Appendix Q: Energy Discipline Report

Point Defiance Bypass Project

Energy Discipline Report

Washington State Department of Transportation

September 2012

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Summary

Introduction

This Energy Discipline Report evaluates the energy consumption and related greenhouse gas (GHG) emissions from the construction and operation of the Project. The study area for this analysis includes the rail line for both the existing service and the proposed new alignment.

The Transportation sector is a significant source of GHG emissions and contributes to climate change primarily through the burning of gasoline and diesel fuels. National estimates show that the transportation sector (including on-road 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 the state relies heavily on hydropower for electricity generation, unlike other states that rely on fossil fuels such as coal, petroleum, and natural gas to generate electricity.

Operational Effects

Currently, there are four daily Amtrak Cascades round trips and one daily Coast Starlight round trip through the study area, for a total of ten trips. The Project would add two daily Amtrak Cascades round trips for a total of 14 daily trips between Seattle and Portland.

Exhibit 1 compares the energy and GHG effects of the Project alternatives. Although the Build Alternative accommodates two additional round trips per day, the Project alignment is 6.5 miles shorter and the trains are more fuel efficient allowing for more energy efficient travel than the current alignment. Therefore, the Build Alternative uses 37 fewer gallons of fuel per day. Additionally, due to more fuel efficient trains and a route reduction, the Build Alternative would produce fewer emissions per trip and fewer total emissions.

Exhibit 1. Alternatives Operation Comparison

Travel from Seattle to Portland	2009	2018	
	Existing	*No Action*	*Build*
Amtrak Cascades Trips Daily	8	8	12
Amtrak Coast Starlight Trips Daily	2	2	2
Distance through Study Area (miles)	26.5	26.5	20
Total Distance Daily (miles)	265	265	273
Diesel Fuel Use Daily (gal)	407	407	322
GHG Emissions (MT CO2e) Daily	4.2	4.2	3.3
Annual Difference [Build Minus No Action] (MT CO2e)			-321

Construction Effects

Energy is required for construction of the Project. Construction machinery uses fuel in hauling materials and building the transportation facility. Energy is also used in the production of materials used for construction. Construction energy analysis involves the various activities, and types and quantities of materials used in the construction of the project, such as excavation, embankment, and structural materials. The total amount of construction energy calculated for the Project is a summation of the energy used for each type of construction activity.

The construction analysis also included both on-site emissions from construction equipment operation and emissions produced off-site to create and transport construction materials. Off-site energy use is called "embodied energy," and is included in the factors used to calculate construction energy and emissions. The majority of construction emissions are from fuel combustion from equipment used on-site. Project construction would produce minor GHG emissions as a result of the operation of construction equipment, worker vehicles, and trucks transporting equipment, parts, and materials. These emissions would be temporary and short-term.

There is a rough relationship between the dollar cost and energy costs; thus, the alternatives can be compared for cost efficiency. Construction energy and GHG estimates shown in Exhibit 2 are therefore based on Project costs.

Exhibit 2. Construction Energy and GHG Emissions

	Existing and No Action	Build
Construction Energy Requirements (MBtu)	0	539,000
Construction GHG Emissions (MT CO2e)	0	41,000

Effects of Changing Climate on the Project

FRA and WSDOT acknowledge the effects of climate change may alter the function, sizing, and operations of transportation facilities. In addition to mitigating GHG emissions, FRA and WSDOT must also ensure that transportation facilities can adapt to the changing climate. To ensure that transportation facilities function as intended for their planned lifespan, they should be designed to perform under the variable conditions expected as a result of climate change.

FRA and WSDOT considered the information on climate change with regard to preliminary design as well as the potential for changes in the surrounding natural environment. The Project is designed to more than 50 years. As part of its standard design, the Project has incorporated features that would provide greater resilience and function with the potential effects brought on by climate change. For example, shifting the rail line inland would protect the Project from sea level rise.

Operational Minimization Measures

FRA and WSDOT and its transportation partners are working to reduce energy consumption and GHG emissions from the transportation sector throughout the state, including the rail system.

