 MT CO_2e during the same time periods, and the Build Alternative is calculated to produce 895 MT CO_2e. Based on the precision of this methodology, the No Build and Build alternatives are equivalent in their contributions to greenhouse gas emissions.

The Build and No Build Alternatives result in similar quantities of emissions because they affect traffic in similar ways. With both alternatives, additional traffic leads to increased congestion and more vehicles traveling below 30 miles per hour. Vehicles traveling at below about 30 miles per hour are less efficient than vehicles traveling at somewhat higher speeds.

Potential Measures to Minimize Emissions

Total GHG emissions to construct each project alternative depend on a number of variables, including the energy used at the construction site and the length of truck trips transporting materials to and from the construction site.

Because fuel use is directly related to GHG emissions, any steps taken to minimize fuel use would reduce GHG emissions as well. WSDOT could seek to set up active construction areas, staging areas, and material transfer sites in ways that reduce equipment and vehicle idling. WSDOT could also work with our partners to promote ridesharing and other commute trip reduction efforts for employees working on the project.

Because project operation emissions are dependant on the number of vehicles traveling on the roadway and their fuel efficiency, steps to improve driving conditions on the roadway will reduce the greenhouse gas emissions. WSDOT and its transportation partners are working to reduce greenhouse gas emissions from the transportation sector throughout the state, including the SR 520 corridor. These activities include providing alternatives to driving alone such as carpooling, vanpooling, and transit, reducing the need to travel by motor vehicle by developing bike and pedestrian friendly communities, and optimizing system efficiency through variable speeds and tolling.

Future Conditions Related to Climate Change

Governor Gregoire committed the state to preparing for and adapting to the effects of climate change as part of Executive Order 0702. A focus sheet entitled Preparing for Impacts (available at

http://www.ecy.wa.gov/pubs/0801003.pdf) provides a brief summary of the key climate changes that Washington is likely to experience over the next 50 years:

- Increased temperature (heat waves, poor air quality)
- Changes in volume and timing of precipitation (reduced snow pack, increased erosion, flooding)
- Ecological effects of a changing climate (spread of disease, altered plant and animal habitats, negative impacts on human health and wellbeing)
- Sea level rise, coastal erosion

5. Mitigation

What could be done to avoid or minimize negative effects?

Construction

Building the proposed project would consume large amounts of energy that would no longer be available for other purposes. To reduce energy use related to project construction, WSDOT could implement the following potential measures:

- Adhere to construction practices that encourage efficient energy use, such as limiting idling equipment and locating staging areas near work sites.
- Encourage carpooling of workers to the site.
- Purchase construction materials from local suppliers to limit transportation fuel consumption.
- Increase public transit, vanpooling, and non-motorized facilities and programs.
- Promote regular vehicle maintenance to improve efficiency.
- Increase fuel efficient vehicles in fleet.

Operation

The Build Alternative would result in a small net savings in energy consumption when compared with the No Build Alternative. Thus, no operational mitigation measures are anticipated.

6. Conclusion

Based on the energy consumption estimates during operation, the Build Alternative would result in some energy savings when compared to the No Build and would provide increased mobility and access to transit. However, the difference likely falls within the margin of error for current methodologies. Therefore, from the perspective of energy consumption, the energy consumption during operations for the Build Alternative and No Build Alternative are essentially the same.

The construction of the project would result in a loss of energy resources that would not be available for other uses. However, the estimated average annual energy consumption during construction represents less than 0.2 percent of the annual energy consumed in the state of Washington.

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Attachment 1

Calculations for Estimated Energy Consumption

Mode	Annual VMT (millions)		Energy Consumption (Btu/mile)		Energy Consumed (millions Btu)		Btu per Gallon of Gasoline or Diesel		Gallons of Fuel (millions)
Existing Conditions									
Passenger Vehicle	541	*	5,942	=	3,215,000	/	124,000	=	25.93
Heavy Duty	4	*	23,260	=	105,000	/	139,000	=	0.76
Transit Bus	17	*	37,310	=	629,000	/	139,000	=	4.53
Total	562			=	3,949,000				31.21
No Build 2030									
Passenger Vehicle	776	*	5,942	=	4,609,000	/	124,000	=	37.17
Heavy Duty	6	*	23,260	=	150,000	/	139,000	=	1.08
Transit Bus	24	*	37,310	=	902,000	/	139,000	=	6.49
Total	806			=	5,661,000				44.74
Build 2030									
Passenger Vehicle	775	*	5,942	=	4,603,000	/	124,000	=	37.12
Heavy Duty	6	*	23,260	=	150,000	/	139,000	=	1.08
Transit Bus	24	*	37,310	=	901,000	/	139,000	=	6.48
Total	805			=	5,654,000				44.68

