INTERSTATE 5 COLUMBIA RIVER CROSSING

Energy Technical Report for the Final Environmental Impact Statement

May 2011

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Cover Sheet

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Energy Technical Report for the Final Environmental Impact Statement:

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ACRONYMS

Acronym	Description
ADA	Americans with Disabilities Act
BMP	best management practice
BNSF	Burlington Northern Santa Fe Railroad
Btu	British thermal unit
CAFE	Corporate Average Fuel Economy
CD	collector-distributor
CEQ	Council on Environmental Quality
CH_4	methane
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
CPU	Clark Public Utilities
CRC	Columbia River Crossing
CTR	Commute Trip Reduction (Washington)
C-TRAN	Vancouver area transit service provider
DEIS	Draft Environmental Impact Statement
DOT	U.S. Department of Transportation
ECO	Employee Commute Options (Oregon)
EF	emission factor
eGRID	emissions and Generation Resource Integrated Database
EM	emissions
EO	Executive Order
ERP	Expert Review Panel
EPA	U.S. Environmental Protection Agency
FCR	fuel consumption rate
FEIS	Final Environmental Impact Statement
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GHG	greenhouse gas
HB	House Bill
HFC	hydrofluorocarbon
ISTEA	Intermodal Surface Transportation Efficiency Act
kWh	kilowatt hour
LCDC	Land Conservation and Development Commission
LPA	locally preferred alternative
LRT	light rail transit

LRV	light rail vehicle
MAX	Metropolitan Area Express
mBtu	million British thermal unit
Metro	Portland area metropolitan planning organization
MOVES	Mobile Vehicle Emission Simulator
MT	metric ton
N_2O	nitrous oxide
NEPA	National Environmental Policy Act
NPCC	Northwest Power and Conservation Council
NWPP	Northwest Power Pool
OAR	Oregon Administrative Rule
ODOE	Oregon Department of Energy
ODOT	Oregon Department of Transportation
OTC	Oregon Transportation Council
OTP	Oregon Transportation Plan
PFC	perfluorocarbon
PGE	Portland General Electric
PSD	Prevention of Significant Deterioration
RCW	Revised Code of Washington
ROD	Record of Decision
RTC	Regional Transportation Council
RTPO	Regional Transportation Planning Organization
SPUI	single-point urban interchange
SR	State Route
TDM	transportation demand management
TEA-21	Transportation Equity Act for the 21st Century
TPR	Transportation Planning Rule
TriMet	Portland area transit service provider
TSM	transportation system management
USC	United States Code
USDOE	United States Department of Energy
VMT	vehicle miles traveled
WAC	Washington Administrative Code
WCI	Western Climate Initiative
WSDOT	Washington State Department of Transportation
WTC	Washington Transportation Commission

1. Summary

1.1 Introduction

Transportation across the I-5 bridges crossing between Vancouver, Washington and Portland, Oregon consumes energy and emits carbon dioxide (CO_2) and other greenhouse gases (GHGs). This report estimates the amount of energy that would be required and the amount of GHGs that would be emitted during construction of the project alternatives (referred to as “temporary effects”), as well as the energy consumption and associated GHG emissions resulting from private, freight, and public vehicles operating within the study area (referred to as “long-term effects”).

1.2 Description of Alternatives

This technical report evaluates the CRC project’s locally preferred alternative (LPA) and the No-Build Alternative. The LPA includes two design options: The preferred option, LPA Option A, which includes local vehicular access between Marine Drive and Hayden Island on an arterial bridge; and LPA Option B, which does not have arterial lanes on the light rail/multi-use path bridge, but instead provides direct access between Marine Drive and the island with collector-distributor (CD) lanes on the two new bridges that would be built adjacent to I-5. In addition to the design options, if funding availability does not allow the entire LPA to be constructed in one phase, some roadway elements of the project would be deferred to a future date. This technical report identifies several elements that could be deferred, and refers to that possible initial investment as LPA with highway phasing. The LPA with highway phasing option would build most of the LPA in the first phase, but would defer construction of specific elements of the project. The LPA and the No-Build Alternative are described in this section.

1.2.1 Adoption of a Locally Preferred Alternative

Following the publication of the Draft Environmental Impact Statement (DEIS) on May 2, 2008, the project actively solicited public and stakeholder feedback on the DEIS during a 60-day comment period. During this time, the project received over 1,600 public comments.

During and following the public comment period, the elected and appointed boards and councils of the local agencies sponsoring the CRC project held hearings and workshops to gather further public input on and discuss the DEIS alternatives as part of their efforts to determine and adopt a locally preferred alternative. The LPA represents the alternative preferred by the local and regional agencies sponsoring the CRC project. Local agency-elected boards and councils determined their preference based on the results of the evaluation in the DEIS and on the public and agency comments received both before and following its publication.

In the summer of 2008, the local agencies sponsoring the CRC project adopted the following key elements of CRC as the LPA:

- A replacement bridge as the preferred river crossing,
- Light rail as the preferred high-capacity transit mode, and
- Clark College as the preferred northern terminus for the light rail extension.

The preferences for a replacement crossing and for light rail transit were identified by all six local agencies. Only the agencies in Vancouver – the Clark County Public Transit Benefit Area Authority (C-TRAN), the City of Vancouver, and the Regional Transportation Council (RTC) – preferred the Vancouver light rail terminus. The adoption of the LPA by these local agencies does not represent a formal decision by the federal agencies leading this project – the Federal Highway Administration (FHWA) and Federal Transit Administration (FTA) – or any federal funding commitment. A formal decision by FHWA and FTA about whether and how this project should be constructed will follow the FEIS in a Record of Decision (ROD).

1.2.2 Description of the LPA

The LPA includes an array of transportation improvements, which are described below. When the LPA differs between Option A and Option B, it is described in the associated section. For a more detailed description of the LPA, including graphics, please see Chapter 2 of the FEIS.

1.2.2.1 Multimodal River Crossing

Columbia River Bridges

The parallel bridges that form the existing I-5 crossing over the Columbia River would be replaced by two new parallel bridges. The eastern structure would accommodate northbound highway traffic on the bridge deck, with a bicycle and pedestrian path underneath; the western structure would carry southbound traffic, with a two-way light rail guideway below. Whereas the existing bridges have only three lanes each with virtually no shoulders, each of the new bridges would be wide enough to accommodate three through-lanes and two add/drop lanes. Lanes and shoulders would be built to full design standards.

The new bridges would be high enough to provide approximately 95 feet of vertical clearance for river traffic beneath, but not so high as to impede the take-offs and landings by aircraft using Pearson Field or Portland International Airport to the east. The new bridge structures over the Columbia River would not include lift spans, and both of the new bridges would each be supported by six piers in the water and two piers on land.

North Portland Harbor Bridges

The existing highway structures over North Portland Harbor would not be replaced; instead, they would be retained to accommodate all mainline I-5 traffic. As discussed at the beginning of this chapter, two design options have emerged for the Hayden Island and Marine Drive interchanges. The preferred option, LPA Option A, includes local vehicular access between Marine Drive and Hayden Island on an arterial bridge. LPA Option B does not have arterial lanes on the light rail/multi-use path bridge, but instead provides direct access between Marine Drive and the island with collector-distributor lanes on the two new bridges that would be built adjacent to I-5.

LPA Option A: Four new, narrower parallel structures would be built across the waterway, three on the west side and one on the east side of the existing North Portland Harbor bridges. Three of the new structures would carry on- and off-ramps to mainline I-5. Two structures west of the existing bridges would carry traffic merging onto or exiting off of I-5 southbound. The new structure on the east side of I-5 would serve as an on-ramp for traffic merging onto I-5 northbound.

The fourth new structure would be built slightly farther west and would include a two-lane arterial bridge for local traffic to and from Hayden Island, light rail transit, and a multi-use path for pedestrians and bicyclists. All of the new structures would have at least as much vertical clearance over the river as the existing North Portland Harbor bridges.

LPA Option B: This option would build the same number of structures over North Portland Harbor as Option A, although the locations and functions on those bridges would differ, as described below. The existing bridge over North Portland Harbor would be widened and would receive seismic upgrades.

LPA Option B does not have arterial lanes on the light rail/multi-use path bridge. Direct access between Marine Drive and the island would be provided with collector-distributor lanes. The structures adjacent to the highway bridge would carry traffic merging onto or exiting off of mainline I-5 between the Marine Drive and Hayden Island interchanges.

1.2.2.2 Interchange Improvements

The LPA includes improvements to seven interchanges along a 5-mile segment of I-5 between Victory Boulevard in Portland and SR 500 in Vancouver. These improvements include some reconfiguration of adjacent local streets to complement the new interchange designs, as well as new facilities for bicyclists and pedestrians along this corridor.

Victory Boulevard Interchange

The southern extent of the I-5 project improvements would be two ramps associated with the Victory Boulevard interchange in Portland. The Marine Drive to I-5 southbound on-ramp would be braided over the I-5 southbound to the Victory Boulevard/Denver Avenue off-ramp. The other ramp improvement would lengthen the merge distance for northbound traffic entering I-5 from Denver Avenue. The current merging ramp would be extended to become an add/drop (auxiliary) lane which would continue across the river crossing.

***Potential phased construction option*:** The aforementioned southbound ramp improvements to the Victory Boulevard interchange may not be included with the CRC project. Instead, the existing connections between I-5 southbound and Victory Boulevard could be retained. The braided ramp connection could be constructed separately in the future as funding becomes available.

Marine Drive Interchange

All movements within this interchange would be reconfigured to reduce congestion for motorists entering and exiting I-5 at this location. The interchange configuration would be a single-point urban interchange (SPUI) with a flyover ramp serving the east to north movement. With this configuration, three legs of the interchange would converge at a point on Marine Drive, over the I-5 mainline. This configuration would allow the highest volume movements to move freely without being impeded by stop signs or traffic lights.

The Marine Drive eastbound to I-5 northbound flyover ramp would provide motorists with access to I-5 northbound without stopping. Motorists from Marine Drive eastbound would access I-5 southbound without stopping. Motorists traveling on Martin Luther King Jr. Boulevard westbound to I-5 northbound would access I-5 without stopping at the intersection.

The new interchange configuration changes the westbound Marine Drive and westbound Vancouver Way connections to Martin Luther King Jr. Boulevard and to northbound I-5. These two streets would access westbound Martin Luther King Jr. Boulevard farther east. Martin Luther King Jr. Boulevard would have a new direct connection to I-5 northbound.

In the new configuration, the connections from Vancouver Way and Marine Drive would be served, improving the existing connection to Martin Luther King Jr. Boulevard east of the interchange. The improvements to this connection would allow traffic to turn right from Vancouver Way and accelerate onto Martin Luther King Jr. Boulevard. On the south side of Martin Luther King Jr. Boulevard, the existing loop connection would be replaced with a new connection farther east.

A new multi-use path would extend from the Bridgeton neighborhood to the existing Expo Center light rail station and from the station to Hayden Island along the new light rail line over North Portland Harbor.

LPA Option A: Local traffic between Martin Luther King Jr. Boulevard/Marine Drive and Hayden Island would travel via an arterial bridge over North Portland Harbor. There would be some variation in the alignment of local streets in the area of the interchange between Option A and Option B. The most prominent differences are the alignments of Vancouver Way and Union Court.

LPA Option B: With this design option, there would be no arterial traffic lanes on the light rail/multi-use path bridge over North Portland Harbor. Instead, vehicles traveling between Martin Luther King Jr. Boulevard/ Marine Drive and Hayden Island would travel on the collector-distributor bridges that would parallel each side of I-5 over North Portland Harbor. Traffic would not need to merge onto mainline I-5 to travel between the island and Martin Luther King Jr. Boulevard/Marine Drive.

Potential phased construction option**:** The aforementioned flyover ramp could be deferred and not constructed as part of the CRC project. In this case, rather than providing a direct eastbound Marine Drive to I-5 northbound connection by a flyover ramp, the project improvements to the interchange would instead provide this connection through the signal-controlled SPUI. The flyover ramp could be constructed separately in the future as funding becomes available.

Hayden Island Interchange

All movements for this interchange would be reconfigured. The new configuration would be a split tight diamond interchange. Ramps parallel to the highway would be built, lengthening the ramps and improving merging speeds. Improvements to Jantzen Drive and Hayden Island Drive would include additional through, left-turn, and right-turn lanes. A new local road, Tomahawk Island Drive, would travel east-west through the middle of Hayden Island and under the I-5 interchange, improving connectivity across I-5 on the island. Additionally, a new multi-use path would be provided along the elevated light rail line on the west side of the Hayden Island interchange.

LPA Option A: A proposed arterial bridge with two lanes of traffic, one in each direction, would allow vehicles to travel between Martin Luther King Jr. Boulevard/ Marine Drive and Hayden Island without accessing I-5.

LPA Option B: With this design option there would be no arterial traffic lanes on the light rail/multi-use path bridge over North Portland Harbor. Instead, vehicles traveling between Martin Luther King Jr. Boulevard/Marine Drive and Hayden Island would travel on the collector-distributor bridges that parallel each side of I-5 over North Portland Harbor.

SR 14 Interchange

The function of this interchange would remain largely the same. Direct connections between I-5 and SR 14 would be rebuilt. Access to and from downtown Vancouver would be provided as it is today, but the connection points would be relocated. Downtown Vancouver I-5 access to and from the south would be at C Street rather than Washington Street, while downtown connections to and from SR 14 would be made by way of Columbia Street at 4th Street.

The multi-use bicycle and pedestrian path in the northbound (eastern) I-5 bridge would exit the structure at the SR 14 interchange, and then loop down to connect into Columbia Way.

Mill Plain Interchange

This interchange would be reconfigured into a SPUI. The existing “diamond” configuration requires two traffic signals to move vehicles through the interchange. The SPUI would use one efficient intersection and allow opposing left turns simultaneously. This would improve the capacity of the interchange by reducing delay for traffic entering or exiting the highway.

This interchange would also receive several improvements for bicyclists and pedestrians. These include bike lanes and sidewalks, clear delineation and signing, short perpendicular crossings at the ramp terminals, and ramp orientations that would make pedestrians highly visible.

Fourth Plain Interchange

The improvements to this interchange would be made to better accommodate freight mobility and access to the new park and ride at Clark College. Northbound I-5 traffic exiting to Fourth Plain would continue to use the off-ramp just north of the SR 14 interchange. The southbound I-5 exit to Fourth Plain would be braided with the SR 500 connection to I-5, which would eliminate the non-standard weave between the SR 500 connection and the off-ramp to Fourth Plain as well as the westbound SR 500 to Fourth Plain Boulevard connection.

Additionally, several improvements would be made to provide better bicycle and pedestrian mobility and accessibility, including bike lanes, neighborhood connections, and access to the park and ride.

SR 500 Interchange

Improvements would be made to the SR 500 interchange to add direct connections to and from I-5. On- and off-ramps would be built to directly connect SR 500 and I-5 to and from the north, connections that are currently made by way of 39th Street. I-5 southbound traffic would connect to SR 500 via a new tunnel underneath I-5. SR 500 eastbound traffic would connect to I-5 northbound on a new on-ramp. The 39th Street connections with I-5 to and from the north would be eliminated. Travelers would instead use the connections at Main Street to connect to and from 39th Street.

Additionally, several improvements would be made to provide better bicycle and pedestrian mobility and accessibility, including sidewalks on both sides of 39th Street, bike lanes, and neighborhood connections.

***Potential phased construction option*:** The northern half of the existing SR 500 interchange would be retained, rather than building new connections between I-5 southbound to SR 500 eastbound and from SR 500 westbound to I-5 northbound. The ramps connecting SR 500 and I-5 to and from the north could be constructed separately in the future as funding becomes available.

1.2.2.3 Transit

The primary transit element of the LPA is a 2.9-mile extension of the current Metropolitan Area Express (MAX) Yellow Line light rail from the Expo Center in North Portland, where it currently ends, to Clark College in Vancouver. The transit element would not differ between LPA and LPA with highway phasing. To accommodate and complement this major addition to the region's transit system, a variety of additional improvements are also included in the LPA:

- Three park and ride facilities in Vancouver near the new light rail stations.
- Expansion of Tri-County Metropolitan Transportation District's (TriMet's) Ruby Junction light rail maintenance base in Gresham, Oregon.
- Changes to C-TRAN local bus routes.
- Upgrades to the existing light rail crossing over the Willamette River via the Steel Bridge.

Operating Characteristics

Nineteen new light rail vehicles (LRV) would be purchased as part of the CRC project to operate this extension of the MAX Yellow Line. These vehicles would be similar to those currently used by TriMet's MAX system. With the LPA, LRVs in the new guideway and in the existing Yellow Line alignment are planned to operate with 7.5-minute headways during the "peak of the peak" (the two-hour period within the 4-hour morning and afternoon/evening peak periods where demand for transit is the highest) and 15-minute headways during off-peak periods.

Light Rail Alignment and Stations

Oregon Light Rail Alignment and Station

A two-way light rail alignment for northbound and southbound trains would be constructed to extend from the existing Expo Center MAX station over North Portland Harbor to Hayden Island. Immediately north of the Expo Center, the alignment would curve eastward toward I-5, pass beneath Marine Drive, then rise over a flood wall onto a light rail/multi-use path bridge to cross North Portland Harbor. The two-way guideway over Hayden Island would be elevated at approximately the height of the rebuilt mainline of I-5, as would a new station immediately west of I-5. The alignment would extend northward on Hayden Island along the western edge of I-5, until it transitions into the hollow support structure of the new western bridge over the Columbia River.

Downtown Vancouver Light Rail Alignment and Stations

After crossing the Columbia River, the light rail alignment would curve slightly west off of the highway bridge and onto its own smaller structure over the Burlington Northern Santa Fe (BNSF) rail line. The double-track guideway would descend on structure and touch down on Washington Street south of 5th Street, continuing north on Washington Street to 7th Street. The elevation of 5th Street would be raised to allow for an at-grade crossing of the tracks on Washington Street. Between 5th and 7th Streets, the two-way guideway would run down the center of the street. Traffic would not be allowed on Washington between 5th and 6th Streets and would be two-way between 6th and 7th Streets. There would be a station on each side of the street on Washington between 5th and 6th Streets.

At 7th Street, the light rail alignment would form a couplet. The single-track northbound guideway would turn east for two blocks, then turn north onto Broadway Street, while the single-track southbound guideway would continue on Washington Street. Seventh Street will be converted to one-way traffic eastbound between Washington and Broadway with light rail operating on the north side of 7th Street. This couplet would extend north to 17th Street, where the two guideways would join and turn east.

The light rail guideway would run on the east side of Washington Street and the west side of Broadway Street, with one-way traffic southbound on Washington Street and one-way traffic northbound on Broadway Street. On station blocks, the station platform would be on the side of the street at the sidewalk. There would be two stations on the Washington-Broadway couplet, one pair of platforms near Evergreen Boulevard, and one pair near 15th Street.

East-west Light Rail Alignment and Terminus Station

The single-track southbound guideway would run in the center of 17th Street between Washington and Broadway Streets. At Broadway Street, the northbound and southbound alignments of the couplet would become a two-way center-running guideway traveling east-west on 17th Street. The guideway on 17th Street would run until G Street, then connect with McLoughlin Boulevard and cross under I-5. Both alignments would end at a station east of I-5 on the western boundary of Clark College.