Additional fuel efficiency would be realized with the use of the new models of locomotives being built for this route in the future. The F59PHI locomotives currently being used were state of the art when they were introduced 13 years ago. However, existing freight locomotives being introduced today are 10-12 percent more energy efficient than locomotives built in the mid-1990s. Therefore, it is assumed that new passenger locomotives purchased in the next several years would be at least 10 percent more fuel efficient than the existing F59PHIs.

Construction Minimization Measures

Measures that reduce energy use would also reduce GHG emissions. Construction practices that minimize roadway congestion and encourage efficient energy use would be implemented and possible measures may include the following:

- Limit equipment idling
- Encourage construction workers to carpool
- Locate staging areas near work sites
- Schedule the delivery of materials during off-peak hours to allow trucks to travel to the site with less congestion and at fuel-efficient speeds

Chapter 1 – Project Description

Introduction

Under the High-Speed Intercity Passenger Rail (HSIPR) Program and pursuant to a programmatic Tier I Environmental Assessment (EA) the Federal Railroad Administration (FRA) has approved an application from the Washington State Department of Transportation (WSDOT) to improve the Pacific Northwest Rail Corridor (PNWRC), a federally designated high-speed rail corridor. One project included in the PNWRC application is the Point Defiance Bypass Project (the Project), which would respond to deficiencies in the existing rail operations around Point Defiance. This Discipline Report has been prepared in support of the project-specific EA for the Point Defiance Bypass project.

The Project is located in Pierce County along an existing approximately 20-mile rail corridor between Tacoma and Nisqually.[1] The Project would provide for the re-routing of Amtrak passenger trains from the BNSF rail line that runs along the southern Puget Sound shoreline (Puget Sound route) to the Point Defiance Bypass route, an existing rail corridor that runs along the west side of I-5. The Project would consist of railroad track and support facility improvements, and relocation of the Tacoma Amtrak Station to Freighthouse Square in Tacoma.

Purpose and Need

As described above, the Point Defiance Bypass route is part of the larger PNWRC. Within Washington State, the vision for the PNWRC is to "…improve intercity passenger rail service by reducing travel times and achieving greater schedule reliability in order to accommodate growing intercity travel demand…"[2].

The purpose of the Project is to provide more frequent and reliable high-speed intercity passenger rail service along the PNWRC between Tacoma and Nisqually. In conformity with the decisions under the Tier 1 Programmatic EA, the PNWRC Improvement Program has reduced the overall environmental effects of providing improved passenger rail service with the use of an existing transportation corridor and associated infrastructure, rather than creating a new corridor.

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[1] *The three owners of the project corridor are Sound Transit, Tacoma Rail, and BNSF.*
[2] *WSDOT 2009*

The Project is needed to address the deficiencies in the existing rail alignment around Point Defiance. The existing alignment (Puget Sound route), shared by freight and passenger rail traffic, is near capacity and is therefore unable to accommodate additional high-speed intercity passenger rail service without substantial improvements. In addition, the existing alignment has physical and operational constraints that adversely affect both passenger train scheduling and reliability.

Improving intercity passenger rail service in the project area and meeting the Project needs would be accomplished by:

- Enhanced Frequency: Increasing Amtrak Cascades round-trips from four to six by 2017 to meet projected service demands.
- Improved Reliability: Reducing scheduling conflicts with freight trains that often result in delays, and by minimizing or avoiding operational delays (e.g., drawbridge openings) and weather-related delays (e.g., mudslides), and improving on-time performance from 68 percent to 88 percent.
- Enhanced Efficiency: Enhancing the efficient movement of people by decreasing trip times by 10 minutes, and reducing the amount of time passenger trains spend yielding to freight movements.
- Improved Safety: Constructing at-grade crossings with upgraded safety features, including wayside horns, median barriers, advance warning signals, and traffic signal improvements.

What alternatives are being considered for the Point Defiance Bypass Project?

FRA and WSDOT conducted an evaluation of three build alternatives: the Point Defiance Bypass Alternative, the Shoreline Alternative, and the Greenfield Alternative. Two of the alternatives (the Shoreline Alternative, and the Greenfield Alternative) were eliminated from further study. Although both alternatives could meet the Project's purpose and need, they were determined to be impracticable and unfeasible due to technical constraints, high construction costs, and significant environmental effects. Grade separations were also evaluated for further consideration. FRA and WSDOT's preliminary analysis revealed that current and projected future traffic volumes do not warrant the construction of new grade-separated crossings.