Note
124,000 Btu = 1 gallon of gasoline
139,000 Btu = 1 gallon of diesel
Source: WSDOT (2009); DOE (2008); EIA (2007)

Attachment 2

Model Inputs for Greenhouse Gas Emissions Modeling

EPA MOVES RunSpec File Name:
C:\Documents and Settings\landsbk\My Documents\Climate Change\Projects\SR 520\SR 520 East and West\MOVES\Draft_Runs\090727_SR520_HOV.mrs

Description:
SR 520 HOV Lanes

Domain/Scale: National
Calculation Type: Emission Rates

Time Spans:
Aggregate By: Hour
Years:
2006
2030

Months:
March
Days:
Weekdays
Hours:
Begin Hour: 07:00 - 07:59
End Hour: 07:00 - 07:59

Geographic Bounds:
LINK geography
Selection: WASHINGTON - King County

On Road Vehicle Equipment:
Compressed Natural Gas (CNG) - Motor Home
Compressed Natural Gas (CNG) - Passenger Car
Compressed Natural Gas (CNG) - Passenger Truck
Compressed Natural Gas (CNG) - School Bus
Compressed Natural Gas (CNG) - Transit Bus
Diesel Fuel - Intercity Bus
Diesel Fuel - Motor Home
Diesel Fuel - Passenger Car

Diesel Fuel - Passenger Truck
Diesel Fuel - School Bus
Diesel Fuel - Transit Bus
Electricity - Motor Home
Electricity - Passenger Car
Electricity - Passenger Truck
Electricity - School Bus
Electricity - Transit Bus
Ethanol (E85) - Motor Home
Ethanol (E85) - Passenger Car
Ethanol (E85) - Passenger Truck
Ethanol (E85) - School Bus
Ethanol (E85) - Transit Bus
Gasoline - Motor Home
Gasoline - Passenger Car
Gasoline - Passenger Truck
Gasoline - School Bus
Gasoline - Transit Bus
Liquid Propane Gas (LPG) - Motor Home
Liquid Propane Gas (LPG) - Passenger Car
Liquid Propane Gas (LPG) - Passenger Truck
Liquid Propane Gas (LPG) - School Bus
Liquid Propane Gas (LPG) - Transit Bus

Road Types:
Urban Restricted Access

Pollutants And Processes:
Running Exhaust Atmospheric CO2
Running Exhaust CO2 Equivalent
Running Exhaust Methane (CH4)
Running Exhaust Nitrous Oxide (N2O)
Running Exhaust Total Energy Consumption

Strategies:

Strategies:

Manage Input Data Sets:

General Output:
    Output Database Server Name: [using default]
    Output Database Name: 090717_sr5202_HOVlanes
    Output Time Factors:
        Time Units: Hours
        Mass Units: Grams
        Energy Units: Joules
        Distance Units: Miles

Output Emissions Breakdown:
    On Road/Off Road
    Road Type
    Output Time Step
        Hour
    Geographic Output Detail
        LINK

Advanced Performance Features:
    Do Not Execute:
    Save Data From:
    Do Not Save Generator Data
    Saved Data Database Server Name: [using default]
    Saved Data Database Name: [using default]
    Custom Default Database Server Name: [using default]
    Custom Default Database Name: [using default]
    Perform Final Aggregation (if necessary)

EPA MOVES RunSpec File Name:
C:\Documents and Settings\landsbk\My Documents\Climate Change\Projects\SR 520\SR 520 East and West\MOVES\Draft_Runs\090727_SR520_Trucks.mrs

Description:
SR 520 Trucks

Domain/Scale: National
Calculation Type: Emission Rates

Time Spans:
- Aggregate By: Hour
- Years:
  - 2006
  - 2030
- Months:
  - March
- Days:
  - Weekdays
- Hours:
  - Begin Hour: 07:00 - 07:59
  - End Hour: 07:00 - 07:59

Geographic Bounds:
- LINK geography
- Selection: WASHINGTON - King County

On Road Vehicle Equipment:
- Compressed Natural Gas (CNG) - Light Commercial Truck
- Compressed Natural Gas (CNG) - Refuse Truck
- Compressed Natural Gas (CNG) - Single Unit Long-haul Truck
- Compressed Natural Gas (CNG) - Single Unit Short-haul Truck
- Diesel Fuel - Combination Long-haul Truck
- Diesel Fuel - Combination Short-haul Truck
- Diesel Fuel - Light Commercial Truck
- Diesel Fuel - Refuse Truck