Park and Ride Stations

Three park and ride stations would be built in Vancouver along the light rail alignment:

- Within the block surrounded by Columbia, Washington 4th and 5th Streets, with five floors above ground that include space for retail on the first floor and 570 parking stalls.
- Between Broadway and Main Streets next to the stations between 15th and 16th Streets, with space for retail on the first floor, and four floors above ground that include 420 parking stalls.
- At Clark College, just north of the terminus station, with space for retail or C-TRAN services on the first floor, and five floors that include approximately 1,910 parking stalls.

Ruby Junction Maintenance Facility Expansion

The Ruby Junction Maintenance Facility in Gresham, Oregon, would need to be expanded to accommodate the additional LRVs associated with the CRC project. Improvements include additional storage for LRVs and other maintenance material, expansion of LRV maintenance bays, and expanded parking for additional personnel. A new operations command center would also be required, and would be located at the TriMet Center Street location in Southeast Portland.

Local Bus Route Changes

As part of the CRC project, several C-TRAN bus routes would be changed in order to better complement the new light rail system. Most of these changes would re-route bus lines to downtown Vancouver where riders could transfer to light rail. Express routes, other than those listed below, are expected to continue service between Clark County and downtown Portland. The following table (Exhibit 1-1) shows anticipated future changes to C-TRAN bus routes.

Exhibit 1-1. Proposed C-TRAN Bus Routes Comparison

C-TRAN Bus Route	Route Changes
#4 - Fourth Plain	Route truncated in downtown Vancouver
#41 - Camas / Washougal Limited	Route truncated in downtown Vancouver
#44 - Fourth Plain Limited	Route truncated in downtown Vancouver
#47 - Battle Ground Limited	Route truncated in downtown Vancouver
#105 - I-5 Express	Route truncated in downtown Vancouver
#105S - I-5 Express Shortline	Route eliminated in LPA (The No-Build runs articulated buses between downtown Portland and downtown Vancouver on this route)

Steel Bridge Improvements

Currently, all light rail lines within the regional TriMet MAX system cross over the Willamette River via the Steel Bridge. By 2030, the number of LRVs that cross the Steel Bridge during the 4-hour PM peak period would increase from 152 to 176. To accommodate these additional trains, the project would retrofit the existing rails on the Steel Bridge to increase the allowed light rail speed over the bridge from 10 to 15 mph. To accomplish this, additional work along the Steel Bridge lift spans would be needed.

1.2.2.4 Tolling

Tolling cars and trucks that use the I-5 river crossing is proposed as a method to help fund the CRC project and to encourage the use of alternative modes of transportation. The authority to toll the I-5 crossing is set by federal and state laws. Federal statutes permit a toll-free bridge on an interstate highway to be converted to a tolled facility following the reconstruction or replacement of the bridge. Prior to imposing tolls on I-5, Washington and Oregon Departments of Transportation (WSDOT and ODOT) would have to enter into a toll agreement with U.S. Department of Transportation (DOT). Recently passed state legislation in Washington permits WSDOT to toll I-5 provided that the tolling of the facility is first authorized by the Washington legislature. Once authorized by the legislature, the Washington Transportation Commission (WTC) has the authority to set the toll rates. In Oregon, the Oregon Transportation Commission (OTC) has the authority to toll a facility and to set the toll rate. It is anticipated that prior to tolling I-5, ODOT and WSDOT would enter into a bi-state tolling agreement to establish a cooperative process for setting toll rates and guiding the use of toll revenues.

Tolls would be collected using an electronic toll collection system: toll collection booths would not be required. Instead, motorists could obtain a transponder that would automatically bill the vehicle owner each time the vehicle crossed the bridge, while cars without transponders would be tolled by a license-plate recognition system that would bill the address of the owner registered to that license plate.

The LPA proposes to apply a variable toll on vehicles using the I-5 crossing. Tolls would vary by time of day, with higher rates during peak travel periods and lower rates during off-peak periods. Medium and heavy trucks would be charged a higher toll than passenger vehicles. The traffic-related impact analysis in this FEIS is based on toll rates that, for passenger cars with transponders, would range from $1.00 during the off-peak to $2.00 during the peak travel times (in 2006 dollars).

1.2.2.5 Transportation System and Demand Management Measures

Many well-coordinated transportation demand management (TDM) and transportation system management (TSM) programs are already in place in the Portland-Vancouver Metropolitan region and supported by agencies and adopted plans. In most cases, the impetus for the programs is from state-mandated programs: Oregon's Employee Commute Options (ECO) rule and Washington's Commute Trip Reduction (CTR) law.

The physical and operational elements of the CRC project provide the greatest TDM opportunities by promoting other modes to fulfill more of the travel needs in the project corridor. These include:

- Major new light rail line in exclusive right-of-way, as well as express bus and feeder routes;
- Modern bicycle and pedestrian facilities that accommodate more bicyclists and pedestrians, and improve connectivity, safety, and travel time;
- Park and ride lots and garages; and
- A variable toll on the highway crossing.

In addition to these fundamental elements of the project, facilities and equipment would be implemented that could help existing or expanded TSM programs maximize capacity and efficiency of the system. These include:

- Replacement or expanded variable message signs or other traveler information systems in the CRC project area;
- Expanded incident response capabilities;
- Queue jumps or bypass lanes for transit vehicles where multi-lane approaches are provided at ramp signals for entrance ramps;
- Expanded traveler information systems with additional traffic monitoring equipment and cameras, and
- Active traffic management.

1.2.3 LPA Construction

Construction of bridges over the Columbia River is the most substantial element of the project, and this element sets the sequencing for other project components. The main river crossing and immediately adjacent highway improvement elements would account for the majority of the construction activity necessary to complete this project.

1.2.3.1 Construction Activities Sequence and Duration

The following table (Exhibit 1-2) displays the expected duration and major details of each element of the project. Due to construction sequencing requirements, the timeline to complete the initial phase of the LPA with highway phasing is the same as the full LPA.

Exhibit 1-2. Construction Activities and Estimated Duration

Element	Estimated Duration	Details
Columbia River bridges	4 years	• Construction is likely to begin with the bridges. • General sequence includes initial preparation, installation of foundation piles, shaft caps, pier columns, superstructure, and deck.
Hayden Island and SR 14 interchanges	1.5 - 4 years for each interchange	• Each interchange must be partially constructed before any traffic can be transferred to the new structure. • Each interchange needs to be completed at the same time.
Marine Drive interchange	3 years	• Construction would need to be coordinated with construction of the southbound lanes coming from Vancouver.
Demolition of the existing bridge	1.5 years	• Demolition of the existing bridges can begin only after traffic is rerouted to the new bridges.
Three interchanges north of SR 14	4 years for all three	• Construction of these interchanges could be independent from each other or from the southern half of the project. • More aggressive and costly staging could shorten this timeframe.
Light rail	4 years	• The river crossing for the light rail would be built with the bridges. • Any bridge structure work would be separate from the actual light rail construction activities and must be completed first.
Total Construction Timeline	6.3 years	• Funding, as well as contractor schedules, regulatory restrictions on in-water work, weather, materials, and equipment, could all influence construction duration. • This is also the same time required to complete the smallest usable segment of roadway – Hayden Island through SR 14 interchanges.

1.2.3.2 Major Staging Sites and Casting Yards

Staging of equipment and materials would occur in many areas along the project corridor throughout construction, generally within existing or newly purchased right-of-way or on nearby vacant parcels. However, at least one large site would be required for construction offices, to stage the larger equipment such as cranes, and to store materials such as rebar and aggregate. Suitable sites must be large and open to provide for heavy machinery and material storage, must have waterfront access for barges (either a slip or a dock capable of handling heavy equipment and material) to convey material to the construction zone, and must have roadway or rail access for landside transportation of materials by truck or train.

Three sites have been identified as possible major staging areas:

1. Port of Vancouver (Parcel 1A) site in Vancouver: This 52-acre site is located along SR 501 and near the Port of Vancouver’s Terminal 3 North facility.
2. Red Lion at the Quay hotel site in Vancouver: This site would be partially acquired for construction of the Columbia River crossing, which would require the demolition of the building on this site, leaving approximately 2.6 acres for possible staging.
3. Vacant Thunderbird hotel site on Hayden Island: This 5.6-acre site is much like the Red Lion hotel site in that a large portion of the parcel is already required for new right-of-way necessary for the LPA.

A casting/staging yard could be required for construction of the over-water bridges if a precast concrete segmental bridge design is used. A casting yard would require access to the river for barges, including either a slip or a dock capable of handling heavy equipment and material; a large area suitable for a concrete batch plant and associated heavy machinery and equipment; and access to a highway and/or railway for delivery of materials.

Two sites have been identified as possible casting/staging yards:

1. Port of Vancouver Alcoa/Evergreen West site: This 95-acre site was previously home to an aluminum factory and is currently undergoing environmental remediation, which should be completed before construction of the CRC project begins (2012). The western portion of this site is best suited for a casting yard.
2. Sundial site: This 50-acre site is located between Fairview and Troutdale, just north of the Troutdale Airport, and has direct access to the Columbia River. There is an existing barge slip at this location that would not have to undergo substantial improvements.

1.2.4 The No-Build Alternative

The No-Build Alternative illustrates how transportation and environmental conditions would likely change by the year 2030 if the CRC project is not built. This alternative makes the same assumptions as the build alternatives regarding population and employment growth through 2030, and also assumes that the same transportation and land use projects in the region would occur as planned. The No-Build Alternative also includes several major land use changes that are planned within the project area, such as the Riverwest development just south of Evergreen Boulevard and west of I-5, the Columbia West Renaissance project along the western waterfront in downtown Vancouver, and redevelopment of the Jantzen Beach shopping center on Hayden Island. All traffic and transit projects within or near the CRC project area that are anticipated to be built by 2030 separately from this project are included in the No-Build and build alternatives. Additionally, the No-Build Alternative assumes bridge repair and continuing maintenance costs to the existing bridge that are not anticipated with the replacement bridge option.

1.3 Long-term Effects

As detailed above, this technical report analyzes the No-Build Alternative and four options to the LPA, including:

- **LPA Option A** – Full build of the LPA with vehicular access between Marine Drive and Hayden Island on an arterial bridge.
- **LPA Option B** – Full build of the LPA with vehicular access between Marine Drive and Hayden Island on collector-distributor lanes.
- **LPA Option A with highway phasing** – LPA with some deferred highway elements and vehicular access between Marine Drive and Hayden Island on an arterial bridge.
- **LPA Option B with highway phasing** – LPA with some deferred highway elements and vehicular access between Marine Drive and Hayden Island on collector-distributor lanes.

For the purposes of this report, there are no differences between LPA Options A and B (i.e., access between Marine Drive and Hayden Island) as a result of the scales of analysis. Hereafter, LPA Option A and LPA Option B are indistinguishable and are collectively referred to as “LPA

Full Build." Similarly, LPA Option A with highway phasing and LPA Option B with highway phasing are collectively referred to as "LPA with highway phasing."

The long-term effects also referred to as the operational effects, of the project alternatives on energy and GHG emissions are the result of interstate private, freight, and public vehicular travel within the study area across the I-5 and I-205 bridge crossings between Washington and Oregon.

The methodology used to estimate the long-term effects of the project has been updated between the DEIS and FEIS.

The analysis methodology used for estimating long-term energy consumption associated with motor vehicle use in the DEIS was based on methodologies outlined in the Oregon Energy Manual. GHG emissions were estimated using data provided by the Environmental Protection Agency (EPA). According to the EPA, CO_2 is responsible for approximately 95 percent of the GHGs emitted by vehicles, the remaining five percent is composed of methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorcarbons (PFCs), and sulfur hexafluoride. To provide a better estimate of the total global warming potential (i.e., GHG emissions from vehicles), these remaining gases are converted into CO_2 equivalents (CO_2e); see Section 2.5.3.5 for additional detail. For the remainder of this report, GHG emissions and CO_2e are considered synonymous unless specifically stated otherwise.

The FEIS analysis utilized a new model produced by the EPA called Mobile Vehicle Emissions Simulator (MOVES). This model was first released as a finalized product in December 2009 and was used to estimate energy consumption and CO_2e from motor vehicles.

Light rail transit, transit maintenance facilities, and park and ride lots do not directly emit GHGs, but consume electricity that was generated by GHG-emitting means. This energy consumption was based on data provided by the Portland-Milwaukie Light rail project and GHG emissions were based on EPA's eGRID data. The regional (Washington, Clackamas, Multnomah, and Clark counties) and local (12.2 mile segment of I-5) long-term energy and CO_2e emissions for the No-Build and LPA are summarized in Exhibit 1-3.

Exhibit 1-3. Long-term Effects of the No-Build and LPA Full Build

	2030 No-Build					2030 LPA Full Build				
Scale/Vehicle Type	**Energy Consumed (mBtu)**	**Electricity Consumed (kWh)**	**Gasoline Consumed (gal)**	**Diesel Consumed (gal)**	**CO_2e Emissions (MT)**	**Energy Consumed (mBtu)**	**Electricity Consumed (kWh)**	**Gasoline Consumed (gal)**	**Diesel Consumed (gal)**	**CO_2e Emissions (MT)**
Macroscale-Private[a]										
All Vehicles	321,993	0	2,117,430	423,144	24,491	320,218	0	2,074,444	449,364	24,361
subtotal	*321,993*	*0*	*2,117,430*	*423,144*	*24,491*	*320,218*	*0*	*2,074,444*	*449,364*	*24,361*
Macroscale-Transit[a]										
C-TRAN 40' Diesel	546	0	0	3,935	40	510	0	0	3,674	37
C-TRAN 40' Hybrid	32	0	0	232	2	28	0	0	203	2
C-TRAN 60' Articulated	34	0	0	244	2	0	0	0	0	0
TriMet 40' Diesel	3,325	0	0	23,977	241	3,325	0	0	23,977	241
Light Rail Transit	631	184,800	0	0	76	667	195,600	0	0	80
Bus Maintenance Facilities	147	43,220	0	0	19	147	43,220	0	0	19
LRT Maintenance Facilities	36	10,563	0	0	5	39	11,291	0	0	5
Park and Rides	3	887	0	0	0.382	6	1,684	0	0	0.725
subtotal	*4,754*	*239,469*	*0*	*28,388*	*385*	*4,722*	*251,795*	*0*	*27,854*	*385*
Total	**326,747**	**239,469**	**2,117,430**	**451,532**	**24,876**	**324,940**	**251,795**	**2,074,444**	**477,218**	**24,746**
Microscale-Private[b]										
Cars	4,006	0	32,315	0	304	3,729	0	30,081	0	283
Medium Trucks	168	0	1,351	0	13	155	0	1,247	0	12
Heavy Trucks	933	0	0	6,728	72	941	0	0	6,786	73
Total	**5,107**	**0**	**33,666**	**6,728**	**389**	**4,825**	**0**	**31,328**	**6,786**	**368**

Note: These estimates do not include the energy required to construct the project. Energy consumed by the construction of the project is discussed in Section 5, Temporary Effects.

mBtu = million British thermal units; kWh = kilowatt hour; gal = gallons; MT = metric ton

a The macroscale is region-wide (Washington, Clackamas, Multnomah, and Clark counties) and daily energy consumption and CO_2e emissions are reported.

b The microscale focuses on a 12.2-mile segment of I-5 and AM and PM peak period (8 hours) energy consumption and CO_2e emissions are reported.

The LPA Full Build consists of many project features that are expected to reduce travel demand across the I-5 Columbia River Crossing as well as increase operating speeds relative to the No-Build Alternative. Higher operating speeds, up to approximately 55 mph, reduce energy consumption and CO_2e emissions.

In addition to these travel demand and operational benefits, the LPA would also reduce the frequency of collisions and would therefore reduce the project's operational impacts. Energy consumption and CO_2e emissions associated with bridge lifts, which would no longer be necessary with the LPA, would also account for a reduction of approximately 2 percent.

1.4 Temporary Effects

The temporary effects of the project alternatives on energy and CO_2e emissions are those associated with constructing the project, rather than the operations of the project.

The analysis methodology for estimating temporary energy use was based on the Caltrans methodology, which relates the amount of energy consumed to the costs of a particular construction activity (e.g. clearing and grading, laying pavement). Energy consumption estimates were converted to gallons of fuel, which were then used to calculate CO_2e emissions based on EPA emission factors.

Energy consumption and CO_2e emissions were estimated using the Caltrans methodology and revised construction cost estimates for the LPA Full Build and LPA with highway phasing, which are summarized in Exhibit 1-4.

Exhibit 1-4. Temporary Effects of the LPA Full Build and LPA with Highway Phasing

	LPA Full Build		LPA with Highway Phasing	
Alternative Construction Element	**Energy Consumed (mBtu)**	**CO_2e Emissions (MT)**	**Energy Consumed (mBtu)**	**CO_2e Emissions (MT)**
Project Cost (2009$)	$2,748,885,746		$2,419,043,922	
South Highway Approach	3,749,355	284,626	2,562,518	194,529
North Highway Approach	2,414,630	183,303	2,131,189	161,786
Columbia River Bridges	2,983,369	226,477	2,983,369	226,477
Transit	2,329,751	176,859	2,230,794	169,347
Total	**11,477,104**	**871,265**	**9,907,871**	**752,139**

mBtu = million British thermal units; MT = metric ton

As described above, there are four primary differences between the LPA Full Build and LPA with highway phasing. Under the LPA with highway phasing, there would be:

- No north legs of the SR 500 interchange,
- No Victory Braid, and
- No Marine Drive fly-over.

These three elements would all be constructed in the same time frame under the LPA Full Build.

Although more construction phases would likely increase energy use and CO_2e emissions associated with mobilization, the LPA with highway phasing is a smaller and less expensive project, and constructing this alternative would consume slightly less energy requirements and have slightly lower CO_2e emissions for the design year. However, future phases that would construct the full project would have additional CO_2e emissions after the design year and are not analyzed in this report.

While there is no construction proposed under the No-Build Alternative specific to this project per se, it is inaccurate to state that this alternative would not have any construction-related energy requirements or GHG emissions. For example, pot holes may need filling, the I-5 bridge decks would likely need to be resurfaced and striped, and additional local capacity improvements may be needed to alleviate congestion along the I-5 mainline. Although cost estimates for these maintenance activities are outside the purview of this analysis and quantifiable energy consumption and GHG emissions have not been quantified, it is important to realize that the No-Build Alternative would have construction-related energy consumption and CO_2e emissions that would not occur with the LPA.

1.5 Mitigation

1.5.1 Long-term Effects

There are no existing regulations that quantitatively limit energy consumption or CO_2e emissions; therefore, no mitigation is warranted. Nonetheless, both the LPA Full Build and LPA with highway phasing would require less energy and emit less CO_2e compared to the No-Build Alternative. While mitigation is not required by law, other measures may be considered to further reduce energy consumption and/or to reduce or offset CO_2e emissions.

1.5.2 Temporary Effects

There are no defined regulatory mitigation measures for temporary effects to energy use and CO_2e emissions. However, a variety of measures could be implemented to reduce the effects of the project emissions and energy use associated with construction. These measures would largely encompass conservation of construction materials and best management practices (BMPs). Such BMPs could include:

- Construction materials reuse and recycling.
- Turning off equipment when not in use to reduce energy consumed during idling.
- Maintaining equipment in good working order to maximize fuel efficiency.
- Routing truck traffic through areas where the number of stops and delay would be minimized, and using off-peak travel times to maximize fuel efficiency.
- Scheduling construction activities during daytime hours or during summer months when daylight hours are the longest to minimize the need for artificial light.
- Implementing emission-control technologies for construction equipment.
- Using ultra low sulfur and biodiesel in construction equipment (for other non-CO_2e air quality purposes, such as particulate matter and volatile organic compounds).
- Using electric-powered construction equipment where feasible to reduce CO_2e emissions associated with diesel engines.