What's happening in the bypass corridor today?

The rail line between TR Junction and East "D" Street in Tacoma hosts both freight and commuter trains, including freight operators Tacoma Rail and BNSF, and Sound Transit's *Sounder* commuter rail service. Freight train traffic between TR Junction and East "D" Street averages under two trains per day, while Sound Transit currently operates 18 trains per day between Freighthouse Square and Seattle each weekday, and also offers occasional special event trains, usually on weekends, to serve sporting and other events in Seattle. *Sounder* service to Lakewood begins in late 2012.

What would happen if the Project were not built?

If the Project were not built (the No Build Alternative), Amtrak's Cascades and Coast Starlight passenger train service would continue to use the existing Puget Sound route. The No Build Alternative includes only the minor maintenance and repair activities necessary to keep the existing Puget Sound route operational. With the No Build Alternative, it would be expected that as freight traffic increases, congestion would adversely affect Amtrak service reliability, and the travel time for Amtrak trains between Seattle and Portland would increase.

Along the Point Defiance Bypass route, the Tacoma Rail and BNSF freight services would continue. The at-grade crossings at Clover Creek Drive Southwest, North Thorne Lane Southwest, Berkeley Street Southwest, 41st Division Drive, and Barksdale Avenue Southwest would not be upgraded.

Sound Transit's *Sounder* commuter passenger trains will become operational in late 2012 between the Tacoma Dome Station at Freighthouse Square in Tacoma and Sound Transit's Lakewood Station (on the Point Defiance Bypass route) with as many as 18 *Sounder* trains per day.

What are the proposed improvements and related activities of the Point Defiance Bypass Project?

The Project consists of railroad track and support facility improvements, and the relocation of Amtrak's Tacoma Station. Exhibit 3 shows the components of the Build Alternative. The following details specific components of the Build Alternative.

- **Construct New Track Adjacent to the Existing Main Line –** A new 3.5-mile track adjacent to the existing main line would be constructed from South 66th Street (Rail MP 6.9) in Tacoma to between Bridgeport

