CHAPTER 4. GREENHOUSE GAS EMISSIONS

4.1 HOW WERE GREENHOUSE GAS EMISSIONS IN THE COMBINED STUDY AREA EVALUATED?

This chapter evaluates *greenhouse gas (GHG) emissions*, a component of air quality, at a programmatic level. GHG emissions are inventoried as part of GHG reduction efforts to minimize *climate change*. Unlike air pollutant emissions, which have local or regional effects, GHG emissions contribute to cumulative carbon dioxide (CO_2) concentrations on a global scale.

Because the Phase 1 Draft EIS is programmatic and is not a project-level analysis, it is not possible to quantify differences among alternatives with regard to GHG given the lack of detail about materials and sources that would be used. However, this chapter provides a qualitative comparison to indicate the likely range of impacts among the alternatives. This analysis is conducted in light of the fact that Washington State regulations (Revised Code of Washington Chapter 80.80) address GHG emissions from baseload electrical generation and direct utilities to consider both achievement of GHG emission limits and economic impacts to ratepayers.

The EIS Consultant Team used available data for carbon *sequestration* to estimate GHG contributions associated with vegetation removal during construction, and to compare how the loss of CO_2 absorption would relate to state and federal reporting thresholds for GHGs. Likewise, available data for lifecycle GHG emissions were used to estimate GHG contributions associated with traditional and non-wire technologies (such as demand response components included in Alternative 2) for electricity transmission.

Greenhouse Gas Emissions Key Findings

The primary differences among alternatives with regard to GHGs are the degree to which trees would need to be removed (resulting in a loss of carbon storage or *sequestration*) and the lifecycle GHG cost of materials from which the projects would be constructed.

Construction of new overhead lines that require new corridors and a larger amount of clearing (Alternative 1, Option A, and Alternative 3) could result in significant impacts. However, impacts could be mitigated to a less-than-significant level through engineering controls, purchase offsets, vegetation replacement, or offset acquisition.

Peak generation plants (Alternative 2, Option D) have the potential to generate operational GHG emissions, resulting in a moderate impact.

Continuous emissions from operation of stationary sources such as peak generation plants are qualitatively considered. It is not possible to quantify these emissions without specific data on the operational characteristics of such sources.

This chapter describes GHG emissions, carbon sequestration, and lifecycle emissions.

4.1.1 Greenhouse Gases Defined

Gases that trap heat in the atmosphere are referred to as greenhouse gases (GHGs) because, like a greenhouse, they capture heat radiated from the earth. The accumulation of GHGs has been identified as a driving force in global climate change. Definitions of climate change vary among regulatory authorities and the scientific community. In general, however, climate change can be described as the changing of the earth's climate caused by natural fluctuations and human activities that alter the composition of the global atmosphere.

The principal GHGs of concern include the following:

- Carbon dioxide (CO_2);
- Methane (CH_4);
- Nitrous oxide (N_2O);
- Sulfur hexafluoride (SF_6);
- Perfluorocarbons (PFCs); and
- Hydrofluorocarbons (HFCs).

Conventionally, GHGs have been reported as CO_2 equivalents (CO_2e). CO_2e takes into account the relative potency of GHGs other than CO_2 and converts their quantities to an equivalent amount of CO_2.

Electric utilities, including PSE, often use SF_6 in electric equipment at substations, because of its effectiveness as an insulating gas.

Each of the principal GHGs has a long atmospheric lifetime, existing in the atmosphere for one year to several thousand years. In addition, the potential heat-trapping ability of each of these gases varies significantly. For example, CH_4 is 28 times as potent as CO_2 at trapping heat, while SF_6 is 23,500 times more potent than CO_2 (IPCC, 2013). The ability of these gases to trap heat is called global warming potential (GWP).

In emissions inventories, GHG emissions are typically reported in terms of metric tons of CO_2 equivalents (CO_2e). CO_2e are calculated as the product of the mass emitted of a given GHG and its specific GWP. While CH_4 and N_2O have much higher GWPs than CO_2, CO_2 is emitted in such vastly higher quantities that it accounts for the majority of GHG emissions in CO_2e, both from residential developments and human activity in general.

The primary human activities that release GHGs include combustion of *fossil fuels* for transportation, heating, and electricity; agricultural practices that release CH_4, such as livestock production and decomposition of crop residue; and industrial processes that release smaller amounts of gases with high global warming potential such as SF_6, PFCs, and HFCs. Deforestation and land cover conversion have also been identified as contributing to global warming by reducing the earth's capacity to remove CO_2 from the air and altering the earth's albedo (surface reflectance), thus allowing more solar radiation to be absorbed.