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2. Methods

2.1 Introduction

This section describes the methodologies and assumptions that were used to estimate the energy requirements and GHG emissions for the existing conditions, No-Build Alternative, and the LPA. More specifically, this section identifies and expounds on: the project's study area, guidelines for determining the effects of the project alternatives, information and data resources, and the analysis methodologies used to quantify the amount of energy that would be consumed and GHGs that would be emitted by the project alternatives.

At the time when the CRC DEIS was prepared, there were no methodologies accepted industry-wide to estimate transportation operational energy use and GHG emissions. The methodology used in the DEIS was based on well-established equations that relate distances traveled and fuel economy to estimate the amount of fuel consumed. However, the DEIS methodology was novel in the sense of how it integrated CO_2 emission factors for different energy sources (e.g., gasoline, diesel, electricity, etc.), utilized traffic simulation data, and accounted for the operational speeds of the project by using different fuel economies according to vehicle class and over a speed distribution, compared to other methodologies that were based on vehicle miles traveled (VMT) and a single fuel economy.

The DEIS approach had the distinct advantage of providing detailed estimates that reflected the effect of multiple transportation factors that varied across the range of alternatives. However, its disadvantage was that the level of detail was only available for a relatively small geographic area. The method was useful for comparing alternatives, but it did not provide estimates of impacts on a broader scale, for example at the regional level.

Since that time, the EPA released the MOVES model. The MOVES model is intended to replace EPA's previous air quality model, MOBILE6, but also estimates operational carbon dioxide equivalents, which are equated to GHG emissions. The MOVES model provides estimates that reflect the effect of multiple vehicle operating factors on emissions, and can do so at both the project and the regional levels. Based on these advantages, the CRC project has used the MOVES model (December 2009 release version) to estimate the operational energy and GHG emissions analyses for the FEIS.

The CRC project team also solicited feedback from stakeholder groups and an expert review panel consisting of leading professionals from around the nation. As a result, the scope of the energy and GHG analyses have been refined with respect to:

- The study area,
- Time period of analysis,
- Methodologies used to estimate operational ("long-term effects") energy use and GHG emissions, and
- Additional scenarios.

Changes to the study area are described in Section 2.2, differences in the time period of analysis and methodology in Section 2.5.2 and 2.5.3, and additional scenarios are discussed in Section 4.4.

2.2 Study Area

The effects of the project alternatives on energy consumption and GHG emissions could be described differently depending on the element of the project under consideration. For example, the project's effects from construction could be defined by the geographical limits of the construction area, and the operational effects of the project on energy could be interpreted as the areas used by transit and highway vehicles. However, because the supply and distribution of petroleum (Washington's and Oregon's primary energy source for the transportation sector) is regulated at the state level and GHG emissions have global implications, a broader study area may also be deemed as more appropriate. Most of the energy supply and demand data have not been itemized down to the city scale. Therefore, while the analysis focuses on the areas described below, the implications are generally larger in scope. Additional detail is provided in Section 2.5, Analysis Methods and Section 3, Affected Environment.

As described above, the study area is one element of the energy and GHG analyses that has changed between the DEIS and this FEIS. The following sections describe how the study area has been revised.

2.2.1 DEIS Study Area

Excluding the transit system, which is described in the next paragraph, the energy and GHG analyses presented in the DEIS focused on a 0.9 mile segment of the I-5 bridge crossing and a 0.9 mile segment of I-205. These segments of I-5 and I-205 served as the DEIS study area for the following reasons:

- Estimating energy consumption and GHG emissions as a function of regional VMT and a single fuel economy does not appropriately account for the operational benefits (i.e., more fuel-efficient speeds) of the project alternatives, which affects the amount of energy consumed and GHG emissions.
- The most pronounced change in travel demand and operational speeds, which identify differences between project alternatives, are best represented on I-5 around the I-5 river crossing.
- There were much smaller, but still measurable, impacts on the I-205 river crossing; these changes were due to traffic diversion (improving I-5 draws some traffic from I-205 to I-5, typically resulting in shorter trips; tolling I-5 pushes some traffic from I-5 to I-205, typically resulting in longer trips).
- Detailed forecasts on future travel behavior were developed for about 23 miles of I-5. However, because the effects of the project on I-205 were concentrated in a relatively small section of I-205, the same level of detailed forecasts were available for only a much smaller segment of I-205.

For the energy consumption and GHG emissions associated with transit operations, the DEIS study area covered system-wide (TriMet and C-TRAN) transit operations. This study area for transit operations was based on the following reasons:

- The TriMet and C-TRAN transit systems are finite, therefore future projections can be appropriately evaluated using absolute numbers in addition to the relative differences;
- Differences in transit VMT between alternatives was more pronounced compared to the differences in VMT for private passenger and freight vehicles; and

- Effects of operating speed on I-5 and I-205 on bus fuel efficiency was expected to be small since the majority of operating time would be either on local streets or within exclusive rights-of-way.

2.2.2 FEIS Study Area

The study area for the FEIS covers a much larger geographical area compared to the DEIS. Due to the advantages and disadvantages of an enlarged study area described above and below, a two-tiered approach was used.

- **Macroscale:** This area of analysis covers Metro's four-county region, including Washington, Clackamas, Multnomah, and Clark counties. Consistent with Metro's regional travel demand model, the macroscale analysis includes all road types, including freeways, ramps, and primary and secondary arterials. Similar to the DEIS, system-wide transit service from TriMet and C-TRAN is also included. This scale is the most comprehensive representation of the total change in energy consumption and GHG emissions due to the project. The macroscale uses traffic volumes and speeds obtained from Metro's regional travel demand model for the four-county region and daily (24 hours) energy consumption and CO_2e emissions are reported.
- **Microscale:** This area of analysis focuses on the I-5 corridor between 134th Street in Vancouver to the I-5/I-405 interchange in Portland, approximately 12.2 miles. This microscale provides similar benefits compared to the approach in the DEIS, but incorporates a longer section of I-5 with more traffic volume and speed data. The limits of this area were based on the locations where traffic volumes and operating speeds are relatively similar between project alternatives and are consistent with the four sub areas analyzed for air quality. At this scale, the energy consumption and GHG emission estimates are less representative of the total amount, but differences between project alternatives are the most pronounced. The microscale uses traffic volumes and speeds obtained from the traffic simulation model for the 12.2-mile section of I-5 between Vancouver and Portland. AM and PM peak period (8 hours) energy consumption and CO_2e emissions are reported for these periods only.

2.3 Effects Guidelines

Guidelines for assessing potential energy effects were based on applicable laws and regulations. There are federal and state laws that require entities emitting in excess of threshold values to measure, report, and in some instances, obtain permits to emit GHGs. However, the majority federal, state, and local laws quantitatively regulate energy use or GHG emissionsmainly in terms of conserving energy, providing means to improve the efficiency of energy use, and long-term GHG emission reduction goals. These policies were considered in terms of the project's consistency with those policies and are discussed in the following section.

2.3.1 Federal Laws, Regulations, and Policies

2.3.1.1 National Environmental Policy Act

The National Environmental Policy Act (NEPA) (42 USC 4332) requires that federal agencies consider environmental effects before taking actions that could substantially affect the human environment. As interpreted by the Council on Environmental Quality (CEQ), NEPA requires that "environmental consequences" of the proposed project are considered in the decision-making process, including: "energy requirements and conservation potential of various alternatives and mitigation measures." Sec. 1502.15(e).

FHWA Technical Advisory T 6640.8A provides guidance on the preparation of environmental documents, including the analysis of energy effects. It states that an environmental impact statement "…should discuss in general terms the construction and operational energy requirements and conservation potential of the various alternatives under consideration."

Analysis of climate change impacts in NEPA documents is a fairly recent development. On February 18, 2010, the Council on Environmental Quality (CEQ) released draft guidance on consideration of the effects of climate change and GHG emissions. Specifically, in the NEPA context, climate change issues arise in relation to the consideration of the GHG emissions of a proposed action and alternative actions, and the effects of climate change on a proposed action or alternative actions. The CEQ's draft guidance directs agencies to quantitatively and qualitatively address direct and indirect GHG emissions for projects that emit in excess of 25,000 metric tons of carbon dioxide equivalents (CO_2e) per year. Furthermore, the CEQ advises agencies to consider whether an action's long-term GHG emissions should receive a similar analysis.The CEQ originally announced that the draft guidance on climate impacts would be formalized in 2010; however, the formal adoption of the guidance has yet to occur.

2.3.1.2 The Clean Air Act

On May 10, 2010 the EPA issued a final rule that establishes thresholds for GHG emissions; these thresholds dictate when new and existing industrial facilities will be required to obtain permits under the New Source Review Prevention of Significant Deterioration (PSD) and title V Operating Permit programs. This development is known as "the tailoring rule", since it effectively tailors the requirements of the Clean Air Act (CAA) to limit which facilities will be required to obtain PSD and title V permits. The EPA estimates that the facilities responsible for approximately 70 percent of the national GHG emissions from stationary sources will be impacted by these permitting requirements. These facilities will include the largest emitters of GHGs, including power plants, refineries, cement producers, and the country's largest commercial facilities.

2.3.1.3 Title 42 of the United States Code (42 USC 6201, 13401, and 13431)

The U.S. Energy Policy Conservation Act focuses on energy conservation, reduced reliance on foreign energy sources (mainly petroleum), use of alternative fuels, and increased efficiency in energy use. Policies related to energy include:

- Providing for improved energy efficiency in motor vehicles (42 USC 6201);
- Increasing economic efficiency by meeting future needs for energy services at the lowest cost, by considering technologies that improve the efficiency of energy end use, while conserving energy supplies such as oil (42 USC 13401);
- Reducing the air, water, and other environmental effects (including emissions of greenhouse gases) related to energy production, distribution, transportation, and use by developing an environmentally sustainable energy system (42 USC 13401); and
- Reducing the demand for oil in the transportation sector for all motor vehicles (42 USC 13431).

2.3.1.4 Energy Policy Act of 2005

The Energy Policy Act of 2005 amended and supersedes several previous energy policy acts including the National Energy Act of 1978 (Public Law 95-619), the Energy Policy and Conservation Act Amendments of 1985 (Public Law 99-58), and the Energy Policy Act of 1992

(Public Law 102-486). The Energy Policy Act of 2005 includes transportation related provisions to:

- Reduce reliance on foreign energy sources (mainly petroleum).
- Increase efficiency in motor vehicles.
- Increase use of recovered mineral content in federally funded projects involving procurement of cement or concrete.

2.3.1.5 Clean Energy Act of 2007

On December 19, 2007, President George W. Bush signed into law the Clean Energy Act of 2007, which required in part that automakers boost fleetwide fuel efficiency to 35 miles per gallon by the year 2020. The previous Corporate Average Fuel Economy (CAFE) standard for mid-size cars, set in 1984, required manufacturers to achieve an average of 27.5 miles per gallon, and a second CAFE standard required an average of 22.2 miles per gallon for light trucks such as minivans, sport utility vehicles, and pickups. The 2007 CAFE standards under the George W. Bush administration required that these standards be increased such that the new cars and light trucks sold each year deliver a combined fleet average of 35 miles per gallon by 2020.

On May 19, 2009, President Barack Obama announced revisions to the CAFE standards, which have since been adopted by rule. Key revisions to the CAFE standards include:

- CAFE standards apply to 2012-2016 vehicle model years for all passenger vehicles sold in the United States;
- Beginning in 2012, yearly gains in fuel efficiency of 5 percent or more and in subsequent years; and
- By 2016 (four years sooner than 2007 CAFE targets), vehicle fleets must achieve a combined average fuel economy of 35.5 mpg (39 mpg for cars and 30 mpg for light trucks).

The energy and CO_2e analyses presented in this report account for the 2007 CAFE standards, but not the 2009 CAFE standards revised under the Obama administration.

2.3.1.6 Intermodal Surface Transportation Efficiency Act (ISTEA) (PL 102-240)

The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 was established to maintain and expand the national transportation system. The purpose of the act is *"to develop a National Intermodal Transportation System that is economically efficient, environmentally sound, provides the foundation for the Nation to compete in the global economy and will move people and goods in an energy efficient manner."*

ISTEA strengthens the metropolitan planning process by giving more emphasis to intermodal planning, coordination with land-use planning and development, and consideration of economic, energy, environmental, and social effects.

When Congress reauthorized ISTEA in 1998 as the Transportation Equity Act for the 21st Century ("TEA-21") the 20 existing planning factors were streamlined to seven, including the requirement that such plans consider projects and strategies that will "protect and enhance the environment, promote energy conservation and improve quality of life." 23 USC Section 135 (c)(D).

2.3.1.7 FHWA Technical Advisory T 6640.8A (1987)

FHWA Technical Advisory T 6640.8A provides guidance on the preparation of environmental documents including the analysis of energy effects. It states that an environmental impact statement, "…should discuss in general terms the construction and operational energy requirements and conservation potential of the various alternatives under consideration."

2.3.2 State Laws, Regulations, and Policies

2.3.2.1 Western Climate Initiative

In 2007, the governors of Washington, Oregon, California, Arizona and New Mexico launched the Western Climate Initiative (WCI). WCI requires partners to set an overall regional goal to reduce emissions, develop a market-based, multi-sector mechanism to help achieve that goal, and participate in a cross-border greenhouse gas registry. As of August 2007, British Columbia, Manitoba, and Utah have also joined the WCI.

On August 22, 2007, members of WCI announced a regional, economy-wide greenhouse gas emissions target of 15 percent below 2005 levels by 2020, or approximately 33 percent below business-as-usual levels. Under the memorandum of understanding developed in February 2007, WCI members agreed to jointly set a regional emissions target. In 2008, Montana, Quebec, and Ontario joined the WCI and recommendations for the design of a regional cap-and-trade program covering multiple economic sectors were published. In 2009, the WCI set the regional cap and adopted a reporting rule for 2012 capped sectors and additional non-capped sectors of interest.

The WCI regional target is designed to be consistent with existing targets set by individual member states and does not replace these goals since the WCI target is not as strong as the Washington and Oregon state-wide goals, or the regional goals of the Portland Metro area.

2.3.2.2 Washington's State Environmental Policy Act

On May 27, 2010 the Washington Department of Ecology (Ecology) released draft guidance regarding the evaluation of climate change impacts under the State Environmental Policy Act (SEPA). The guidance proposes analysis of direct and indirect GHG emissions potentially resulting from government actions covered under SEPA, including the issuance of land use and construction permits for many projects (i.e. commercial, industrial, and larger residential developments). The guidance also describes mitigation measures that may be required of project developers.

Ecology originally announced that the rules would be finalized by the end of 2010. A December 10, 2010 update from Ecology stated that the final draft of its GHG/SEPA Working Paper will be released in mid to late January in 2011.

2.3.2.3 Oregon State Energy Plan

The Oregon Department of Energy created a State Energy Plan for 2005-2007. It includes an energy action plan with recommendations and goals to help ensure that Oregon has an adequate supply of affordable and reliable energy. Goals related to transportation energy include the following:

- Reduce single-occupancy vehicle commuting.
- Implement Oregon's Renewable Energy Action Plan (this plan includes long- and short-term goals for electricity generation and transportation fuels).

- Implement strategy for reducing greenhouse gases (this includes emissions from transportation sources).

2.3.2.4 Oregon Transportation Plan

The Oregon Transportation Plan (OTP) is "the overarching policy document among a series of plans that together form the state transportation plan" and "considers all modes of Oregon's transportation system as a single system and addresses the future needs of Oregon's airports, bicycle and pedestrian facilities, highways and roadways, pipelines, ports and waterway facilities, public transportation and railroad through 2030 (ODOT 2006a)." The OTP acknowledges the delicate balance between an efficient transportation system and environmental, economic, and community responsibilities. Goal 4 – Sustainability, Policy 4.2 – Energy Supply specifically identifies three strategies that support diversification of energy sources, cleaner energy supply, and practices that increase fuel efficiencies, including:

- **Strategy 4.2.1:** Support efforts to develop a long range plan for moving toward a diversified and cleaner energy supply. Work with federal, state, regional and local jurisdictions and agencies as well as transportation providers, shippers and the general public.
- **Strategy 4.2.2:** Support the conversion of passenger vehicles and public transportation fleets to more fuel-efficient and alternative fuels, especially to those using renewable and cleaner fuels. Review and change the tax credit provisions to encourage these activities as appropriate.
- **Strategy 4.2.3:** Work with federal, state, regional and local jurisdictions and agencies as well as transportation providers, shippers and the general public to develop a contingency plan for fuel shortages affecting passenger and freight transportation (ODOT 2006a).

2.3.2.5 Oregon Highway Plan

The Oregon Highway Plan defines policies and investment strategies for Oregon's state highway system for the next 20 years and further refines the goals and policies of the Oregon Transportation Plan. Several of these relate to energy use and are similar to those found in the OTP. For example, Goal 4 is "to optimize the overall efficiency and utility of the state highway system through the use of alternative modes and travel demand management strategies." TDM techniques are discussed under Policy 4.D and these TDM measures have the goals of decreasing energy consumption, congestion, and vehicle miles traveled.

2.3.2.6 Oregon Statewide Planning Goals – (Oregon Administrative Rules Chapter 660 Division 15 [OAR 660-015])

In 1991, the Land Conservation and Development Commission (LCDC) adopted the Oregon Transportation Planning Rule (TPR) (OAR 660-012-0000). The TPR is responsible for the application of the statewide planning goals to newly incorporated cities, annexation, and urban development on rural lands (OAR 660-015). The core of this program consists of 19 statewide planning goals and two of these goals are applicable to this report: Goal 12, Transportation and Goal 13, Energy Conservation.

Goal 12 – Transportation (OAR 660-015-0000(12))

Goal 12 relates to transportation whose purpose is to provide and encourage a safe, convenient and economic transportation system. It states that transportation plans must encourage the conservation of energy. In addition, transportation systems shall to the fullest extent possible, be planned to utilize existing facilities and rights-of-way within the state provided that such use is not inconsistent with the environmental, energy, land-use, economic or social policies of the state.

Section 35 of OAR 660-12 relates to evaluation and selection of transportation system alternatives. It states that "the transportation system shall minimize adverse economic, social, environmental and energy consequences."

Goal 13 – Energy Conservation (OAR 660-015-0000(13))

Goal 13 states that land and uses developed on the land shall be managed and controlled so as to maximize the conservation of all forms of energy, based on sound economic principles (OAR 660-015).

2.3.2.7 The Climate Change Integration Act (Oregon House Bill 3543)

On August 7, 2007, Governor Kulongoski signed the Climate Change Integration Act, (also known as Oregon House Bill [HB] 3543), which codifies emission reduction goals previously proposed by the Governor. The Climate Change Integration Act has two major components.

First, the new law creates greenhouse gas emissions reduction goals. Under HB 3543, Oregon intends to stop growth of GHG emissions by 2010; reduce the emissions 10 percent below 1990 levels by 2020; and achieve a 75 percent reduction below 1990 levels by 2050. Oregon's reduction targets are substantially more aggressive than those adopted by Washington State, which aim to achieve 1990 levels by 2020, and a 50 percent reduction below 1990 levels by 2050.

Second, HB 3543 created the Oregon Global Warming Commission ("Commission"), which is tasked with the responsibility of recommending policies to State and local governments to reduce GHG emissions. The Commission is also responsible for examining the viability of a state-wide or multi-state cap-and-trade program or other market base mechanisms. The Commission is expected promulgate rules to direct agencies on how to regulate and enforce the act. At this time, the law does not require the transportation sector to take any specific actions.