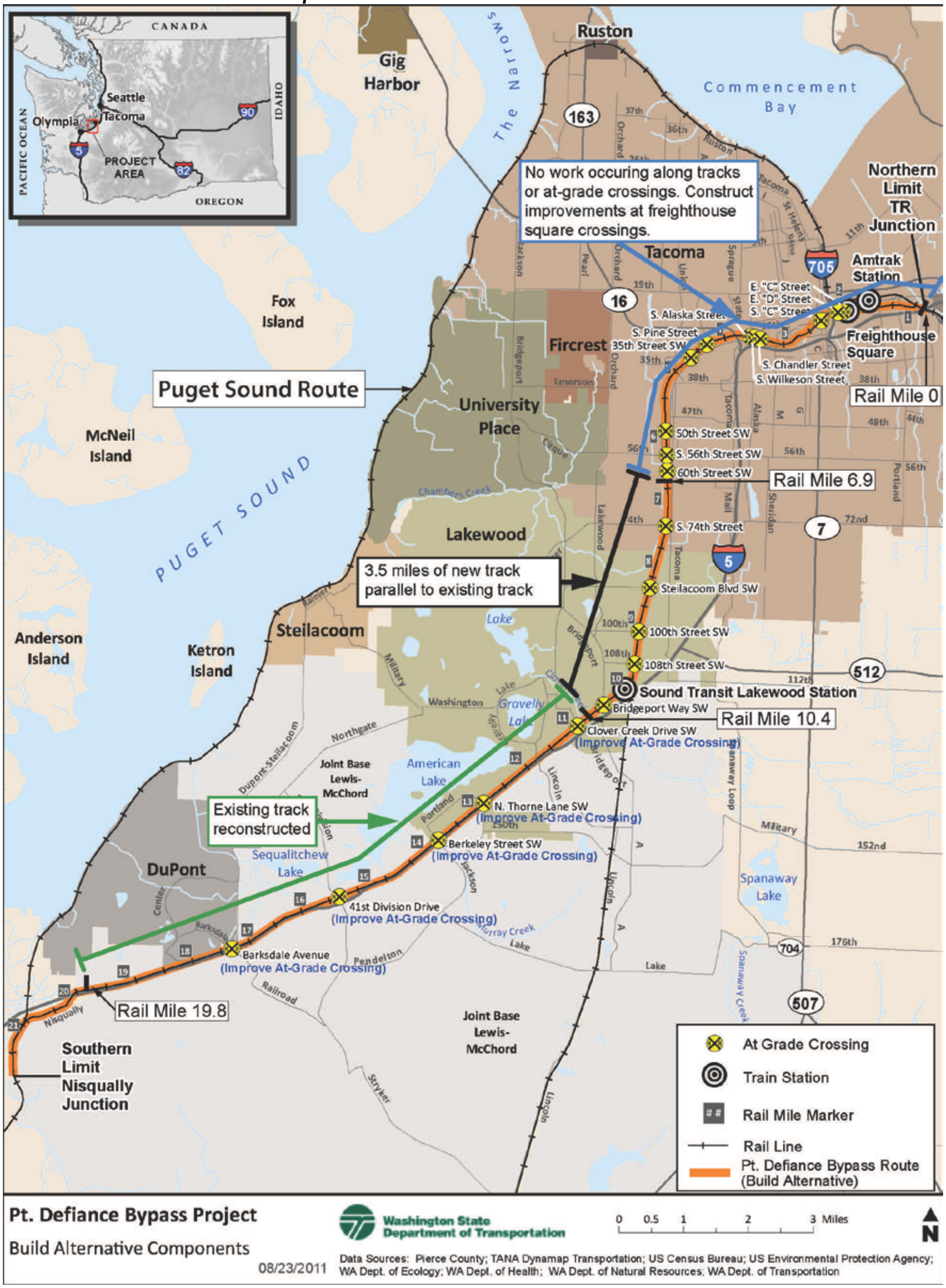
Way SW (Rail MP 10.4) and Clover Creek Drive SW (Rail MP 10.9) in Lakewood.

- **Reconstruct and Rehabilitate the Existing Main Line –** Starting just southwest of Bridgeport Way Southwest (Rail MP 10.4) in Lakewood, the existing track would be reconstructed to a location southeast of the I-5/Mounts Road Southwest interchange (Rail MP 19.8) at Nisqually Junction.
- **Improvements at at-Grade Crossings –** Several grade crossings would be improved with wayside horns, gates, traffic signals and signage, sidewalks, median separators, and warning devices. These crossings include Clover Creek Drive Southwest, North Thorne Lane Southwest, Berkeley Street Southwest, 41st Division Drive and Barksdale Avenue.
- **Tacoma Amtrak Station Relocation –** The existing Tacoma Amtrak Station would be relocated from its Puyallup Avenue location to the Tacoma Dome Station at Freighthouse Square, at 430 E. 25th Street in Tacoma.

What are the proposed operational changes that would result from the Point Defiance Bypass Project?

Amtrak's existing Cascades and Coast Starlight passenger train service would be rerouted from the Puget Sound route along the Puget Sound shoreline to the Point Defiance Bypass route. The Project would also provide for additional Amtrak Cascades service by increasing the number of round trips provided from 4 to 6, or a total of 12 Cascades service train trips. Amtrak Coast Starlight would also travel on the Point Defiance Bypass route for a total of two Coast Starlight service train trips. The speed of these passenger trains would be up to 79 mph.

Exhibit 3. Build Alternative Components



Chapter 2 – Methodology

The methodology used for this analysis is consistent with the *WSDOT Guidance for Project-Level Greenhouse Gas and Climate Change Evaluations* dated October 2010.

The study area for this analysis includes the rail line for both the existing service and the proposed new alignment. The Project office provided data on train frequency and Project costs.

Train efficiency information was drawn from the Pacific Northwest Rail Corridor Program (PNWRC) EA (WSDOT, 2009).