Diesel Fuel - Single Unit Long-haul Truck
Diesel Fuel - Single Unit Short-haul Truck
Electricity - Light Commercial Truck
Electricity - Refuse Truck
Electricity - Single Unit Short-haul Truck
Ethanol (E85) - Light Commercial Truck
Ethanol (E85) - Refuse Truck
Ethanol (E85) - Single Unit Long-haul Truck
Ethanol (E85) - Single Unit Short-haul Truck
Gasoline - Combination Long-haul Truck
Gasoline - Combination Short-haul Truck
Gasoline - Light Commercial Truck
Gasoline - Refuse Truck
Gasoline - Single Unit Long-haul Truck
Gasoline - Single Unit Short-haul Truck
Liquid Propane Gas (LPG) - Light Commercial Truck
Liquid Propane Gas (LPG) - Refuse Truck
Liquid Propane Gas (LPG) - Single Unit Long-haul Truck
Liquid Propane Gas (LPG) - Single Unit Short-haul Truck

Road Types:
Urban Restricted Access

Pollutants And Processes:
Running Exhaust Atmospheric CO2
Running Exhaust CO2 Equivalent
Running Exhaust Methane (CH4)
Running Exhaust Nitrous Oxide (N2O)
Running Exhaust Total Energy Consumption

Strategies:

Strategies:

Manage Input Data Sets:

General Output:
Output Database Server Name: [using default]

```
    Output Database Name: 090730_sr5202_trucks_hour
    Output Time Factors:
        Time Units: Hours
        Mass Units: Grams
        Energy Units: Joules
        Distance Units: Miles

Output Emissions Breakdown:
    On Road/Off Road
    Road Type
    Output Time Step
        Hour
    Geographic Output Detail
        LINK

Advanced Performance Features:
    Do Not Execute:
    Save Data From:
    Do Not Save Generator Data
    Saved Data Database Server Name: [using default]
    Saved Data Database Name: [using default]
    Custom Default Database Server Name: [using default]
    Custom Default Database Name: [using default]
    Perform Final Aggregation (if necessary)
```

EPA MOVES RunSpec File Name:
C:\Documents and Settings\landsbk\My Documents\Climate Change\Projects\SR 520\SR 520 East and West\MOVES\Draft_Runs\090727_SR520_GP.mrs

Description:
SR 520 General Purpose Lanes

Domain/Scale: National
Calculation Type: Emission Rates

Time Spans:
Aggregate By: Hour
Years:
2006
2030

Months:
March
Days:
Weekdays
Hours:
Begin Hour: 07:00 - 07:59
End Hour: 07:00 - 07:59

Geographic Bounds:
LINK geography
Selection: WASHINGTON - King County

On Road Vehicle Equipment:
Compressed Natural Gas (CNG) - Motor Home
Compressed Natural Gas (CNG) - Passenger Car
Compressed Natural Gas (CNG) - Passenger Truck
Diesel Fuel - Motor Home
Diesel Fuel - Passenger Car
Diesel Fuel - Passenger Truck
Electricity - Motor Home
Electricity - Passenger Car

Electricity - Passenger Truck
Ethanol (E85) - Motor Home
Ethanol (E85) - Passenger Car
Ethanol (E85) - Passenger Truck
Gasoline - Motor Home
Gasoline - Passenger Car
Gasoline - Passenger Truck
Liquid Propane Gas (LPG) - Motor Home
Liquid Propane Gas (LPG) - Passenger Car
Liquid Propane Gas (LPG) - Passenger Truck

Road Types:
Urban Restricted Access

Pollutants And Processes:
Running Exhaust Atmospheric CO2
Running Exhaust CO2 Equivalent
Running Exhaust Methane (CH4)
Running Exhaust Nitrous Oxide (N2O)
Running Exhaust Total Energy Consumption

Strategies:

Strategies:

Manage Input Data Sets:

General Output:
Output Database Server Name: [using default]
Output Database Name: 090717_SR5202_GPlanes
Output Time Factors:
Time Units: Hours
Mass Units: Grams
Energy Units: Joules
Distance Units: Miles

Output Emissions Breakdown:
On Road/Off Road

```
    Road Type
    Output Time Step
        Hour
    Geographic Output Detail
        LINK

Advanced Performance Features:
    Do Not Execute:
    Save Data From:
    Do Not Save Generator Data
    Saved Data Database Server Name: [using default]
    Saved Data Database Name: [using default]
    Custom Default Database Server Name: [using default]
    Custom Default Database Name: [using default]
    Perform Final Aggregation (if necessary)
```