Besides the Climate Change Integration Act, the 2007 Oregon Legislature enacted two other pieces of legislation relating to Climate Change:

- Renewable Energy Standard requiring Oregon's largest utilities to acquire 25 percent of their electricity from new, homegrown renewable energy sources by 2025. Smaller Oregon utilities must meet smaller renewable energy targets of 5 percent or 10 percent of their electricity by 2025. (SB 838, June 6, 2007).
- Renewable Fuel Standard requiring minimum amounts of biodiesel (2 percent) and ethanol (10 percent) to be blended into all diesel and gasoline sold in the state (respectively) once minimum thresholds for in-state production of these renewable fuels are met. (HB 2210, July 3, 2007).

2.3.2.8 Washington State Engrossed Substitute Senate Bill 6508 (2006)

This legislation amends the Motor Fuel Quality Act (RCW 19.112) and requires gasoline sold in the state to contain at least 2 percent ethanol and diesel to contain at least 2 percent biodiesel. It requires state vehicles to use 20 percent biodiesel by the year 2009. While these blended fuels generally result in lower CO_2e emissions per gallon consumed, blended fuels also tend to have lower energy content per gallon, which results in a slight increase in the gallons of fuel consumed. As a result of this offset, the total net potential CO_2e emission reductions associated with blended fuels is uncertain at this time and blended fuels are generally regarded as having similar tailpipe emissions compared to non-blended fuels.

2.3.2.9 Revised Code of Washington (RCW) 43.21F.015

Washington State Energy Office's Energy Policy Division receives its statutory guidance from the RCW 43.21F.015 and Title 194 of the Washington Administrative Code (WAC). The relevant energy policies outlined in the RCW are:

- The development and use of a diverse array of energy resources with emphasis on renewable energy resources shall be encouraged;
- The supply of energy must be sufficient to insure the health and economic welfare of its citizens; and
- Energy conservation and elimination of wasteful and uneconomic uses of energy and materials must be encouraged, and this conservation should include, but is not limited to, resource recovery and materials recycling.

2.3.2.10 Washington State Transportation Plan

The 2007 - 2026 Transportation Plan is the state's blueprint for implementing programs and developing budgets for projects that will be implemented in the future. The plan identifies four policy recommendations that relate to energy, including:

- Increase the efficiency of operating the existing systems and facilities.
- Minimize the use of resources and increase the use of recycled materials.
- Support development and implementation of a state policy on alternative fuel development and use which could include the identification of possible regulatory and tax structures.
- Identify opportunities and strategies for addressing the growing demand for alternative fuels and their benefits to the environment.

The Transportation Plan also specifically acknowledges the role of transportation in climate change and greenhouse gas emissions, and identifies bills passed by legislature that are aimed at reducing greenhouse gas emissions.

2.3.2.11 Washington State Highway System Plan

The draft 2007 - 2026 Washington State Highway System Plan addresses the state highway system and is an element of Washington's Transportation Plan. The Highway Plan includes a comprehensive assessment of existing and projected 20-year deficiencies on Washington's highway system. One of the goals of the plan is to improve the state's transportation infrastructure to increase operational efficiency. This would also have a positive effect on energy use by reducing demand for petroleum.

2.3.2.12 Washington Transportation Commission Policy

WSDOT follows two types of policy guidance: Washington Transportation Commission policy and WSDOT policy. The Transportation Commission's Policy Catalog lists several policies relating to environmental protection including the following general policy:

- Minimize and avoid where practical air, water and noise pollution, energy usage, use of hazardous materials, flood impacts, and impacts on wetlands and heritage resources from transportation activities.

Section 6.3.5 of the Policy Catalog relates to use of non-renewable energy resources and its policy is to improve the energy efficiency of the transportation system and reduce the consumption of and dependence upon non-renewable energy resources.

2.3.2.13 Washington State Executive Order 07-02 and Washington SB 6001

Washington State originally set a number of GHG emission reduction targets through Executive Order 07-02 (EO 07-02), issued by Governor Gregoire on February 7, 2007. That order established the following targets for reducing Washington's GHG emissions:

- By January 1, 2020, reduce GHG emissions to 1990 levels;
- By January 1, 2035, reduce emissions to 25 percent below 1990 levels; and
- By January 1, 2050, reduce emissions to the lesser of 50 percent below 1990 levels or 70 percent below the projected annual emissions level for 2050.

On May 3, 2007, the Washington legislature passed SB 6001, which among other things, adopted the Governor's Climate Change Challenge goals into statute. SB 6001 does not direct how targeted reductions can be achieved. The governor is tasked with developing policy recommendations for the legislature on how the state can achieve the goals adopted by SB 6001.

Governor Gregoire formed a stakeholder group called the Climate Advisory Team to develop policy recommendations to be submitted in the 2008 legislative session to achieve the law's stated goals. These recommendations, though not limited by SB 6001 were aimed to, at a minimum, assess 1) market mechanisms (such as a "cap and trade" system), 2) carbon sequestration in forests and geological formations; 3) closure and replacement of the highest GHG emitting power plants at the end of their useful life; 4) utilization of landfill and geothermal gases for electric generation and to reduce methane emissions; and 5) regulatory and tax policies to achieve the Act's emission reduction.

2.3.2.14 Revised Code of Washington (RCW) 47.01.440

Consistent with EO 07-02, this legislation adopts broad statewide goals to reduce annual per capita VMT by 2050 and provides WSDOT with the following directives:

- Establish benchmarks relative to a statewide baseline of 75 billion VMT; decrease annual per capita VMT by 18 percent by 2020, 30 percent by 2035, and 50 percent by 2050.
- By July 1, 2008, establish and convene a collaborative process to develop a set of tools and best practices to assist state, regional, and local entities in making progress towards the benchmarks described above (completed in 2008, resulted in the Climate Action Team).
- Report to the transportation committees of the legislature and identify strategies to reduce vehicle miles traveled in the state as well as successful strategies in other jurisdictions that may be applicable in the state that recognize the differing urban and rural transportation requirements (part of the 2008 Climate Action Team).
- Report to the transportation committees of the legislature and identify anticipated impacts of these goals on small businesses, low-income residents, agricultural employers and

their employees, distressed rural counties, and counties with a more than 50 percent of the land base in public or tribal lands.

WSDOT has prepared a guidance document for project level greenhouse gas and climate change evaluations in September 2009. With assistance from the Washington State Department of Transportation, the Puget Sound Regional Council has released the Final Environmental Impact Statement for *Transportation 2040*, which is a long-range planning document that includes region-wide inventories of future greenhouse gas emissions under a variety of transportation infrastructure and management alternatives.

2.3.2.15 Washington Executive Order (EO) 09-05

On May 21, 2009, Governor Gregoire signed EO 09-05. Below are the key elements relating to transportation infrastructure.

- **Reducing Greenhouse Gases from Transportation**
  - *Fuel Standards* – Provide recommendations for low-carbon fuel standards or alternatives to reduce carbon in transportation fuels by July 2010.
  - *Vehicle Miles Traveled* – By Dec. 2010, develop estimates of vehicle miles traveled (VMT), evaluate and develop recommendations on existing VMT benchmarks to address low or no emission vehicles, and develop other strategies for reducing transportation emissions.
  - *Regional Transportation Plans* – Work with larger regional transportation planning organizations (RTPOs) to develop regional transportation plans and report on progress by December 2011.
  - *West Coast Green Highway* – Develop and seek federal funding for the electrification of the West Coast interstate highway, to purchase electric vehicles, and to install infrastructure to support electric vehicles and other efficient low-carbon vehicles.
- **Adapting to and Preparing for Unavoidable Impacts**
  - *Sea Level Rise* – Evaluate the potential impacts of sea level rise on the state's shoreline areas and develop recommendations for addressing these impacts.
  - *Water Resources* – Develop guidelines, tools and recommendations for anticipated changes in water resources due to climate change.

2.3.3 Local Laws, Regulations, and Policies

2.3.3.1 Northwest Power and Conservation Council (NPCC) Fifth Northwest Electric Power and Conservation Plan

The NPCC is a unique organization formed by the states Idaho, Montana, Oregon, and Washington that is authorized by Congress to act as an interstate compact agency. Regional planning, policies, and goals related to electrical supply are coordinated within this group. Some of the main goals and policies of this latest plan include:

- Securing cost-effective conservation measures to minimize electrical use (this policy costs less than construction of new generation sources and provides a hedge against market swings).

2.3.3.2 City of Portland Comprehensive Land Use Plan

The City of Portland Comprehensive Land Use Plan includes a section on energy policy. Policy 7.6 relates to improving the energy efficiency for transportation. Among its objectives are to promote construction of a regional light rail transit system, reduce gas and diesel use by conventional buses, autos, and trucks by increasing fuel efficiency.

2.3.3.3 Clark County Comprehensive Plan

One of the countywide transportation planning policies in the comprehensive plan is to establish a regional transportation system which encourages energy efficiency.

2.3.3.4 City of Vancouver

The City of Vancouver has adopted the Clark County transportation policies, including the goal of encouraging energy efficiency in the regional transportation system, and expounds on these policies with additional detail specific to the City's goals and needs.

2.3.3.5 Local Action Plan on Global Warming

A plan jointly developed and adopted by the City of Portland and Multnomah County in April 2001, which established a goal of reducing GHG emissions to 10 percent below 1990 levels by 2010.

The Climate Action Plan, which succeeds the Local Action Plan on Global Warming, was adopted in October 2009. The Climate Action Plan revised the GHG reduction targets to 30 percent below 1990 levels by 2030 and 80 percent below by 2050.

2.3.4 Summary of Applicable Regulations

The estimated energy consumption for the I-5 CRC alternatives will be used to determine if the project is consistent with the policies listed above. Although all future alternatives are expected to result in higher GHG emissions compared to existing 2005 conditions, the project's effects will be assessed on how it relates to the No-Build Alternative. There are no regulations per se that set limits on energy use or GHG emissions. Rather, the project should show that energy would be used wisely and that ways to reduce or minimize energy use are considered in project decisions.

2.4 Data Collection

2.4.1 General Methods

Energy supply and demand in Washington and Oregon have been generally characterized by energy supply sources and use sectors. The following sources have provided information on general energy supply and demand: United States Department of Energy/Energy Information Administration, Washington Office of the Department of Commerce, and the Oregon Department of Energy. For example, existing energy supply and demand was provided by documents such as the *Annual Energy Outlook, 2005 through 2009* versions, (USDOE 2005-2009), *State of Oregon Energy Plan* (ODOE 2005), and the *Washington 2007 Biennial Energy Report* (Department of Commerce 2007). Historical, existing, and future energy demand data from the Energy Information Administration was also used.

In addition to the general resources describing energy supply and demand for Washington and Oregon, more specific data related to fuel consumption rates were obtained from ODOT (1988) and USDOE (2007a), traffic stream composition was obtained from the Metro regional travel demand model, and energy consumption for transit vehicles was provided by TriMet and C-TRAN staff (local public transit service providers). Project-specific data was collected from the project team, including construction cost estimates, travel demand forecasts, traffic operations data, and transit operations data.

2.5 Analysis Methods

The methodologies used in the energy and GHG analyses allow the identification of the project alternatives' potential adverse and beneficial effects on energy in compliance with the NEPA, applicable state environmental legislation, and local and state planning and land use policies. The analyses included variations in the type and amount of energy that would be consumed to build and operate the CRC alternatives. This information was used to determine if shifts in energy usage will occur and how energy used for the project will affect regional energy demand and supply. The energy analysis addresses four primary issues:

- Energy consumed during operation of the I-5 CRC.
- Energy consumed during construction of the I-5 CRC.
- Potential measures to reduce or offset operational and construction effects on energy.
- CO_2 equivalent emissions resulting from use of electricity, gasoline, and diesel.

Because gasoline and diesel are the primary energy sources for the transportation sector, the energy analysis focuses on the supply and demand of energy derived from petroleum-based fuel sources. Unless specifically defined otherwise, references to energy relate to energy originating from crude oil products.

The methodologies used in the energy analysis are intended to reflect the relative energy that would be required for the future without and with the project. Energy analysis methodologies cannot provide a complete or absolute estimate of energy needed for a project because future travel demand forecasts are relative in nature and modeling all roadways within the study area for volumes and speeds is not reasonable. Nonetheless, the approach taken in this FEIS that estimates the energy consumption and GHG emissions at the regional and localized levels provides sound conclusions that can be used to identify project impacts and assist in informative decision-making processes.

As described above, the time period of analysis and the specific methodology used to estimate GHG emissions have changed between the DEIS and the FEIS. These changes are specifically addressed in Sections 2.5.2 and 2.5.3 below.

2.5.1 Significance Thresholds

As described in Section 2.3, Effects Guidelines, there are no regulatory significance thresholds related to energy use or conservation. Instead, substantial effects in energy use would occur if the project alternatives increased demand to the point where the supply of energy (e.g., petroleum reserves) was insufficient to meet existing and future projected demand, or there were an increase in energy use that created concern in meeting the demand for energy.

While many jurisdictions identify the desire to minimize the amount of GHG emissions and have identified long-term goals and reduction targets, there are no regulatory standards that quantifiably limit a project's greenhouse gas emissions.

2.5.2 Time Period of Analysis

As described above, the time period of analysis is one area where the energy and GHG analyses differ between the DEIS and this FEIS and these differences are described below.

2.5.2.1 DEIS Time Period of Analysis

The DEIS used a 24-hour time period of analysis. The energy and GHG analyses were based on traffic volumes and speeds obtained from an eight-hour (four-hour AM peak period and four-hour PM peak period) traffic simulation model as well as data that were interpolated and extrapolated from the simulated data. Although some data were interpolated and extrapolated, this 24-hour time period approach provides a more comprehensive picture of GHG emissions compared to a strict peak period approach and is a more typical unit of measurement.

2.5.2.2 FEIS Time Period of Analysis

The FEIS also uses a 24-hour time period of analysis for the macroscale level of analysis. The limits of the macroscale are based on the four-county region covered by Metro's regional travel demand model (Washington, Clackamas, Multnomah, and Clark counties). At the macroscale, 24-hour traffic volumes and speeds are readily available from the demand model and, given that this scale is intended to present the most comprehensive estimates of energy consumption and GHG emissions, a 24-hour time period of analysis is appropriate.

At the microscale, the FEIS uses an 8-hour time period of analysis. This 8-hour period actually consists of two separate 4-hour peak periods, one in the AM and one in the PM. The advantage of this approach is that the traffic volumes and speeds for this 8-hour time period is the most accurate and the energy and GHG emission estimates are strictly based on available traffic simulation data. Additionally, narrowing the scope of the time period could better highlight differences between the project alternatives. The disadvantage of this approach is that the LPA substantially improves congestion during the mid-day time period between the AM and PM peak periods, which would not be reflected in the 8-hour time period. As a result, the magnitude of energy savings and reductions in GHG emissions would likely be more dramatic on daily basis.

2.5.3 Long-term Effects Approach

The long-term effects of the project on energy and GHG emissions are associated with the "operations" of the facility, which is based on the amount of fuel energy used by automobiles (including private and freight vehicles) and transit vehicles in the study area.

2.5.3.1 Private Automobile Energy Use

The specific methodology for estimating operational energy use and GHG emissions from private and freight vehicles has been revised between the DEIS and this FEIS. These changes are described below and a comparison of the two methodologies that validates the conclusions of the DEIS is provided below in Section 2.5.4.

Both DEIS and FEIS methodologies are based on data from the Metro travel demand model. This model accounts for changes in capacity, travel times, changes in land use patterns, trip diversions, mode split, and eliminated trips. The travel demand estimated from Metro's demand model served as the inputs into the VISSIM microsimulation model. The microsimulation model accounts for how vehicles interact with the transportation infrastructure as well as how vehicles interact with each other. Additional detail on the traffic analysis is found in the CRC Traffic Technical Report (CRC 2010a).

DEIS Methodology

The DEIS analyses were based on the ODOT methodology for estimating operational energy usage by private and freight vehicles. This methodology accounts for several factors, including: the volume of vehicles, length of roadway segment, types of vehicles, average vehicle speed, fuel consumption rates, and the type of fuels used (ODOT 2006). The following equation represents the relationships between these factors, and the general formula for calculating vehicle fuel energy use:

$$E = V \times L \times FCR \times CF$$

Where E = Energy consumed (Btu)

V = Volume of private and freight vehicles

L = Length of roadway segment (miles)

FCR = Fuel Consumption Rate (gallons/mile) (based on vehicle type and speed)

CF = Conversion Factor (Btu/gallon) (based on fuel type – gasoline or diesel)

Note: Other factors also affect vehicle fuel use and therefore energy consumption such as pavement surface, ambient temperature, vehicle age, and vehicle operating characteristics (e.g., acceleration, deceleration, and idling). These factors were not considered in the DEIS methodology.

For the DEIS, the segment of the I-5 bridge crossing between the SR 14 and Hayden Island interchanges, which is approximately 0.9 miles long, was selected as the DEIS study segment. The DEIS analysis of I-205 also used a study segment length of 0.9 miles to be consistent with the I-5 analysis. The energy analysis was based on the change in travel demand over these 0.9 mile segments, as opposed to total regional VMT, for the following reasons:

- Travel demand forecasts are relative in nature and emphasis should be put on changes in travel demand as opposed to absolute values;
- The most pronounced change in travel demand, which identifies differences in project alternatives, was the difference across the I-5 and I-205 bridge crossings;
- The differences in region-wide VMT for each alternative were miniscule, therefore not adequately illustrating the effects of each project alternative; and
- Estimating energy consumption as a function of VMT and a single fuel economy does not appropriately account for the operational benefits (i.e., increased speeds) of the project alternatives, which affects the amount of energy consumed.

Using this approach, the DEIS GHG emission estimates associated with private and freight vehicle use were not intended to be representative of the total or complete amount of energy used or CO_2 emitted by the project. Rather, these estimates were considered in concert with each other and the value of those estimates were in their relative differences.

Average daily traffic volumes were obtained from the CRC Traffic Technical Report (CRC Project Team 2010a). These daily traffic volumes were developed as part of the CRC traffic analysis and were based on regional travel demand modeling completed by the local metropolitan planning organizations; Metro (Portland area) and the RTC (Vancouver area). Vehicle classification count data along I-5 and I-205 was used to determine the traffic stream composition by vehicle type (automobiles, medium-duty trucks, and heavy-duty trucks). The proportions of these vehicle types were analyzed because of the difference in fuel consumption rates and fuel type used.

Fuel consumption rates over a range of speeds for each vehicle class were based on data obtained by using revised fuel correction factors from Caltrans, as predicted by the Motor Fuel Consumption Model (ODOT 1997), Table 2.8 of the *EIA Annual Energy Review, 2007 Monthly Energy Review* (USDOE 2007a), and Table A7 of the *EIA Annual Energy Outlook* (USDOE 2005-2009). The ODOT data provided historical fuel consumption rates as well as forecasts out to 2015 for automobiles and heavy trucks. A linear growth rate was derived from these data and used to extrapolate fuel consumption rates out to 2030.

All private automobiles, light-duty trucks, and motorcycles were assumed to use gasoline, while heavy-duty trucks, such as freight vehicles, were assumed to use diesel. The fuel conversion factors vary depending on the fuel type; 123,976 Btu/gallon for gasoline and 138,691 Btu/gallon for diesel (Vadas et. al 2007).