Operational Analysis

Operational energy use was estimated from train fuel efficiency information prepared as part of the PNWRC EA, combined with route distance through the study area. GHG emissions were derived from the energy use and based on emission factors from The Climate Registry's General Reporting Protocol.

Train Fuel Use

Exhibit 4 reports the trip length and average fuel use for Amtrak Cascades trains running between Portland and Seattle in both 2009 and 2018. The 2009 values were used to determine existing conditions and 2018 values were used to estimate future fuel requirements.

Exhibit 4 .Train Fuel Efficiency

Travel from Seattle to Portland	Existing (2009) and No Build (2018)	Build (2018)
Fuel Use per Trip (gal)	286	212
Trip Distance (miles)	186	180
Fuel Economy (mpg)	0.7	0.8

The Project would reduce the distance trains travel through the south Tacoma area from 26.5 miles to 20.0 miles.

Greenhouse Gas Emissions

Diesel combustion results primarily in CO_2 emissions, but also produces small amounts of other gases. Of those other gases, methane (CH_4) and nitrous oxide (N_2O) are both GHGs.

Global Warming Potential

Global warming potentials (GWP) compare the ability of other gases to warm the atmosphere to the ability of CO_2. For example, CH_4 warms the atmosphere 21 times more, per unit, than CO_2. The GWPs for gases considered in this analysis are shown in the Exhibit 5.

Emission Factors

Emission factors describe the quantity of GHGs released during fuel combustion. The quantity of carbon dioxide is determined by the chemical properties of the fuel. The quantities of other GHGs depend on both the type of engine and the type of fuel used. Emission factors used in this analysis are shown in Exhibit 5.

Exhibit 5. Global Warming Potentials and Emission Factors

Gas	GWP[3]	Emission Factors[4]
CO_2	1	10.15 kg/gallon
CH_4	21	0.8 g/gallon
N_2O	310	0.26 g/gallon

Construction Analysis

Construction energy use was calculated using the California Department of Transportation (CalTrans) methodology that correlates project cost information to project energy use. The energy factors were also developed by CalTrans[5] and include the energy used to obtain the raw materials, manufacture and transport the supplies, and construct the facility. Embodied emissions are not directly calculable but are part of the energy factors.

Energy factors are based on 1977 dollars and were updated to current project cost estimates using the most current CalTrans Index for Selected Construction Items.[6]

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[3] *The Climate Registry. General Reporting Protocol. Appendix B.*
[4] *The Climate Registry. General Reporting Protocol.*
[5] *California Department of Transportation. "Energy and Transportation Systems." July 1983.*
[6] *California Department of Transportation. "Price Index for Selected Highway Construction Items." http://www.dot.ca.gov/hq/esc/oe/contract_progress/cost-index-summary.pdf.*

Factors are available for the following project types:

- Urban highways
- Rural highway widening
- Interchanges
- Steel girder bridges
- Concrete girder bridges

Specific factors are not available for rail projects so the Project was qualitatively compared to the type of work and materials used for a highway project. An urban conventional highway widening project was chosen for the Project to reflect conservative results.

The GHG emissions analysis assumed all construction energy would be provided by diesel and used the diesel CO_2 emission factors provided by The Climate Registry's *General Reporting Protocol*.[7] N_2O and CH_4 emissions were assumed to be a similar proportion as for a highway project and estimated to be 5 percent of the total CO_2 emissions. N_2O and CH_4 emissions were converted to CO_2 according to their GWP and reported as CO_2 equivalents (CO_2e). CO_2e represent the various GHG emissions as a single unit.

Conversion factors for CO_2e construction GHG emissions are listed in Exhibit 6.

Exhibit 6. Conversion Factors for Construction Analysis

Conversion	Factor
Dollars to Btu	**5,920 Btu/$**
Diesel Energy Content	**139,000 Btu/gal**
GHG Emissions	**10.66 kg CO_2e/gal**

[7] *The Climate Registry,* General Reporting Protocol, *Version 1.1, May 2008.*

Chapter 3 – Affected Environment

Energy Use

A passenger train consumes about 55,000 BTUs of energy per vehicle mile; in comparison, a typical automobile consumes about 5,517 BTUs of energy per vehicle mile. The energy for a passenger train is in the form of diesel fuel, a hydrocarbon-based petroleum based product. As discussed in Chapter 2, Exhibit 4, the average fuel economy of a passenger train is approximately 0.7 miles per gallon (mpg).