4.1.2 Carbon Sequestration

Terrestrial carbon sequestration is the process in which atmospheric CO_2 is taken up into plants or soil and subsequently "trapped." Terrestrial sequestration can occur through planting trees, restoring wetlands, land management, and forest fire management. This analysis focuses on the terrestrial sequestration associated specifically with trees and shrubs, as related to the proposed project.

> A **carbon sink** is a natural environment that absorbs more CO_2 than it releases.

Trees and shrubs act as both *carbon sinks* and carbon sources. Vegetation can act as a carbon sink by absorbing CO_2 from the atmosphere, releasing oxygen through photosynthesis, and retaining the carbon within the vegetation. Trees also act as a carbon source when they are dying and decomposing; the carbon that was stored in the trees is released and reacts with oxygen in the air to form CO_2. Younger trees that are growing rapidly can store more carbon in their leaves than older trees. However, the total amount of carbon sequestered annually by healthy, large trees is greater than younger trees because the greater number of leaves compensates for the lower productivity of larger trees (USDA, 2011; N.L. Stephenson et al., 2014).

Trees suffering from disease will slow and eventually arrest the process of photosynthesis, thus limiting the ability of the affected tree to act as a carbon sink. Therefore, maintaining healthy trees keeps carbon stored in trees; however, some landscape maintenance activities result in GHG emissions (USDA, 2011). For example, water use, fertilizer use, exhaust from gas- and diesel-powered landscape equipment, and vehicle trips for maintenance crews result in CO_2 emissions.

4.1.3 Lifecycle Emissions

Although there is no regulatory definition for *lifecycle emissions*, the term is generally used to refer to all emissions associated with the creation and existence of a project, including emissions from the manufacture and transportation of component materials, and even from the manufacture of the machines required to produce those materials. However, since it is impossible to accurately estimate the entire chain of emissions associated with any given project, lifecycle analyses have limited effectiveness in assessing emissions for this SEPA analysis.

The federal Council on Environmental Quality (CEQ) has updated its *Draft Guidance for Greenhouse Gas Emissions and Climate Change Impacts,* which makes no reference to lifecycle emissions (CEQ, 2014). CEQ recommends that agencies rely on basic National Environmental Policy Act (NEPA) principles and consider all reasonably foreseeable effects that may result from proposed actions, using reasonable temporal and spatial parameters, rather than engaging in analyses that focus on speculative emissions (CEQ, 2014).

However, the CEQ recognizes that proposed land and resource management actions evaluated under NEPA can result in both carbon emissions and carbon sequestration. Agencies should compare net GHG emissions and changes in sequestered carbon that are relevant in light of the proposed actions and timeframes under consideration. Agencies have substantial experience estimating GHG emissions and sequestration, and numerous tools and methods are available. CEQ encourages agencies to use quantitative tools when it would be useful for informing decision-makers and the public. When a quantitative analysis would not be useful, a qualitative analysis should be completed, and an agency should explain its basis for doing so.

4.2 WHAT ARE THE RELEVANT PLANS, POLICIES, AND REGULATIONS?

Air quality in the Puget Sound region is regulated and enforced by federal and state agencies—the U.S. Environmental Protection Agency (EPA) and Washington State Department of Ecology (Ecology). Several local study area communities have plans or policies addressing GHG emissions. King County provides overarching guidance policy for the region on GHGs and climate change through implementation of its Strategic Climate Action Plan, discussed below.

4.2.1 U.S. Environmental Protection Agency

The EPA is the federal agency responsible for implementing the Clean Air Act (CAA). The U.S. Supreme Court ruled on April 2, 2007, that CO_2 is an air pollutant as defined under the CAA, and that the EPA has the authority to regulate emissions of GHGs.

On December 9, 2009, the EPA Administrator signed two distinct findings regarding GHGs under Section 202(a) of the CAA, which states that the EPA Administrator should regulate and develop standards for "emission[s] of air pollution from any class or classes of new motor vehicles or new motor vehicle engines, which in [its] judgment cause, or contribute to, air pollution which may reasonably be anticipated to endanger public health or welfare." The final rule was effective January 14, 2010. The rule addresses two distinct findings: Endangerment Finding and Cause or Contribute Finding.

Under the Endangerment Finding, the Administrator found that the current and projected concentrations of the six key GHGs (CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6) in the atmosphere threaten the public health and welfare of current and future generations. Under the Cause or Contribute Finding, the Administrator found that the combined emissions of these GHGs from new motor vehicles and new motor vehicle engines contribute to GHG pollution, which threatens public health and welfare.

4.2.2 Washington State Department of Ecology

At the state level, in December 2010, Ecology adopted Chapter 173-441 Washington Administrative Code – Reporting of Emissions of Greenhouse Gases. This rule institutes mandatory GHG reporting for the following:

- Facilities that emit at least 10,000 metric tons of GHGs per year in Washington; or
- Suppliers of liquid motor vehicle fuel, special fuel, or aircraft fuel that supply products equivalent to at least 10,000 metric tons of CO_2 per year in Washington.