FEIS Methodology

Since the completion of the DEIS analyses for energy use and GHG emissions, the EPA released the MOVES model. The first finalized version of this model, “MOVES2010,” was released in December 2009 and was used in this analysis (hereafter simply referred to as “MOVES”). The MOVES model is intended to replace EPA’s previous air quality model, MOBILE6, but also estimates operational energy consumption and GHG emissions. Based on stakeholder input and project staff recommendations the CRC project decided to use the MOVES model for the operational energy and GHG emissions analyses in this FEIS. Additional detail on energy use and GHG emissions associated with private automobile and freight vehicle use is provided in Appendix A, Private Vehicles Operational Analysis.

While the DEIS methodology is based on *stated* fuel consumption rates over a speed distribution (e.g., 25 miles per gallon at 55 mph), MOVES uses vehicle and operating characteristics to *derive* the amount of energy used. For example, MOVES accounts for the existing and forecasted vehicle age distribution and turnover rates, which affect the proportion of newer and more fuel efficient vehicles that are in use. MOVES also accounts for oscillations around the operating speed, such as accelerating, braking, cruising, and idling. After these vehicle and operating characteristics are entered into the model, MOVES produces “energy rates” that identify how much energy is consumed per vehicle class per mile for a given operating speed.

For this FEIS, the national scale was selected, which incorporates vehicle age distribution and weighted fleet mixes. The national weighted fleet mix, compared to the regional and local fleet mix, refers to the weighted proportion, for example, of single-unit two-, three-, and four-axle trucks that are collectively referred to as “medium trucks.” The time span selected was for weekdays during July, which represents “typical” operating conditions often selected by traffic engineers as a representative time frame useful for planning purposes. Both AM and PM peak hours were selected for each vehicle class. The weather parameters were based on Washington County data, which of the four-county macroscale study area, is most similar to the immediate areas around the Columbia River Bridge. For the macroscale analysis, both restricted and unrestricted road types were assumed, while the microscale analysis only used energy and GHG emission rates that were based on restricted road types.

Regional and local traffic stream compositions (i.e., proportions of cars, medium trucks, and heavy trucks) were determined by the Metro regional travel demand model. For the macroscale analysis, these energy and emission rates were then applied to daily VMT for each operating speed bin and road type (restricted and unrestricted) produced by Metro’s regional travel demand model. A regional travel demand model calculates the amount of vehicles or people that will use a given roadway based on surrounding land uses and the transportation infrastructure. Metro’s regional travel demand model consists of freeways, ramps, and primary and secondary arterials in the four-county area of Washington, Clackamas, Multnomah, and Clark counties. Similar to the DEIS, the FEIS macroscale analysis includes system-wide transit service from TriMet and C-TRAN. MOVES is not capable of producing energy or emission rates for light rail transit since GHG emissions are associated with the upstream generation of electricity as opposed to the operations; therefore, the DEIS methodology for estimating energy consumption was used. Although not all roadways are included in the Metro demand model and operating speeds are not as accurate compared to a microsimulation model, the majority of roads are included and the model captures travel demand diversions to other roadway facilities.

For the microscale analysis, energy rates were derived for 4 hours in the AM peak period and 4 hours in the PM peak period to coincide with the traffic simulation model time frames. A traffic simulation model does not estimate the amount of travel demand, rather how vehicles interact with their environment and other drivers. The AM 4-hour and PM 4-hour energy rates were then applied to the hourly traffic volume and speed data from the VISSIM traffic simulation model between 134th Street in Vancouver and the I-5/I-405 interchange in Portland, approximately 12.2 miles. The limits of this area were based on locations where traffic volumes and operating speeds are relatively similar between project alternatives, and is consistent with the four subareas analyzed for air quality.

The vehicle composition was based on data provided by the Metro travel demand model and was broken down by time period and road type.

Transit service is not included in the microscale analysis since most of the transit lines are either shorter or longer than the limits of the microscale study area and because the fleet mix provided by the Metro demand model only provides three vehicle classifications (car, medium trucks, and heavy trucks).

Since the microscale analysis only includes I-5, diverted travel, demand to other roadway facilities is not accounted for (but are accounted for in the macroscale analysis); however, the traffic volume and speed data are the most accurate because they are obtained from the microsimulation model. As a result, the energy consumption estimates are less representative of the absolute amount, and emphasis should be placed on the relative differences between project alternatives.

2.5.3.2 Bus Transit Energy Use

Since the Metro travel demand model does not distinguish between bus transit vehicles and other heavy vehicles and because the majority of bus VMT is along local roadways where operating speeds are more stable and less influential on fuel economy, the amount of energy consumed by bus transit operations was based on the ODOT methodology for private and freight vehicles, similar to the DEIS.

Vehicle miles traveled for each bus transit line were provided in the CRC Transit Technical Report (CRC Project Team 2010b). Use of the system-wide bus VMT was used to estimate energy consumption, as opposed to operating characteristics at the microscale, for the following reasons:

- The TriMet and C-TRAN transit systems are finite, therefore future projections can be appropriately evaluated on the absolute nominal values in addition to the relative differences;
- Differences in bus VMT between alternatives was more apparent compared to the differences in VMT for private and freight vehicles; and

- Effects of operating speed on I-5 and I-205 on bus fuel efficiency was expected to be small since the majority of operating time would be either on local streets or within exclusive rights-of-way.

Dissimilar from the private and freight vehicle energy use and CO_2 emission estimates, where the emphasis should be placed on the relative differences between alternatives, this approach provides complete estimates of energy use and CO_2 emissions associated with the project since the transit system in finite.

Existing bus fuel consumption rates were provided by TriMet (Lehto 2007a), C-TRAN (Pickering 2007), and the CRC project team (Stonecliffe 2009). TriMet also provided historical bus fuel consumption rates, which were used to develop a linear growth rate and extrapolate future 2030 bus fuel efficiency (Appendix B, Transit Operational Analysis). Fuel consumption rates varied slightly per bus operator (TriMet or C-TRAN) and by bus type (40-foot diesel, 40-foot diesel-electric hybrid, 60-foot articulated).

2.5.3.3 Light Rail Transit Energy Use

The energy analysis for light rail transit in this FEIS used the same methodology presented in the DEIS since MOVES cannot produce energy rates specifically and uniquely for this transportation mode. Energy consumed by operating light rail was determined using the same equation used for automobiles, but with slightly different units. This equation is:

$$E = V \times L \times FCR \times CF$$

Where E = Energy consumed (Btu)

V = Volume of light rail cars

L = Length of rail segment (miles)

FCR = Fuel Consumption Rate (kWh/mile) (based average operating speed)

CF = Conversion Factor (Btu/kWh)

Future car miles (V x L) traveled were obtained from the Transit Technical Report (CRC Project Team 2010b). The fuel consumption rate for this analysis was based on TriMet records for the MAX light rail system, which averages approximately six kWh/car mile (or 12 kWh/car mile for two-car trains) (Lehto 2007b). The fuel conversion factor for electricity is 3,412 Btu/kWh (USDOE 2005). Similar to bus transit, this methodology for light rail provides a complete estimate of energy use and CO_2 emissions associated with the project since the transit system is finite.

The amount of energy consumed by each transit line was combined to get the total energy use per day. Additional detail is provided in Appendix B, Transit Operational Analysis.

2.5.3.4 Transit-Related Facilities

Bus and light rail transit maintenance facilities are needed to support transit operations, and require energy for heating, lighting, equipment operations etc. The following support facilities were accounted for in this analysis:

- Bus Maintenance Facilities
  - C-TRAN
  - Center Street

    - Powell
    - Merlo
- Light Rail Maintenance Facilities
    - Elmonica
    - Ruby Junction

Data on energy consumption for transit maintenance facilities was provided by the Portland-Milwaukie Light Rail Project (Metro 2008). This project reviewed the amount of energy consumed by the Center Street bus maintenance facility in fiscal 2005 to estimate the amount of energy consumed per square foot. Similarly, an energy consumption rate per square foot was calculated for light rail maintenance facilities based on fiscal year 2000 data for Elmonica and Ruby Junction.

Park and ride lots are also needed to support transit operations, and require energy for lighting. Park and ride lots accounted for in this analysis include:

- Salmon Creek
- 99th Street
- BPA
- Clark (new)
- Mill (new)
- Columbia (new)
- Fisher’s Landing
- 18th Street
- Expo Center
- Delta Park

Energy consumption associated with park and ride facilities were also based on data provided by the Portland-Milwaukie Light Rail Project (Metro 2008). The Portland-Milwaukie Light Rail Project evaluated the fiscal year 1997 energy consumption data of two park and ride lots to derive an energy consumption rate (in Btu per parking space).

2.5.3.5 Greenhouse Gas Emissions

The primary difference between the DEIS and FEIS analyses is in respect to the GHG emissions analysis. Since the GHG emissions are derived from the energy consumption calculations, the differences between the DEIS and FEIS methodologies are largely captured in Section 2.5.3.1, above. However, additional detail on these differences is provided below and a comparison of the two methodologies that validates the conclusions of the DEIS is provided below in Section 2.5.4.

DEIS Methodology

The DEIS methodology for estimating GHG emissions is based on the energy equation described in Section 2.5.3.1, above, but includes additional variables that relate fuel consumption and GHG emissions.

Vehicles that use petroleum-based fuel sources emit greenhouse gases. The United Nations Framework Convention on Climate Change identifies six primary greenhouse gases, including: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorcarbons (PFCs), and sulfur hexafluoride (vehicles typically don't emit PFCs or sulfur hexafluoride). Emissions of CH_4, N_2O, and HFCs from vehicle usage is difficult to quantify, but typically represent roughly five to six percent of the GHG emissions from passenger vehicles, while CO_2 accounts for 94 to 95 percent. As a result, the EPA uses a CO_2 equivalents (CO_2e) conversion factor for the remaining GHGs emitted to provide a better estimate of the total global warming potential (EPA 2005a). A general equation for estimating CO_2 and CO_2e emissions can be expressed as:

$$EM = V \times L \times FCR \times EF \times CDE$$

Where EM = Emissions of CO_2 or CO_2e (lbs)

V = Volume of private or freight vehicles or light rail cars

L = Length of roadway or rail segment (miles)

FCR = Fuel Consumption Rate (gallons/mile or kWh/mile)

EF = Emission factor (lbs of CO_2/gallon or lbs of CO_2/kWh) (based on fuel type)

CDE = Carbon dioxide equivalents conversion factor (100/95)

The emissions (EM) can be expressed as pounds of CO_2 when strictly referring only to CO_2, or pounds of CO_2e if describing the total global warming potential (i.e., accounting for the other five percent of GHGs emitted by vehicles). The data used in this report, such as the emission factors, generally focus on CO_2, which is later converted to CO_2e. For the purposes of this report, the terms "GHG" and "CO_2e" are used interchangeably.

The volume (V), length (L), and fuel consumption rate (FCR) are used to estimate the amount of fuel consumed. The emission factor (EF) is the amount of CO_2 that would be emitted during combustion of a gallon of fuel or the generation of a kWh. The CO_2 to CO_2e conversion factor (CDE; 100/95) represents the approximate proportions of CO_2 and the other GHGs emitted during fuel combustion.

Based on data from the EPA, the emission factors (EF) used in this analysis were 19.4 pounds of CO_2 per one gallon of gasoline and 22.2 pounds for one gallon of diesel (EPA 2005b).

It appears unlikely that a gallon of gasoline or diesel, which generally weighs around six pounds, could produce 19.4 to 22.2 pounds of CO_2 when burned. However, most of the weight of the CO_2 doesn't come from the fuel itself, but from the oxygen in the air that is used to combust the fuel. When fuel burns, the carbon and hydrogen separate. The hydrogen combines with oxygen to form water (H_2O), and carbon combines with oxygen to form carbon dioxide (CO_2). To illustrate and estimate the CO_2 content, the EPA offers the following general equation that can be expressed as:

$$EF = CC \times OF \times MWR$$

Where EF = Emissions factor (lbs of CO_2/gal) (based on fuel type)

CC = Carbon content (lbs of carbon/gallon) (2,421 grams of carbon per gallon of gasoline and 2,778 grams of carbon per gallon of diesel; converted to lbs/gallon)

OF = Oxidation factor (proportion of oxidized carbon)

MWR = Molecular weight ratio (44/12; ratio of CO_2/C)

The carbon content (CC) values are the recommended EPA quantities for the amount of carbon in a typical gallon of gasoline or diesel (EPA 2005b). The EPA recommends an oxidation factor

(OF) of 0.99, which indicates that 99 percent of the carbon in the fuel is fully oxidized, while 1 percent remains un-oxidized (i.e., about 1 percent forms carbon monoxide, CO, which is not a greenhouse gas). The molecular weight ratio (MWR) is based on the molecular weight of CO_2 (one atom of carbon = 12 plus two atoms of oxygen = 32 [16 each]; total 44) compared to the atomic weight of carbon (carbon = 12).

Light rail transit would use electricity supplied by electrical substations as its energy source. For the DEIS, 40 percent of the electricity was assumed to be provided by Portland General Electric (PGE) and 60 percent from Clark Public Utilities (CPU). This breakdown was based on the anticipated geographical locations of the substations.

Of the 40 percent of electricity assumed to come from PGE, 42.0 percent was assumed to be generated from coal and 13.9 percent was assumed from natural gas to be consistent with PGE's breakdown of primary energy sources used to generate electricity (PGE 2007). The remaining 55.9 percent of PGE's energy comes from other sources (e.g. hydropower, nuclear, biomass) that do not emit CO_2 when used to generate electricity.

Of the 60 percent of electricity assumed to be provided by CPU, 28.0 percent was assumed to come from natural gas combustion and seven percent from coal firing. The remaining 65 percent of CPU's electricity is generated from renewable, non-CO_2 emitting sources (e.g. hydropower, nuclear, biomass). These assumptions are consistent with the breakdown of electricity sources according to CPU (CPU 2007).

The generation of electricity from natural gas and coal emits CO_2. According to the USDOE, approximately 2.095 lbs of CO_2 are emitted to produce 1 kWh of electricity from coal, and 1.321 lbs of CO_2 are emitted to produce 1 kWh of electricity from natural gas (USDOE 2007a). These emission factors were used to estimate the amount of CO_2 emissions associated with the electricity needed to operate light rail. In order to reflect fair representation of operational energy requirements for all modes (e.g. bus, rail, private automobiles, trucks), it was necessary to include the amount of energy required to generate electricity even though the end-use of electricity does not emit CO_2.

Under this approach, it is important to note that the CO_2 emission estimates associated with light rail transit account for both the generation of electricity and the end-use. Conversely, CO_2 emission estimates for private, freight, and bus transit vehicles are limited to end-use emissions and do not account for the amount of CO_2 emitted during the extraction of crude oil and refinement processes.

FEIS Methodology

The FEIS methodology for estimating CO_2e emissions is represented as:

$$EM = V \times L \times ER$$

Where EM = Emissions of CO_2e (lbs)

V = Volume of private or freight vehicles or light rail cars

L = Length of roadway or rail segment (miles)

ER = Emission rate from MOVES (speed-sensitive; grams/mile)

This equation is similar to the DEIS methodology, except the *derived* emission rate from MOVES (ER) replaces the *stated* or assumed fuel consumption rate (FCR) based on EPA testing and/or historical data, emission factor (EF), and carbon dioxide equivalents conversion factor (CDE).

The emission rate derived by MOVES accounts for vehicle characteristics (e.g., age, condition) and operating characteristics (e.g., acceleration, braking, cruising, idling).

Another difference between the DEIS and FEIS analyses are the *input assumptions* into the *methodology*. In the DEIS, electricity needed to operate light rail was assumed to be provided by PGE and CPU. Data specific to PGE and CPU operations regarding the distribution of primary energy sources (i.e., the amount of electricity generated from coal, natural gas, etc.) and emission factors for each primary energy source were used to calculate the CO_2e emissions. For the FEIS, the PGE and CPU specific data were substituted with data from EPA's emission and Generation Resource Integrated Database (eGRID). eGRID is a comprehensive source of data on the environmental characteristics of almost all electric power generated in the United States. eGRID is unique in that it links air emissions data, including CO_2, CH_4, and N_2O emissions, with electric generation data for United States power plants. The decision to use eGRID data from the Northwest Power Pool (NWPP) were based on the following reasons:

- The distribution of primary energy sources from PGE and CPU change over time and the resulting CO_2e emission estimates could vary substantially, compared to eGRID NWPP data that is temporally less volatile;
- Local electricity use may not have been generated locally since electricity is frequently distributed across the NWPP region;
- The State of Washington uses eGRID NWPP data for the climate registry, and is also used by the Department of Ecology for emissions inventory;
- Use of the eGRID NWPP data maintains uniformity between project level analyses and State of Washington procedures related to air quality conformity requirements;
- Metro, the Vancouver and Portland area Metropolitan Planning Organization, is in the process of releasing a Greenhouse Gas Inventory, which will utilize eGRID NWPP data; and
- WSDOT and ODOT recommendations.

A sensitivity analysis was completed to compare the light rail CO_2e emission estimates based on the PGE and CPU localized data versus the eGRID NWPP data (eGRID 2007). While the light rail CO_2e emission estimates based eGRID NWPP data were 5 to 7 percent higher compared to the estimates based on PGE and CPU data, the conclusions of both analyses were consistent; i.e., both the LPA Full Build and LPA with highway phasing result in higher light rail CO_2e emissions relative to No-Build as a result of increased service. Since the light rail CO_2e emission estimates were higher using the eGRID NWPP data, the disclosure of operational impacts is, if anything, conservatively high.

eGRID data were also used to estimate the GHG emissions associated with the electricity consumed by transit maintenance facilities and park and ride lots.

2.5.4 Long-term Effects DEIS Methodology Validation

The DEIS methodology was novel in the sense of how it integrated carbon dioxide (CO_2) emission factors for different energy sources (e.g. gasoline, diesel, electricity etc.), utilized traffic simulation data, and accounted for the operational speeds of the project by using different fuel economies according to vehicle class and over a speed distribution. This was a substantial improvement over other methodologies that were based on vehicle miles travelled (VMT) and a single fuel economy.

After the publication of the DEIS, EPA released the Mobile Vehicle Emission Simulator (MOVES) model that estimates operational CO_2e emissions. Based on stakeholder input and project staff recommendations the CRC project team decided to use the MOVES model to for the operational energy and GHG emissions analyses in the FEIS.

Since no other methodologies were available at the time when the DEIS was prepared to gauge the accuracy of the estimates, the project team deemed it desirable to confirm the validity of the methodology and conclusions presented in the DEIS. A series of sensitivity tests were conducted and determined the following:

- The effects of differing input assumptions for existing fuel economies and future forecasts resulted in differences between the DEIS and MOVES CO_2e estimates of 10 to 24 percent;
- When input assumptions are the same, the DEIS methodology provides CO_2e emission estimates that are approximately 1.8 percent within MOVES estimates; i.e., the additional parameters included in the MOVES model only affect emission estimates by a nominal amount;
- Variations in the input assumptions are the primary cause for differences between emission estimates, not the methodology itself; and
- For all three sensitivity tests, the relative differences between the five emission estimates were in the same for the DEIS and MOVES methodologies, which indicates that the methodology used in the DEIS and the conclusions drawn from the analyses are valid for evaluating alternatives.

Additional information on how and why the DEIS and MOVES input assumptions differ is provided in Appendix C, Methodology Comparison and Validation.