The Amtrak Cascades currently makes four daily round trips between Seattle and Portland. In addition, the Coast Starlight travels through the study area on its daily round trip between Seattle and Los Angeles, CA. Information regarding current trip distance, fuel and energy use and GHG emissions are shown in Exhibit 7.

Exhibit 7. Existing Emissions

Train Travel Through the Study Area	Existing (2009)
Daily Amtrak Cascades trips	8
Daily Amtrak Coast Starlight trips	2
Distance Through the Study Area (miles)	26.5
Total Distance Through the Study Area (miles)	265
Fuel use at 0.7 mpg	186 (gallons)
Energy Use (Mbtu)	57
GHG Emissions (MT CO_2e)	4.2

Yard operations also consume diesel fuel; however, since the Project does not include rail yard operations, fuel consumption quantities are not included as part of the analysis for the Project.

Motor vehicles also consume fuel as they move through the study area and wait for trains to pass. Energy use depends on the number and type of vehicles. Because of this variability, vehicle energy use is assumed to be minimal and is not part of this analysis. Electrical energy is used on the right-of-way to operate switches, crossing guards, and communication devices. Each train also operates electrical equipment; however, this energy is generated through on-board power generation and is not included in this analysis.

Chapter 4 – Potential Project Effects

Operational Effects

Currently, there are four daily Amtrak Cascades round trips and one daily Coast Starlight round trip through the study area, for a total of ten trips. The Project would add two daily Amtrak Cascades round trips for a total of 14 daily trips between Seattle and Portland.

Exhibit 8 compares the energy and GHG effects of the Project alternatives. Although the Build Alternative accommodates two additional round trips per day, the Project alignment is 6.5 miles shorter and the trains are more fuel efficient allowing for more energy efficient travel than the current alignment. Therefore, the Build Alternative uses 37 fewer gallons of fuel per day (based on the Fuel Economy rates in Exhibit 8). Additionally, due to more fuel efficient trains and a route reduction, the Build Alternative would produce fewer emissions per trip and fewer total emissions.

Exhibit 8. Alternatives Operation Comparison

Travel from Seattle to Portland	2009	2018	
	Existing	*No Action*	*Build*
Daily Amtrak Cascades trips	8	8	12
Daily Coast Starlight trips	2	2	2
Distance through the Study Area	26.5	26.5	20
Total Distance	265	265	273
Fuel Use per Day (gal)	379	379	341
Energy Use (Mbtu)	57	57	45
GHG Emissions (MT CO2e)	4.2	4.2	3.3
Annual Difference in Energy Use (MBtu)	–	–	-4,360
Annual Difference in GHG Emissions (Build Minus No Action) (MT CO2e)	–	–	-321

Construction Effects

Energy is required for construction of the Project. Construction machinery uses fuel in hauling materials and building the transportation facility. Energy is also used in the production of materials used for construction. Construction energy analysis involves the various activities, and types and quantities of materials used in the construction of the Project, such as excavation, embankment, and structural materials. The total amount of construction energy calculated for the Project is a summation of the energy used for each type of construction activity.

The construction analysis also includes both on-site emissions from construction equipment operation and emissions produced off-site to create and transport construction materials. Off-site energy use is called “embodied energy,” and is included in the factors used to calculate construction energy and emissions. The majority of construction emissions are from fuel combustion from equipment used on site. Construction activities would include demolition of pavement and other structures, earthwork, new rail construction, and new paving. Equipment to be used for construction would include a TLM, truck cranes, vibratory oscillator, dump trucks, loaders, excavators, and typical paving equipment such as graders, asphalt pavers, and rollers. Construction equipment powered by gasoline and diesel engines generate CO and NO_x in exhaust emissions. Project construction would therefore produce minor GHG emissions as a result of the operation of construction equipment, worker vehicles, and trucks transporting equipment, parts, and materials. These emissions would be temporary and short-term.