2.5.5 Temporary Effects Approach

The project's temporary effects on energy supply are solely associated with the construction of the project. The approach for determining energy use during construction was based on an input-output method developed by Caltrans (Caltrans 1983). This method estimates energy requirements using energy factors that were developed for a variety of construction activities (e.g. construction of structures, electrical substations, site work etc.). These energy factors relate project costs with the amount of energy required to manufacture, process, and place construction materials and structures. The general equation for estimating energy consumed during construction can be represented as:

$$E = C \times EF \times DC$$

Where E = Energy consumed (Btu)

C = Cost of a particular construction activity (2009$)

EF = Energy factor (Btu/1973$)

DC = Dollar conversion (1973$/2009$)

The Caltrans energy factors were based on construction cost estimates in 1973 dollars, therefore the dollar conversion is necessary since the project's cost estimates are in 2009 dollars. Although the construction cost estimates and dollar conversion factor will change depending on the year of construction, the estimated amount of energy consumed will not unless actual amount of work changes.

Of the total energy used for construction, 70 percent was assumed to come from diesel and 30 percent from gasoline. Electricity would likely be needed for some construction purposes (e.g.

lighting), but would likely be derived from gas/diesel generators. This breakdown of energy sources was used to estimate the gallons of diesel and gasoline needed to construct the project, and was then used to estimate CO_2e emissions.

The estimated amount of energy consumed by the construction of the project was based on construction cost estimates that have been updated since the DEIS. Additional information is provided in Appendix D, Construction Analysis.

2.5.6 Cumulative Effects Approach

Cumulative effects may occur when a project's effects are combined with those from past, present, and future projects. They can also result from individually small but collectively substantial actions that occur over a long period of time. The energy analysis relies on information generated from the forecasts of future traffic volumes and operations and light rail and bus rapid transit miles traveled. The transportation model takes into account other planned and future projects and the effects of those projects on the various transportation modes, thus capturing cumulative effects (see the Traffic Technical Report, CRC Project Team 2010a). Since the energy analysis uses this information, cumulative effects are included in the analysis.

The project team has addressed the cumulative effects approach in the Cumulative Effects Technical Report (CRC Project Team 2010c).

2.5.7 Mitigation Measures Approach

Mitigation measures for the project's effects on energy supply and demand are difficult to identify and evaluate because of two primary reasons:

- There are no existing federal, state, or local regulations that constrain energy use.
- Regulations and guidelines lack specificity as to the definition of an adverse effect that necessitates mitigation.

However, some general measures can be implemented to reduce long-term and short-term energy effects. Some of these same measures would reduce CO_2e emissions.

2.5.7.1 Mitigation Measures for Long-term Effects

Measures to reduce the operational energy consumption and CO_2e emissions were assumed to be similar with measures that reduce private vehicle travel demand, increase transit and non-motorized mode shares, and improve traffic flow along the I-5 river crossing between Vancouver and Portland. These measures were qualitatively evaluated and integrated into the proposed project. See Section 6.1 for a list of measures that reduce the project's long-term effects.

2.5.7.2 Mitigation Measures for Temporary Effects

Measures taken to reduce the energy consumed by the construction of the project would largely encompass conservation of construction materials and BMPs. See Section 6.2 for a list of potential BMPs.

2.6 Coordination

The project team has coordinated with WSDOT, ODOT, local project sponsors, federal lead agencies, state regulatory agencies, an expert review panel, and the public regarding the energy analysis. During the 60-day comment period for the DEIS, comments from the general public, businesses, public agencies, and stakeholder groups were collected, addressed, and integrated into the analysis prepared for this FEIS. The CRC project team also met with and had the analysis reviewed by an expert review panel that consisted of leading professionals from around the nation. The expert review panel consisted of:

- Kelly McGourty (Chair) – Principal Planner in the Transportation Department of the Puget Sound Regional Council,
- Dr. Ed Beimborn – Professor emeritus from the University of Wisconsin, and
- Kelly Dunlap – NEPA and climate change analysis lead for the California Department of Transportation Environmental Management Office in Sacramento.

These professionals prepared the CRC Greenhouse Gas Emissions Analysis Expert Review Panel Report (ERP 2009) and their recommendations were also integrated into the FEIS analysis.

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3. Affected Environment

3.1 Introduction

Because the supply and distribution of petroleum (Washington's and Oregon's primary energy source in general, and especially for the transportation sector) is regulated and distributed at the national and state levels, the affected environment is broadly inclusive of the U.S., Washington, and Oregon. This section provides a brief and general description of:

- The existing use and demand for energy resources in the nation and region.
- The present energy use for transportation.
- The available and forecasted supply of energy.

Because gasoline and diesel are the primary energy sources for the transportation sector, this discussion provides general information on several energy sources, but focuses on the supply and demand of energy derived from petroleum-based fuel sources. Unless specifically defined otherwise, energy use refers to energy originating from crude oil products since energy derived from these sources generally account for over 95 percent of the total energy demand for the transportation sector.

3.2 National Energy Supply and Demand

The USDOE prepares annual energy outlook reports with projections into the future (USDOE 2005-2009). The Annual Energy Outlook analyzes trends in energy supply and demand worldwide with linkages to projected performance of the U.S. economy and future public policy decisions. The most recent report analyzes historical energy use beginning in 1980 and provides supply and demand forecasts to 2030 (USDOE 2005-2009). Energy supply forecasts are largely based on international oil markets, and national energy demand projections are organized by delivered energy sources and use sectors.

3.2.1 National Energy Supply

The national supply of petroleum largely depends on international factors. The majority of oil suppliers are currently at or near production capacity, with the exception of the Organization of Petroleum Exporting Countries (OPEC), who is the largest contributor to the international supply of petroleum. Since its inception in 1960, OPEC has historically had a substantial role in the international and U.S. petroleum supply. In general, when the world oil price is low (price often tracks supply), OPEC curtails supply, and when the price is high, OPEC increases production.

In 2030, 66 percent of the U.S. petroleum supply is expected to be imported from international oil markets including OPEC members and other countries in the Far East, Caribbean, Europe and North America (other than the U.S.). Of this 66 percent, 37 percent is expected to originate from OPEC suppliers (USDOE 2005-2009).

Historically, world oil prices have varied considerably and are expected to continue to exhibit high fluctuations as a result of political instability, access restrictions, and a reassessment of OPEC producers' ability to influence prices during periods of volatility. As a result, the 2030 national supply of petroleum could vary substantially depending on world oil prices. For example, the USDOE Annual Energy Outlook (2007) world oil prices in 2030 were forecasted for three scenarios: "High Price," "Reference Price," and "Low Price" with the cost of oil at 100, 59, and 36 dollars per barrel, respectively (in 2005 dollars). Two years later, the 2009 USDOE Annual Energy Outlook presented a very different picture with the cost of oil at 200, 130, and 50 dollars per barrel (in 2007 dollars). These fluctuations illustrate the volatility in world oil prices, which will substantially affect 2030 projections of petroleum imports and national supply.

3.2.2 National Energy Demand

The national demand for energy will depend on trends in population, economic activity, energy prices (which are reliant on the factors affecting the national supply described above), and the adoption and implementation of technology. In general, the energy consumption per capita is expected to increase 0.3 percent annually through 2030 primarily as a result of strong economic growth (USDOE 2005 to 2009). However, the nation's economy is becoming less reliant on energy as a result of energy efficient technologies and faster growth in less energy-intensive industries.

USDOE's annual energy outlook organizes national energy demand forecasts in 2030 by delivered energy source (e.g., liquid fuels/petroleum, natural gas, coal, electricity and renewables) and use sectors (e.g., residential, commercial, industrial, and transportation).

According to the USDOE, the delivered energy use from all sources is expected to increase from 95.61 quadrillion Btu in 2009 to 111.18 quadrillion Btu in 2030, equating to annual demand growth rate of 0.8 percent (USDOE 2010a). Energy from liquid fuels and other petroleum products is expected to account for the greatest share of energy demand (approximately 37 percent) with a growth rate of approximately 0.6 percent. The energy demand from renewable sources is expected to have the highest growth rate (4.8 percent from biomass and 5.8 percent from other sources). Exhibit 3-1 summarizes the national consumption for energy in 2009 by energy source with projections out to 2030.

Exhibit 3-1. National Energy Demand for 2009 and 2030 by Energy Source

Energy Source	2009 Energy Demand (quadrillion Btu)	2009 Source Share	2030 Energy Demand (quadrillion Btu)	2030 Source Share	Annual Increase (2009-2030)
Liquid Fuels and Other Petroleum[a]	36.82	38.5%	41.08	36.9%	0.6%
Natural Gas	23.23	24.3%	25.01	22.5%	0.4%
Coal	20.28	21.2%	24.25	21.8%	0.9%
Electricity (Nuclear Power)	8.49	8.9%	9.29	8.4%	0.5%
Electricity (Hydropower)	2.57	2.7%	2.98	2.7%	0.8%
Renewable (Biomass)[b]	2.58	2.7%	5.19	4.7%	4.8%
Renewable (Other)[c]	1.43	1.5%	3.17	2.9%	5.8%
Other[d]	0.21	0.2%	0.20	0.2%	-0.3%
Total	**95.61**	**100.0%**	**111.18**	**100.0%**	**0.8%**

Source: Energy Information Administration, U.S. Department of Energy (USDOE 2010a).

a Includes petroleum-derived fuels and non-petroleum-derived fuels, such as ethanol and biodiesel. Petroleum coke, which is a solid, is included. Also included are natural gas plant liquids, crude oil consumed as a fuel, and liquid hydrogen.

b Includes grid-connected electricity from wood and wood waste, non-electric energy from wood, and biofuels heat and co-products used in the production of liquid fuels, but excludes the energy content of the liquid fuels.

c Includes grid-connected electricity from landfill gas; municipal solid waste; wind; photovoltaic and solar thermal sources; and non-electric energy from renewable sources, such as active and passive solar systems. Excludes electricity imports using renewable sources and non-marketed renewable energy.

d Includes net electricity imports and natural gas losses.

In 2009, the highest demand for energy stemmed from the industrial sector, accounting for approximately 30.1 percent of the total energy demand. By 2030, the industrial sector is expected to consume less energy (29.9 percent of the total demand) as a result of efficiency gains and faster growth in less energy-intensive industries (USDOE 2010b).

The transportation sector is expected to have the second highest demand for energy at 28.2 percent in 2030, which is the same proportionate demand as 2009. Of the total amount of energy demand for the transportation sector, approximately 96.7 percent is expected to come from liquid fuels and other petroleum products in 2030. Despite improvements in fuel consumption rates and increasing use of alternative fuel sources (e.g., electric hybrids), the high passenger travel demand and increasing use of trucks for freight transportation (second highest consumer among the travel modes with a 1.8 percent growth rate) is expected to result in an increase in energy demand in the transportation sector (USDOE 2010b). Exhibit 3-2 provides a breakdown of energy use for each sector and source.

Exhibit 3-2. National Energy Demand for 2009 and 2030 by Energy Sector

Energy Source	2009 Energy Demand (quadrillion Btu)	2009 Source Share	2030 Energy Demand (quadrillion Btu)	2030 Source Share	Annual Increase (2009-2030)
Residential					
Liquid Fuels and Other Petroleum	1.18	5.5%	0.88	3.8%	-1.2%
Natural Gas	4.91	22.8%	5.03	21.5%	0.1%
Coal	0.01	0.0%	0.01	0.0%	-1.2%
Renewable[a]	0.43	2.0%	0.42	1.8%	0.0%
Electricity	4.70	21.9%	5.58	23.9%	0.9%
Electricity (Related Losses)	10.27	47.8%	11.45	49.0%	0.5%
Residential Total	21.49	100.0%	23.38	100.0%	0.4%
Residential Total (relative to other use sectors)		**22.5%**		**21.0%**	
Commercial					
Liquid Fuels and Other Petroleum	0.57	3.1%	0.52	2.3%	-0.4%
Natural Gas	3.16	17.2%	3.66	15.8%	0.8%
Coal	0.06	0.3%	0.07	0.3%	0.4%
Renewable[b]	0.10	0.6%	0.10	0.4%	0.0%
Electricity	4.53	24.7%	6.16	26.6%	1.7%
Electricity (Related Losses)	9.90	54.1%	12.63	54.6%	1.3%
Commercial Total	18.32	100.0%	23.14	100.0%	1.3%
Commercial Total (relative to other use sectors)		**19.2%**		**20.8%**	
Industrial[c]					
Liquid Fuels and Other Petroleum	8.35	29.0%	8.82	26.5%	0.3%
Natural Gas	7.45	25.9%	8.20	24.7%	0.5%
Coal	1.27	4.4%	1.96	5.9%	2.6%
Renewable (Biofuels Heat and Coproducts)	0.74	2.6%	1.90	5.7%	7.5%
Renewable[d]	1.44	5.0%	1.79	5.4%	1.2%
Electricity	3.00	10.4%	3.47	10.4%	0.7%
Electricity (Related Losses)	6.56	22.8%	7.12	21.4%	0.4%
Industrial Total	28.81	100.0%	33.26	100.0%	0.7%
Industrial Total (relative to other use sectors)		**30.1%**		**29.9%**	

Energy Source	2009 Energy Demand (quadrillion Btu)	2009 Source Share	2030 Energy Demand (quadrillion Btu)	2030 Source Share	Annual Increase (2009-2030)
Transportation					
Liquid Fuels and Other Petroleum	26.25	97.2%	30.37	96.7%	0.7%
Natural Gas (Pipeline Fuel)	0.63	2.3%	0.74	2.3%	0.8%
Natural Gas (Compressed)	0.04	0.2%	0.15	0.5%	12.0%
Electricity	0.02	0.1%	0.05	0.1%	4.8%
Electricity (Related Losses)	0.05	0.2%	0.09	0.3%	4.2%
Transportation Total	27.00	100.0%	31.40	100.0%	0.8%
Transportation Total (relative to other use sectors)		**28.2%**		**28.2%**	

Source: Energy Information Administration, U.S. Department of Energy (USDOE 2010b).

a Includes wood used for residential heating, geothermal heat pumps, solar thermal hot water heating, and solar photovoltaic electricity generation.

b Includes commercial sector consumption of wood and wood waste, landfill gas, municipal solid waste, and other biomass for combined heat and power.

c Includes energy for combined heat and power plants, except those whose primary business is to sell electricity, or electricity and heat, to the public.

d Includes consumption of energy produced from hydroelectric, wood and wood waste, municipal solid waste, and other biomass sources.

3.3 Washington Energy Supply and Demand

Quantitative petroleum projections have not been prepared by USDOE at the state level. The Department of Commerce prepares biennial energy reports, however these reports largely provide quantitative analyses on historical energy trends and limited qualitative assessments of future conditions. Nonetheless, Washington's energy supply and demand closely tracks national trends, from which conclusions can be drawn.

3.3.1 Washington Energy Supply

Approximately 90 percent of Washington's current supply of crude oil comes from the Alaska North Slope via the Trans-Alaska Pipeline, where it is then barged in from Valdez. Roughly 10 percent of Washington's crude oil comes from the Western Canada Sedimentary Basin in Alberta by means of the Trans Mountain Pipeline. Five refineries in the Puget Sound area then distribute refined petroleum products to Washington and adjacent states, primarily Oregon (ODOE 2000).

Washington's future supply of petroleum is largely dependent on domestic production and reserves, which are both in decline, and subject to political, economic, and infrastructure factors.

Although Washington's primary suppliers of oil are currently located in Alaska and Canada, international political and economic factors could still substantially affect Washington's future supplies. As described above, international and national supplies of crude oil are affected by world oil prices. World oil prices, in turn, are substantially affected by OPEC production, which are subject to the political stability of and relationships with OPEC countries and global economies.

From the infrastructure standpoint, there is concern about the reliability of the Trans-Alaska Pipeline due to the harsh climatic environment. A disruption in the transport of crude oil to Washington refineries could have substantial effects on petroleum supplies. In addition to potential challenges with the transport of crude oil, Washington refineries are currently near capacity and regulations prohibit capacity expansion. At both state and national levels, the state of the industry's infrastructure is more likely to cause substantial changes in petroleum supplies compared to international or national political factors.

Despite political and infrastructure concerns, Washington is expected to be able to procure adequate petroleum supplies for the foreseeable future.

3.3.2 Washington Energy Demand

According to the Department of Commerce, the total demand for all energy sources in Washington has grown by 1.6 percent between 1985 and 2000 (Department of Commerce 2007). While the total energy demand in Washington exhibits an increasing trend, the per capita consumption rate is in decline. Notable drops in energy consumption per capita rates occurred from 1973 to 1975, 1979 to 1983, and 1999 to 2002. The drops in the energy consumption per capita rates during these time frames were largely resultant of economic downturns and the shutdown of aluminum smelters in the industrial sector. For 2007, the total per capita energy consumption was 320.5 million Btu (USDOE 2007b).

Washington is the leading hydroelectric power producer in the nation. However, as of 2007, energy derived from petroleum products accounted for the largest single share (55.9 percent) of energy consumed in Washington (USDOE 2007b), and is higher than the 2005 national demand of 40.5 percent. Exhibit 3-3 provides a breakdown of Washington's energy use by source.

Exhibit 3-3. Washington's Energy Consumption by Source, 2007

State	Coal (Trillion Btu)	Natural Gas (Trillion Btu)	Petroleum (Trillion Btu)	Electricity (Trillion Btu)	Total Per Capita Energy Consumption, 2007 (Million Btu)
Washington	95.7 (37)	279.7 (24)	846.8 (15)	292.6 (16)	320.5 (31)
Share	6.3%	18.5%	55.9%	19.3%	
United States	22,739.9	23,677.6	40,358.1	12,844.8	336.8
Share	22.8%	23.8%	40.5%	12.9%	

Source: Energy Information Administration, U.S. Department of Energy (USDOE 2007b).

Note: (XX) Indicates national ranking. A ranking of 1 equates to the highest national consumer, a ranking of 50 equates to the lowest national consumer.

Jet fuel, which is a petroleum-derived product, consumption in Washington is relatively high compared to the national average, due in part to SeaTac International Airport and several large Air Force and Navy bases.

USDOE also provides data for Washington's energy consumption by use sector. In 2008, Washington's transportation sector was responsible for most (76.4 percent) of the total energy consumed in the state, which is slightly higher than the national share of 70.3 percent. Exhibit 3-4 provides a summary of Washington's petroleum-derived energy consumption by use sector.

Exhibit 3-4. Washington's Petroleum Consumption by Sector, 2008 (Trillion Btu)

State	Residential	Commercial	Industrial	Transportation	Electric Power[a]	Total
Washington	14.2	11.3	163.9	614.4	0.3	804.1
Share	1.8%	1.4%	20.4%	76.4%	0.0%	
United States	1,203.60	640.3	8,559.80	27,230.30	467.7	38,101.70
Share	3.2%	1.7%	22.5%	71.5%	1.2%	

Source: Energy Information Administration, U.S. Department of Energy (USDOE 2008b).

Note: Totals may not equal sum of components due to independent rounding.

a Petroleum required during generation of electricity.

While Washington's transportation sector's share of energy used is higher than the national average, the amount of petroleum used in Washington by the commercial (1.4 percent) and residential (1.8 percent) sectors is lower than the national usage (1.7 percent and 3.2 percent, respectively). This difference in the allocation of energy demand may result from households becoming more energy efficient as a result of building codes and standards, and commercial sector increased productivity, improvements to the efficiency of buildings, lighting, and equipment and shifts away from energy-intensive businesses.

Within the transportation sector, approximately 97.3 percent of the energy consumed in 2007 came from petroleum products (USDOE 2007c). Exhibit 3-5 compares the Washington and U.S. energy sources used for the transportation sector.

Exhibit 3-5. Washington's Transportation Sector Energy Consumption by Source, 2007 (Trillion Btu)

State	Coal	Natural Gas[a]	Petroleum	Ethanol	Retail Electricity Sales	Total
Washington	0	8.1	664.1	10.2	<0.05	682.4
Share	0.0%	1.2%	97.3%	1.5%	0.0%	
United States	0	668.7	28,333.8	568.9	28.0	29,599.4
Share	0.0%	2.3%	95.7%	1.9%	0.1%	

Source: Energy Information Administration, U.S. Department of Energy (USDOE 2007c).

Note: Totals may not equal sum of components due to independent rounding. Does not include electrical system energy losses.

a Includes supplemental gaseous fuels. Transportation use of natural gas is gas consumed in the operation.

b Incurred in the generation, transmission, and distribution of electricity plus plant use and unaccounted for electrical system energy losses.

Newer vehicles are more fuel-efficient, and it is expected that this trend will continue in the future because of recent government requirements for higher fuel efficiency standards. The promotion of alternative fuel sources for transportation, such as ethanol, biodiesel, compressed natural gas, liquefied petroleum gas, and electricity has also been increasing. For example, there are now several automobile manufacturers that produce hybrid (gas-electric) cars that can achieve almost twice the gasoline mileage of an average passenger automobile and these types of hybrids are becoming more and more popular. Nonetheless, petroleum demand in Washington and the project study area is not expected to slow appreciably because population and vehicle travel continue to increase.

3.4 Oregon Energy Supply and Demand

As described above, the USDOE does not prepare quantitative energy forecasts at the state level. However, parallels can be drawn between Oregon's and Washington's future energy supply and demand based on existing similarities of energy usage.

3.4.1 Oregon Energy Supply

Oregon imports 100 percent of its petroleum. Approximately 90 percent of Oregon's petroleum comes from Washington refineries via the Olympic Pipeline to Portland and then on to Eugene. The remaining 10 percent is delivered by tanker trucks from California, Idaho, and Utah, with a small portion coming directly from Asia and Canada.

There is some concern over the potential volatility of Oregon's petroleum supply. The existing Olympic pipeline that delivers the majority of refined products from Washington is in relatively good working order. However, further up the supply chain is the 600-mile Trans-Alaska Pipeline that transports crude oil to Valdez, which is then barged into Washington. The Trans-Alaska Pipeline operates in a harsh environment, which increases the potential for an accident to upset the flow of crude oil to refineries in Washington. The shipping time from Valdez to Puget Sound is less than 10 days, while shipping from alternative suppliers, such as Asia or the U.S. Gulf Coast, exceeds 30 days. If an accident was to occur, and the transport of crude oil through the Trans-Alaska Pipeline was interrupted, the supply of refined petroleum products to Oregon from Washington would be seriously affected. Further exacerbating the situation is that there is little storage of petroleum in Oregon and an "air bubble" in the supply chain could result in severe shortages of fuel for as long as a month (ODOE 2000). A recent example of reduced domestic supply was experienced during the 2005 hurricane season, which disrupted supplies from oilfields and refineries in the Gulf of Mexico.

Barring a disruption in the transport of crude oil through the Trans-Alaska Pipeline, Washington is expected to provide adequate petroleum supplies to Oregon in the foreseeable future. Nonetheless, ODOE has a contingency plan for problems related to energy supply (ODOE 2005). In the event of shortages, the plan outlines measures to alert the population, as well as ensure that fuel is reserved for use by emergency services such as police, fire, and emergency medical aid. Distribution sites in Oregon maintain some supply stocks of petroleum. However local availability is sensitive to supply, demand, and delivery schedules, and in the past supplies have occasionally been limited.

3.4.2 Oregon Energy Demand

Between 1990 and 1997, Oregon's petroleum consumption grew by about 8 percent (ODOE 2000). In 2007, approximately 45.0 percent of Oregon's energy consumption came from petroleum (USDOE 2007a). Exhibit 3-6 summarizes Oregon's energy demand by source.

Exhibit 3-6. Oregon Energy Consumption by Source, 2007

State	Coal (Trillion Btu)	Natural Gas (Trillion Btu)	Petroleum (Trillion Btu)	Electricity (Trillion Btu)	Total Per Capita Energy Consumption (Million Btu)
Oregon	45.3 (41)	258.2 (28)	384.7 (33)	166.3 (28)	296.7 (40)
Share	5.3%	30.2%	45.0%	19.5%	
United States	22,739.9	23,677.6	40,358.1	12,844.8	336.8
Share	22.8%	23.8%	40.5%	12.9%	

Source: Energy Information Administration, U.S. Department of Energy (USDOE 2007a).

Note: (XX) Indicates national ranking. A ranking of 1 equates to the highest national consumer, a ranking of 50 equates to the lowest national consumer.

With respect to delivered energy use from petroleum, the transportation sector is responsible for the greatest energy consumption. Exhibit 3-7 shows the breakdown of petroleum-derived energy demand by sector.

Exhibit 3-7. Oregon Petroleum Consumption by Sector, 2008 (Trillion Btu)

State	Residential	Commercial	Industrial	Transportation	Electric Power[a]	Total
Oregon	5.7	5.2	39.9	323.1	0.1	374.1
Share	1.5%	1.4%	10.7%	86.4%	0.0%	
United States	1,203.60	640.3	8,559.80	27,230.30	467.7	38,101.70
Share	3.2%	1.7%	22.5%	71.5%	1.2%	

Source: Energy Information Administration, U.S. Department of Energy (USDOE 2008b).

Note: Totals may not equal sum of components due to independent rounding.

a Petroleum required during generation of electricity.

The breakdown of energy sources used within Oregon's transportation sector is relatively similar to the nation's allocation; approximately 95.5 percent of energy used within the transportation sector is supplied by petroleum products (USDOE 2007b). Exhibit 3-8 compares the breakdown of energy sources used in the national and Oregon transportation sectors.

Exhibit 3-8. Oregon's Transportation Sector Energy Consumption, 2007 (Trillion Btu)

State	Coal	Natural Gas[a]	Petroleum	Ethanol	Retail Electricity Sales	Total
Oregon	0	9.9	336.5	5.6	0.2	352.2
Share	0.0%	2.8%	95.5%	1.6%	0.1%	
United States	0	668.7	28,333.8	568.9	28.0	29,599.40
Share	0.0%	2.3%	95.7%	1.9%	0.1%	

Source: Energy Information Administration, U.S. Department of Energy (USDOE 2007b).

Note: Totals may not equal sum of components due to independent rounding. Does not include electrical system energy losses.

a Includes supplemental gaseous fuels. Transportation use of natural gas is gas consumed in the operation.

b Incurred in the generation, transmission, and distribution of electricity plus plant use and unaccounted for electrical system energy losses.

3.5 Existing 2005 Energy Demand

The study area for this FEIS consists of:

- **Macroscale**: a regional area including Washington, Clackamas, Multnomah, and Clark counties that captures travel demand and diverted vehicles along freeways, ramps, and primary and secondary arterials, and
- **Microscale**: a local area that includes a 12.2-mile segment of I-5 crossing the Columbia River between Vancouver and Portland that highlights the differences between the future alternatives, which is helpful during the decision-making processes.

Additional detail on the differences between the macroscale and microscale is provided in Section 2.2.2, above.

Exhibit 3-9 shows the existing 2005 energy use for the macroscale and microscale study areas.

Exhibit 3-9. Existing 2005 Energy Consumption and CO_2e Emissions

	2005 Existing				
Scale/Vehicle Type	Energy Consumed (mBtu)	Electricity Consumed (kWh)	Gasoline Consumed (gal)	Diesel Consumed (gal)	CO_2e Emissions (MT)
Macroscale-Private[a]					
All Vehicles	227,191	0	1,518,078	279,250	17,376
subtotal	*227,191*	*0*	*1,518,078*	*279,250*	*17,376*
Macroscale-Transit					
C-TRAN 40' Diesel	332	0	0	2,391	24
C-TRAN 40' Hybrid	0	0	0	0	0
C-TRAN 60' Articulated	0	0	0	0	0
TriMet 40' Diesel	2,241	0	0	16,159	163

	2005 Existing				
Scale/Vehicle Type	**Energy Consumed (mBtu)**	**Electricity Consumed (kWh)**	**Gasoline Consumed (gal)**	**Diesel Consumed (gal)**	**CO_2e Emissions (MT)**
Light Rail Transit	520	152,400	0	0	62
Bus Maintenance Facilities	147	43,220	0	0	19
LRT Maintenance Facilities	29	8,355	0	0	4
Park and Rides	3	887	0	0	0.382
subtotal	*3,272*	*204,861*	*0*	*18,550*	*272*
Total	**230,463**	**204,861**	**1,518,078**	**297,800**	**17,648**
Microscale-Private[b]					
Cars	2,876	0	23,201	0	220
Medium Trucks	86	0	695	0	7
Heavy Trucks	610	0	0	4,396	47
Total	**3,572**	**0**	**23,896**	**4,396**	**274**

mBtu = million British thermal units; kWh = kilowatt hour; gal = gallons; MT = metric ton

a The macroscale is region-wide (Washington, Clackamas, Multnomah, and Clark counties) and daily energy consumption and CO_2e emissions are reported.

b The microscale focuses on a 12.2-mile segment of I-5 and AM and PM peak period (8 hours) energy consumption and CO_2e emissions are reported.

Exhibit 3-9 indicates that the existing 2005 total daily energy demand for the four-county region is approximately 230,463 mBtu, which results in CO_2e emissions of approximately 17,648 metric tons (MT) of CO_2e. Of the region-wide GHG emissions, approximately 1.4 percent is attributed to transit operations.

Of the 230,463 mBtu and 17,648 MT CO_2e for the region, approximately 1.5 percent is the result of traffic operations during AM and PM peak periods along the 12.2-mile microscale corridor of I-5 between Vancouver and Portland.

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4. Long-term Effects

4.1 Introduction

The project's long-term effects on energy supply and demand relate to the operations of the affected transportation facilities. The facilities were analyzed with respect to transit and traffic (both private vehicles and freight trucks) operational use. Facilities affected by transit operations included all existing and future rights-of-way expected to be used by transit. Data associated with transit and traffic operations were provided by the CRC project team.

Long-term effects associated with CO_2e emissions depend on the amount of energy and fuel consumed during the operation of the facility.

4.2 How is this Section Organized?

The DEIS analysis presented the long-term effects of the project alternatives with respect to 1) the combination of system-level and segment-level choices expressed as the four "full" alternatives, 2) full alternatives versus alternatives with Minimum Operable Segments, and 3) discrete system-level choices.

The analyses and conclusions presented in the DEIS for all elements of the natural and built environments were used to select a package of system- and segment-level choices that now comprise the LPA, which was carried forward into this FEIS for additional analysis. The LPA has two variations that are analyzed in this FEIS; the LPA Full Build and LPA with highway phasing (see Section 1.2 for a detailed description). The long-term effects of the No-Build Alternative and LPA are described below.

This section of the report is comprised of two parts. The first part describes the change in operational energy consumed and CO_2e emissions between the No-Build and LPA alternatives. For these alternatives, the long-term effects are described at the macroscale and microscale levels of analysis to provide the most comprehensive and precise conclusions. The long-term effects are disseminated down to vehicle type, normalized to millions of British thermal units (mBtu), and converted to kilowatt hours (kWh) and gallons of fuel used for easier referencing. The amount of fuel consumed (i.e., electricity, gasoline, and diesel) was then used to estimate the amount of CO_2e emissions.

The second component provides a discussion and evaluation of two additional scenarios; the effects of collisions and the effects of bridge lifts. The effects of these additional scenarios have localized impacts and are presented only at the microscale since neither condition can be modeled at the macroscale.

4.3 Impacts from Full Alternatives

This section describes the operational (long-term) effects related to the No-Build Alternative and the LPA.

As detailed above in Section 1.2, there are four options to the LPA, including:

- **LPA Option A** – Full build of the LPA with vehicular access between Marine Drive and Hayden Island on an arterial bridge.
- **LPA Option B** – Full build of the LPA with vehicular access between Marine Drive and Hayden Island on collector-distributor lanes.
- **LPA Option A with highway phasing** – LPA with some deferred highway elements and vehicular access between Marine Drive and Hayden Island on an arterial bridge.
- **LPA Option B with highway phasing** – LPA with some deferred highway elements and vehicular access between Marine Drive and Hayden Island on collector-distributor lanes.

For the purposes of this report, there are no differences between LPA Options A and B (i.e., access between Marine Drive and Hayden Island) as a result of the scales of analysis. Hereafter, LPA Option A and LPA Option B are indistinguishable and are collectively referred to as "LPA Full Build." Similarly, LPA Option A with highway phasing and LPA Option B with highway phasing are collectively referred to as "LPA with highway phasing."

4.3.1 No-Build Alternative

Under the No-Build Alternative, the I-5 bridge crossing would remain as it is today and no major freeway capacity improvements were assumed. Increased transit service, both bus and light rail transit, was included. Additional detail on other planned projects within the greater study area that are separate from the CRC alternatives are described in the Traffic Technical Report (CRC Project Team 2010a). Exhibit 4-1 summarizes the macroscale (regional) and microscale (local) energy consumption and CO_2e emissions associated with the No-Build Alternative.

Exhibit 4-1. No-Build 2030 Energy Consumption and CO_2e Emissions

	2030 No-Build				
Scale/Vehicle Type	**Energy Consumed (mBtu)**	**Electricity Consumed (kWh)**	**Gasoline Consumed (gal)**	**Diesel Consumed (gal)**	**CO_2e Emissions (MT)**
Macroscale-Private[a]					
All Vehicles	321,993	0	2,117,430	423,144	24,491
subtotal	*321,993*	*0*	*2,117,430*	*423,144*	*24,491*
Macroscale-Transit[a]					
C-TRAN 40' Diesel	546	0	0	3,935	40
C-TRAN 40' Hybrid	32	0	0	232	2
C-TRAN 60' Articulated	34	0	0	244	2
TriMet 40' Diesel	3,325	0	0	23,977	241
Light Rail Transit	631	184,800	0	0	76
Bus Maintenance Facilities	147	43,220	0	0	19
LRT Maintenance Facilities	36	10,563	0	0	5
Park and Rides	3	887	0	0	0.382
subtotal	*4,754*	*239,469*	*0*	*28,388*	*385*
Total	**326,747**	**239,469**	**2,117,430**	**451,532**	**24,876**

Scale/Vehicle Type	2030 No-Build				
	Energy Consumed (mBtu)	Electricity Consumed (kWh)	Gasoline Consumed (gal)	Diesel Consumed (gal)	CO_2e Emissions (MT)
Microscale-Private[b]					
Cars	4,006	0	32,315	0	304
Medium Trucks	168	0	1,351	0	13
Heavy Trucks	933	0	0	6,728	72
Total	**5,107**	**0**	**33,666**	**6,728**	**389**

Note: These estimates do not include the energy required to construct the project. Energy consumed by the construction of the project is discussed in Section 5, Temporary Effects.

mBtu = million British thermal units; kWh = kilowatt hour; gal = gallons; MT = metric ton

a The macroscale is region-wide (Washington, Clackamas, Multnomah, and Clark counties) and daily energy consumption and CO_2e emissions are reported.

b The microscale focuses on a 12.2-mile segment of I-5 and AM and PM peak period (8 hours) energy consumption and CO_2e emissions are reported.

The traffic stream composition was obtained from the Metro travel demand model and is expected to be fairly similar between the existing and No-Build conditions (see Appendix A, Private Vehicle Operational Analysis). By 2030; however, the VMT is expected to increase roughly 41 percent region wide and 18 percent along the 12.2-mile segment of I-5.

As a result of increased travel demand and congestion, which reduces fuel efficiency, the No-Build energy consumption is expected to increase at the macroscale to 326,747 mBtu/day and the total CO_2e emissions are expected to increase to 24,876 MT of CO_2e/day. At the microscale, which is a 12.2-mile section of I-5 across the river crossing, the energy consumption and CO_2e emissions are expected to increase to 5,107 mBtu and 389 MT of CO_2e during the peak 8 hours of the day.

4.3.2 LPA Full Build

The primary differences between the LPA Full Build and the LPA with highway phasing are that the LPA with highway phasing would have:

- No north legs of the SR 500 interchange,
- No Victory Braid, and
- No Marine Drive fly-over.

Under the LPA Full Build, the first three items would be constructed. Additional detail on the differentiating characteristics is provided in Section 1.2. Exhibit 4-2 summarizes the macroscale (regional) and microscale (local) energy consumption and CO_2e emissions associated with the LPA Full Build.

Exhibit 4-2. LPA Full Build 2030 Energy Consumption and CO_2e Emissions

Scale/Vehicle Type	2030 LPA Full Build				
	Energy Consumed (mBtu)	Electricity Consumed (kWh)	Gasoline Consumed (gal)	Diesel Consumed (gal)	CO2e Emissions (MT)
Macroscale-Private[a]					
All Vehicles	320,218	0	2,074,444	449,364	24,361
subtotal	*320,218*	*0*	*2,074,444*	*449,364*	*24,361*

Scale/Vehicle Type	2030 LPA Full Build				
	Energy Consumed (mBtu)	Electricity Consumed (kWh)	Gasoline Consumed (gal)	Diesel Consumed (gal)	CO2e Emissions (MT)
Macroscale-Transit[a]					
C-TRAN 40' Diesel	510	0	0	3,674	37
C-TRAN 40' Hybrid	28	0	0	203	2
C-TRAN 60' Articulated	0	0	0	0	0
TriMet 40' Diesel	3,325	0	0	23,977	241
Light Rail Transit	667	195,600	0	0	80
Bus Maintenance Facilities	147	43,220	0	0	19
LRT Maintenance Facilities	39	11,291	0	0	5
Park and Rides	6	1,684	0	0	0.725
subtotal	*4,722*	*251,795*	*0*	*27,854*	*385*
Total	**324,940**	**251,795**	**2,074,444**	**477,218**	**24,746**
Microscale-Private[b]					
Cars	3,772	0	30,424	0	286
Medium Trucks	156	0	1,261	0	12
Heavy Trucks	945	0	0	6,815	73
Total	**4,825**	**0**	**31,328**	**6,786**	**368**

Note: These estimates do not include the energy required to construct the project. Energy consumed by the construction of the project is discussed in Section 5, Temporary Effects.

mBtu = million British thermal units; kWh = kilowatt hour; gal = gallons; MT = metric ton

a The macroscale is region-wide (Washington, Clackamas, Multnomah, and Clark counties) and daily energy consumption and CO_2e emissions are reported.

b The microscale focuses on a 12.2-mile segment of I-5 and AM and PM peak period (8 hours) energy consumption and CO_2e emissions are reported.

As shown in Exhibit 4-2, the LPA Full Build is expected to consume approximately 324,940 mBtu/day and emit 24,746 MT of CO_2e/day at the macroscale. For the microscale, the LPA Full Build would consume 4,825 mBtu and emit 368 MT of CO_2e during the 8-hour peak period (4 hours during the AM peak and 4 hours during the PM peak period).

As a result of these factors, the macroscale daily operational energy consumed is expected to decrease with the LPA Full Build by 1,807 mBtu and 130 MT CO_2e, or approximately 0.6 and 0.5 percent, respectively. While this is a relatively small rate of reduction, it is noteworthy given that it is the average reduction across the four-county region, much of which is not directly affected by the proposed project.

At the microscale, the project would provide a greater proportional effect, with a decrease in energy use and CO_2e emissions by approximately 282 mBtu and 21 MT CO_2e, or roughly 5.5 percent each.