There is a rough relationship between the dollar cost and energy costs; thus, the alternatives can be compared for cost efficiency. Construction energy and GHG estimates shown in Exhibit 9 are therefore based on Project costs.

Exhibit 9. Construction GHG Emissions

	2018	
	No Action	*Build*
Construction Energy Requirements (MBtu)	**0**	**539,000**
Construction GHG Emissions (MT CO_2e)	**0**	**41,000**

Indirect Effects

The Project is located within an existing rail corridor and urbanized area. The only potential indirect effect tied to the Project is that it may indirectly influence redevelopment near the relocated Amtrak Station at Freighthouse Square (see Land Use Discipline Report[8]). Such redevelopment would be consistent with local zoning and approved by state and local agencies and would take place in previously disturbed areas. The energy requirements for the Project and subsequent redevelopment of the area near Freighthouse Square are small in comparison to state energy resources. Thus, there would be no indirect effects to energy from the Project.

[8] *WSDOT 2012.*

Cumulative Effects

The long-term energy use associated with the Project would be reduced from current conditions. Thus, there would be a beneficial cumulative effect to energy from the Project.

Effects of Changing Climate on the Project

FRA and WSDOT acknowledge that effects of climate change may alter the function, sizing, and operations of our facilities. Therefore, in addition to mitigating GHG emissions, FRA and WSDOT must also ensure that its transportation facilities can adapt to the changing climate. To ensure that our facilities can function as intended for their planned lifespan, they should be designed to perform under the variable conditions expected as a result of climate change. For example, drainage culverts may need to be resized to accommodate more intense rainfall events or increased flows due to more rapid glacial thawing.

The climate projections indicate that Washington State is likely to experience some or all of the following effects over the next 50-100 years:

- Increased temperature leading to more frequent extreme heat events, worsened air quality, and glacial melting
- Sea-level rise, coastal erosion, salt water intrusion
- Changes in the volume and timing of precipitation resulting in reduced snow pack, increased erosion, and more frequent and severe flooding
- Ecological effects of a changing climate including the spread of disease, altered plant and animal habitats, and negative effects on human health and well-being

FRA and WSDOT considered the information on climate change with regard to preliminary design as well as the potential for changes in the surrounding natural environment. The Project is designed to more than 50 years. As part of its standard design, the Project has incorporated features that would provide greater resilience and function with the potential effects brought on by climate change. For example, shifting the rail line inland would protect the Project from sea level rise.

Chapter 5 – Recommended Minimization Measures

Operational

The Project is expected to reduce operational energy consumption from passenger train on between Seattle, Washington, and Portland, Oregon. Energy use is expected to decrease with the Build Alternative because of the reduced distance traveled per trip and more efficient operating speeds.

Additional fuel efficiency would be realized with the use of the new models of locomotives being built for this route in the future. The F59PHI locomotives currently being used were state of the art when they were introduced 13 years ago. However, existing freight locomotives being introduced today are 10-12 percent more energy efficient than locomotives built in the mid-1990s. Therefore, it is assumed that new passenger locomotives purchased in the next several years would be at least 10 percent more fuel efficient than the existing F59PHIs.

FRA, WSDOT and its transportation partners are also working to reduce energy consumption and GHG emissions from the transportation sector throughout the state, including the rail system. Examples of these activities include the following:

- Providing alternatives to driving alone (such as carpooling, vanpooling, and transit);
- Developing transportation facilities that encourage transit, HOV, bike, and pedestrian modes;
- Supporting land use planning and development that encourage such travel modes (such as concentrating growth within urban growth areas);
- Optimizing system efficiency through measures like variable speeds; and
- Using alternative fuels.

Construction

Construction practices that minimize roadway congestion and encourage efficient energy use would be implemented. Minimization measures that reduce energy use would also reduce GHG emissions. Possible minimization measures might include:

- Limiting equipment idling
- Encouraging carpooling of construction workers
- Locating staging areas near work sites
- Scheduling the delivery of materials during off-peak hours to allow trucks to travel to the site with less congestion and at fuel-efficient speeds

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