4.3.3 LPA with Highway Phasing

Distinguishing characteristics between the LPA Full Build and LPA with highway phasing are summarized in Section 4.3.2 and detailed in Section 1.2, above. Exhibit 4-3 summarizes the macroscale (regional) and microscale (local) energy consumption and CO_2e emissions associated with the LPA with highway phasing Alternative.

Exhibit 4-3. LPA with Highway Phasing Energy Consumption and CO_2e Emissions

	2030 LPA with Highway Phasing				
Scale/Vehicle Type	**Energy Consumed (mBtu)**	**Electricity Consumed (kWh)**	**Gasoline Consumed (gal)**	**Diesel Consumed (gal)**	**CO2e Emissions (MT)**
Macroscale-Private[a]					
All Vehicles	320,218	0	2,074,444	449,364	24,361
subtotal	*320,218*	*0*	*2,074,444*	*449,364*	*24,361*
Macroscale-Transit[a]					
C-TRAN 40' Diesel	510	0	0	3,674	37
C-TRAN 40' Hybrid	28	0	0	203	2
C-TRAN 60' Articulated	0	0	0	0	0
TriMet 40' Diesel	3,325	0	0	23,977	241
Light Rail Transit	667	195,600	0	0	80
Bus Maintenance Facilities	*147*	*43,220*	*0*	*0*	*19*
LRT Maintenance Facilities	*39*	*11,291*	*0*	*0*	*5*
Park and Rides	*6*	*1,684*	*0*	*0*	*0.725*
subtotal	*4,722*	*251,795*	*0*	*27,854*	*385*
Total	**324,940**	**251,795**	**2,074,444**	**477,218**	**24,746**
Microscale-Private[b]					
Cars	3,728	0	30,071	0	283
Medium Trucks	157	0	1,266	0	12
Heavy Trucks	940	0	0	6,779	73
Total	**4,825**	**0**	**31,338**	**6,779**	**368**

Note: These estimates do not include the energy required to construct the project. Energy consumed by the construction of the project is discussed in Section 6, Temporary Effects.

mBtu = million British thermal units; kWh = kilowatt hour; gal = gallons; MT = metric ton

a The macroscale is region-wide (Washington, Clackamas, Multnomah, and Clark counties) and daily energy consumption and CO_2e emissions are reported.

b The microscale focuses on a 12.2-mile segment of I-5 and AM and PM peak period (8 hours) energy consumption and CO_2e emissions are reported.

Exhibit 4-3 shows that the macroscale energy consumption and CO_2e emissions would be 324,940 mBtu/day and 24,746 MT of CO_2e in the year 2030 for the LPA with highway phasing. At the macroscale, there are no distinguishing characteristics between the LPA Full Build and LPA with highway phasing, therefore, these energy and GHG emission estimates are the same. At the microscale, the energy consumption and CO_2e emissions are based on an 8-hour time period and are estimated to be 4,825 mBtu and 368 MT of CO_2e. While the energy consumed by each individual vehicle class (i.e., cars, medium trucks, and heavy trucks) varies slightly between the LPA Full Build and LPA with highway phasing, the total energy demand at the microscale is the same and, consequently, the GHG emissions are also the same.

4.3.4 Alternatives Comparison

The relative differences between the future alternatives measure the performance of each alternative and can be used during the decision-making process. Exhibit 4-4 summarizes the existing energy consumption and CO_2e emissions and provides a comparison to the future alternatives to identify the range of magnitude of increase. Exhibit 4-4 also illustrates the relative differences between the future alternatives.

Exhibit 4-4. Existing 2005 and Future 2030 Energy Consumption and CO_2e Emissions

Scale/Vehicle Type	Energy Consumed (mBtu) 2005 Existing	Energy Consumed (mBtu) 2030 No-Build	Energy Consumed (mBtu) 2030 LPA Full Build	Energy Consumed (mBtu) 2030 LPA w/ Highway Phasing	CO_2e Emissions (MT) 2005 Existing	CO_2e Emissions (MT) 2030 No-Build	CO_2e Emissions (MT) 2030 LPA Full Build	CO_2e Emissions (MT) 2030 LPA w/ Highway Phasing
Macroscale-Private[a]								
All Vehicles	227,191	321,993	320,218	320,218	17,376	24,491	24,361	24,361
subtotal	*227,191*	*321,993*	*320,218*	*320,218*	*17,376*	*24,491*	*24,361*	*24,361*
Macroscale-Transit								
C-TRAN 40' Diesel	332	546	510	510	24	40	37	37
C-TRAN 40' Hybrid	0	32	28	28	0	2	2	2
C-TRAN 60' Articulated	0	34	0	0	0	2	0	0
TriMet 40' Diesel	2,241	3,325	3,325	3,325	163	241	241	241
Light Rail Transit	520	631	667	667	62	76	80	80
Bus Maintenance Facilities	*147*	*147*	*147*	*147*	*19*	*19*	*19*	*19*
LRT Maintenance Facilities	*29*	*36*	*39*	*39*	*4*	*5*	*5*	*5*
Park and Rides	*3*	*3*	*6*	*6*	*0.382*	*0.382*	*0.725*	*0.725*
subtotal	*3,272*	*4,754*	*4,722*	*4,722*	*272*	*385*	*385*	*385*
Total	**230,463**	**326,747**	**324,940**	**324,940**	**17,648**	**24,876**	**24,746**	**24,746**
Microscale-Private [b]								
Cars	2,876	4,006	3,729	3,728	220	304	283	283
Medium Trucks	86	168	155	157	7	13	12	12
Heavy Trucks	610	933	941	940	47	72	73	73
Total	**3,572**	**5,107**	**4,825**	**4,825**	**274**	**389**	**368**	**368**

Note: These estimates do not include the energy required to construct the project. Energy consumed by the construction of the project is discussed in Section 6, Temporary Effects.

mBtu = million British thermal units; MT = metric ton

a The macroscale is region-wide (Washington, Clackamas, Multnomah, and Clark counties) and daily energy consumption and CO_2e emissions are reported.

b The microscale focuses on a 12.2-mile segment of I-5 and AM and PM peak period (8 hours) energy consumption and CO_2e emissions are reported.

As shown above, the amount of energy consumed and CO_2e emissions increase at both the macroscale (regional) and microscale (local) in the future compared to existing conditions. These increases are largely due to higher private and freight travel and transit service throughout the study area.

Relative to the No-Build Alternative, the LPA Full Build and LPA with highway phasing Alternatives decrease regional energy consumption by approximately 0.6 percent (1,807 mBtu/day) and CO_2e emissions by 0.5 percent (130 MT of CO_2e/day). The relative differences in local energy consumption and CO_2e emissions are more dramatic; 5.5 percent reduction in energy consumption (282 mBtu/peak period) and 5.5 percent for CO_2e emissions (21 MT of CO_2e/peak period). These regional and local reductions result from three primary reasons. First, the LPA Full Build and LPA with highway phasing include tolling the I-5 crossing, which is expected to decrease the number of cars crossing the river compared to the No-Build Alternative. Second, the LPA Full Build and LPA with highway phasing provide additional high-capacity transit (light rail), which is expected to divert a portion of private vehicular travel demand to transit. Third, the LPA Full Build and LPA with highway phasing decrease congestion along the 12.2-mile section of I-5 between Vancouver and Portland. This decrease in congestion equates to more fuel-efficient operating speeds that reduce energy consumption and CO_2e emissions.

Distinguishing characteristics between the LPA Full Build and LPA with highway phasing are summarized in Section 4.3.2 and detailed in Section 1.2, above. At the macroscale, these differences are not substantial enough to change traffic volumes and speeds in Metro’s regional travel demand model; therefore, the macroscale energy consumption and CO_2e emissions are the same. At the microscale, the energy consumption for each vehicle class would vary slightly, but the total energy consumption would be the same.

4.4 Additional Impact Considerations

The above estimates are based on travel demand modeling and traffic simulations that model the effect of improved operations of I-5, tolling the river crossing and adding the light rail extension to Clark College. In addition to these factors, there are other aspects of the proposed project that could affect operational energy consumption and CO_2e emissions – these include changes in highway safety (reduction in vehicle crashes) and the elimination of bridge lifts. Based on the recommendations from the GHG expert review panel and project staff, this section describes the effects of these two additional considerations.

These additional considerations cannot be readily incorporated into the above estimates of energy consumption and CO_2e emissions. They cannot be modeled at the macroscale, but they can be either qualitatively addressed (vehicle collisions) or quantitatively estimated (bridge lifts) at the microscale.

4.4.1 Long-term Effects of Collisions

According to the CRC Traffic Technical Report (CRC Project Team 2010a), the I-5 Bridge Influence Area experienced 2,051 collisions between January 1, 2002 and December 31, 2006, which represented the most recent, complete, and consecutive years of data at the time the analysis was conducted. This frequency of collisions equates to approximately 1.12 collisions per day and a collision rate that is more than double the average collision rate of similar facilities in Oregon.

The CRC Traffic Technical Report (CRC Project Team 2010a) provides a list of existing deficiencies in highway geometries. Under the No-Build Alternative, increased congestion would exacerbate existing safety concerns and the frequency of collisions would likely increase. An increase in the frequency of collisions also translates to slower operating speeds and increased energy consumption and CO_2e emissions.

Under either version of the LPA (Full Build or with highway phasing), the existing highway geometry deficiencies would be mitigated by adhering to current design standards, and the level of congestion would decrease, which would likely reduce the frequency of collisions. Reducing the frequency of collisions would also reduce energy consumption and CO_2e emissions compared to the No-Build Alternative.

It is difficult to quantify the effects of reducing collision frequencies associated with the LPA Full Build and LPA with highway phasing alternatives because of two primary reasons. First, there is no collision forecasting methodology accepted industry-wide and, therefore, the magnitude of change in collision frequency would be difficult to determine. Second, each collision possesses a distinct set of characteristics that make it unique, difficult to model, and not representative of typical conditions. For example, the location, lane, duration/clearance time, and time of day, are a few among many characteristics that would greatly affect how the mainline operates and the effects on energy consumption and CO_2e emissions.

Although we cannot quantify with accuracy, we can qualitatively conclude with certainty that the LPA Full Build and LPA with highway phasing would result in fewer collisions as a result of better operations and removal of existing design deficiencies compared to the No-Build Alternative and, in turn, the operational energy consumption and CO_2e emissions would also be reduced.

4.4.2 Long-term Effects of Bridge Lifts

The existing I-5 bridge between Vancouver and Portland has a relatively low vertical clearance and bridge lifts are required for some maritime traffic passage. Under the No-Build Alternative, the I-5 bridges would not be replaced and bridge lifts would continue to be required. Under the LPA Full Build and LPA with highway phasing, the I-5 bridges would be replaced with a higher vertical clearance and bridge lifts would no longer be necessary.

Unlike collisions, bridge lift occurrences are more predictable and the effects are easier to model and quantify. For example, bridge lifts are restricted during the PM peak period that was modeled for traffic operations and the duration of a bridge lift is also more uniform.

To quantify the effects of a bridge lift, a single bridge lift was assumed to occur between 9:00 AM and 9:15 AM and the estimated effects are summarized in Exhibit 4-4.

During a bridge lift, traffic operations are interrupted such that the energy consumed and CO_2e emitted would increase. The estimated magnitude of the increase is equivalent to about two percent of all the CO_2e emitted in the 12.2-mile stretch of I-5 during the eight hours of AM and PM peak period traffic. Given that a bridge lift similar to the modeled conditions occur approximately 20 to 30 times per month, it can be concluded that, in addition to the regional CO_2e emission reductions discussed in Section 4.3, the LPA Full Build and LPA with highway phasing alternatives would further reduce energy consumption and CO_2e emissions by these magnitudes on a daily basis.

Exhibit 4-5. Effects of Bridge Lifts on Energy Consumption and GHG Emissions

	2030 No-Build					2030 No-Build with Bridge Lift				
Scale/Vehicle Type	Energy Consumed (mBtu)	Electricity Consumed (kWh)	Gasoline Consumed (gal)	Diesel Consumed (gal)	CO_2e Emissions (MT)	Energy Consumed (mBtu)	Electricity Consumed (kWh)	Gasoline Consumed (gal)	Diesel Consumed (gal)	CO_2e Emissions (MT)
Microscale-Private[a]										
Cars	4,006	0	32,315	0	304	4,083	0	32,931	0	310
Medium Trucks	168	0	1,351	0	13	171	0	1,382	0	13
Heavy Trucks	933	0	0	6,728	72	950	0	0	6,848	74
Total	**5,107**	**0**	**33,666**	**6,728**	**389**	**5,204**	**0**	**34,312**	**6,848**	**397**

mBtu = million British thermal units; kWh = kilowatt hour; gal = gallons; MT = metric ton

a The microscale focuses on a 12.2-mile segment of I-5 and AM and PM peak period (8 hours) energy consumption and CO_2e emissions are reported.

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5. Temporary Effects

5.1 Introduction

The project's temporary effects on energy demand and CO_2e emissions are solely associated with the construction of the project rather than operation of the project. The energy consumed during construction is considered as a temporary effect because no additional energy would be required after the construction is complete (with the exception of the operations of the facility, which is covered in Section 4, Long-term Effects).

The energy use estimates for the construction of the project were based on construction cost estimates that have been refined since the time of the DEIS. While the construction dollar amount for the LPA is relatively similar to the cost estimates listed in the DEIS, the amount of energy consumed and GHG emissions has increased. This is because some work elements were previously aggregated and did not contain a level of detail that could be used in the energy and GHG emission calculations, but still had an estimated dollar amount. For example, the DEIS cost estimates provided a dollar amount for non-distributed construction costs as a whole, but additional detail on the actual construction activities were not available at that time and, accordingly, this portion of the cost estimate did not have any associated energy or GHG calculations. For the FEIS, conversely, the non-distributed construction costs were broken down into steel bridge improvements, stormwater treatment, utility relocation, etc. and energy and GHG emission calculations could now be estimated for the more specific construction activities. Despite the increase in energy consumption and GHG emissions, the relative difference between alternatives identified in the DEIS and its conclusions remain valid.

5.2 Impacts from Full Alternatives

The No-Build Alternative does not include construction of any project specific to addressing the needs and fulfilling the purpose of the CRC project. Accordingly, there are no definable temporary effects on energy consumption and GHG emissions associated with the No-Build Alternative.

While there is no construction proposed under the No-Build Alternative specific to this project per se, it is inaccurate to state that this alternative would not have any construction-related energy requirements or GHG emissions. For example, pot holes may need filling, the I-5 bridge deck would likely need to be resurfaced and striped, and additional local capacity improvements may be needed to alleviate congestion along the I-5 mainline. While improvements such as these would be likely under the No-Build Alternative, cost estimates are outside the purview of this analysis and therefore quantifiable energy consumption and GHG emissions cannot be calculated.

As described in Section 1.2, there are four primary differences between the LPA Full Build and LPA with highway phasing. Under the LPA with highway phasing, there would be:

- No north legs of the SR 500 interchange,
- No Victory Braid, and
- No Marine Drive fly-over.

Under the LPA Full Build, the first three items would be constructed. The temporary effects of the LPA Full Build and LPA with highway phasing alternatives on energy consumption and GHG emissions are summarized in Exhibit 5-1.

Exhibit 5-1. Temporary Effects on Energy Use and CO_2e Emissions Associated with the LPA

	LPA Full Build		LPA with Highway Phasing	
Alternative Construction Element	**Energy Consumed (mBtu)**	**CO_2e Emissions (MT)**	**Energy Consumed (mBtu)**	**CO_2e Emissions (MT)**
Project Cost (2009$)	**$2,748,885,746**		**$2,419,043,922**	
South Highway Approach	3,749,355	284,626	2,562,518	194,529
North Highway Approach	2,414,630	183,303	2,131,189	161,786
Columbia River Bridges	2,983,369	226,477	2,983,369	226,477
Transit	2,329,751	176,859	2,230,794	169,347
Total	**11,477,104**	**871,265**	**9,907,871**	**752,139**

Note:
mBtu = million British thermal units; MT = metric ton

As a result of the additional construction elements, the LPA Full Build would require approximately 14 percent more energy and result in roughly 14 percent more GHG emissions.

6. Mitigation

There are currently no quantitative restrictions on energy use and existing regulations lack quantifiable standards for assessing effects related to energy consumption and CO_2e emissions. Therefore, there are no specific mitigation measures required to reduce the project's long-term or temporary effects.

6.1 Long-term Effects

Operational energy consumption and CO_2e emissions are projected to increase by 2030 under all scenarios, build and No-Build. Both build alternatives include a variety of options that are expected to reduce private vehicle travel demand and improve the operations of the I-5 bridge crossings compared to No-Build.

Options that help the build alternatives reduce travel demand and improve operations relative to the No-Build Alternative include:

- Tolling the I-5 bridge crossing reduces auto trips,
- TDM/TSM measures reduce auto trips,
- Fast and reliable high-capacity transit reduces auto trips,
- Improved bike and pedestrian facilities and connections reduce auto trips, and
- Additional bridge crossing capacity reduces congestion which enables vehicles on the highway to run at more energy efficient speeds and with lower emissions.

Reducing the number of auto trips reduces the amount of operational energy consumed by vehicles and also reduces the amount of CO_2e emissions. Improving traffic congestion allows vehicles to operate at more fuel-efficient speeds that result in lower fuel consumption and CO_2e emissions.

Due to the reduction in travel demand and operational improvements, the LPA Full Build and LPA with highway phasing alternatives both result in lower operational energy consumption and GHG emissions and mitigation measures to reduce long-term effects is not required.

Mitigation is not required for either of the LPA Full Build or LPA with highway phasing alternatives; however, potential measures to reduce the CO_2e emissions could include:

- Planting trees and other vegetation.
- Creating, funding, and supporting programs that further encourage use of public transit.
- Providing additional access and connections for bicyclists and pedestrians, as well as other actions to promote walking and biking over driving.
- Supporting the use of zero- and low-emission vehicles by providing electric car recharge stations at park and ride facilities.

6.2 Temporary Effects

Energy used during construction and in the manufacture of construction materials would be irretrievable. However, fossil fuels are not in short supply at this time and their use would not have a substantially adverse effect on the continued availability of these resources.

There are currently no quantitative restrictions on energy use and existing regulations lack quantifiable standards for assessing effects related to energy consumption and CO_2e emissions. Therefore, there are no specific measures required to reduce the project's temporary effects. That said, the project is developing a Sustainability Strategy which could include measures intended to reduce energy consumption and CO_2e emissions during construction.

Other measures could be implemented to reduce the effects of the project. These measures would largely encompass conservation of construction materials and BMPs. Such BMPs could include:

- Construction materials reuse and recycling.
- Encouraging workers to carpool.
- Turning off equipment when not in use to reduce energy consumed during idling.
- Maintaining equipment in good working order to maximize fuel efficiency.
- As practical, routing truck traffic through areas where the number of stops and delay would be minimized, and using off-peak travel times to maximize fuel efficiency.
- As practical, scheduling construction activities during daytime hours or during summer months when daylight hours are the longest to minimize the need for artificial light.
- As practical, implementing emission-control technologies for construction equipment.
- As practical, using ultra low sulfur (for other non-CO_2e air quality purposes) and biodiesel in construction equipment.

7. Permits and Approvals

There are no specific federal, state, or local permits necessary with respect to energy use and CO_2e emissions. However, the project is subject to review under the applicable regulations described in Section 2.3, Effects Guidelines.

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