In 2007, voters in Washington passed Initiative 937, the Energy Independence Act. The Energy Independence Act requires electric utilities in Washington, serving at least 25,000 retail customers, to use renewable energy and energy conservation in serving those customers. There are 17 utilities which qualify under the Act, including Puget Sound Energy, which provide 81 percent of the electricity sold to retail customers in Washington State.

4.2.3 King County

Regionally, King County recently released its 2015 Strategic Climate Action Plan (SCAP), which is a comprehensive update to the 2012 SCAP (King County, 2015). The SCAP is King County's blueprint for climate action. It provides a resource for county decision-makers, employees, and the general public to learn about the County's climate change commitments. King County has committed to reduce countywide sources of GHG emissions, compared to a 2007 baseline, by 25 percent by 2020, 50 percent by 2030, and 80 percent by 2050 (King County, 2015).

4.2.4 City Governments

Of the 12 cities in the combined study area, 8 have signed the *U.S. Conference of Mayors Climate Protection Agreement*[1], which promotes participation of U.S. cities in the goals of the *Kyoto Protocol* (U.S. Conference of Mayors, 2007). Most of these cities have integrated GHG reduction goals into their comprehensive plans, and/or a specific climate plan, which identify and develop targets, strategies, policies, and regulations to limit the community's impact on climate change.

The Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climate Change, which commits its Parties by setting internationally binding emission reduction targets. The Protocol places a heavier burden on developed nations and was adopted in Kyoto, Japan, on December 11, 1997, and entered into force on February 16, 2005. The United States never ratified the protocol.

Signatories of the U.S. Conference of Mayors Climate Protection Agreement seek to reduce GHG emissions by 7 percent from 1990 levels. This has resulted in the creation of climate action plans at the municipal level that inventory baseline GHG emissions and suggest improvements in government operations and throughout the community that can assist the cities with meeting their reduction goals.

More recently, King County implemented the King County-Cities Climate Collaboration (K4C). King County and 11 cities (Bellevue, Burien, Issaquah, Kirkland, Mercer Island, Redmond, Renton, Seattle, Shoreline, Snoqualmie, and Tukwila), representing 75 percent of the county's population base, have partnered to coordinate and enhance the effectiveness of local government climate and sustainability actions. There are three shared K4C commitments that parallel the Conference of Mayors.

1. Collaborating through the Growth Management Planning Council, Sound Cities Association, and other partners to adopt countywide GHG emissions reduction targets, including mid-term milestones needed to support long-term reduction goals;

2. Building on King County's commitment to measure and report on countywide GHG emissions by sharing this data between cities and partners, establishing a public dashboard for tracking progress, and using the information to inform regional climate action; and

[1] Cities include Bellevue, Clyde Hill, Issaquah, Kirkland, Redmond, Renton, Sammamish, and Yarrow Point.

3. Developing and adopting near-term and long-term government operational GHG reduction targets that support countywide goals, and implementing actions to reduce each local government's GHG footprint.

4.2.4.1 City of Bellevue

The City of Bellevue formally joined K4C in August 2014 and has taken action on all of the three shared K4 commitments to date. The City's climate actions to date include the following:

1. In 2007 Bellevue joined over 1,000 cities nationwide in signing the Mayors' Climate Protection Agreement, establishing a target to reduce communitywide and municipal emissions to 7 percent below 1990 emissions by 2012. Bellevue did not reach this goal.

2. Bellevue formally completed an emissions inventory for the interim years 2006 and 2011, and established a baseline for 2001.

3. Bellevue Department Directors agreed to a renewal of the Environmental Stewardship Initiative Strategic Plan (2013 - 2018).

4. Since 2012, Bellevue has measured GHG emissions on a public dashboard (called Scope 5) that uses transparent emission factors and could be used to report to the Climate Disclosure Project if desired with some additional resources.

5. In July 2014 Bellevue and other cities adopted GHG emission reduction targets of 25 percent by 2020, 50 percent by 2030, and 80 percent by 2050, compared to a 2007 baseline.

6. In November 2014 Bellevue entered into a community energy reduction campaign, the Georgetown University Energy Prize (GUEP), which awards a $5 million prize to the small or medium sized U.S. city that can save the most residential and municipal energy over a two year period. The Community Energy Efficiency Plan is guiding Bellevue's energy reduction efforts.

Additionally, the City of Bellevue addresses climate change and GHG emissions reductions by promoting resources available to residents through PSE (City of Bellevue, 2015). In addition, the City implemented "Solarize Bellevue," a campaign to reduce the cost of solar electricity for Bellevue residents and businesses. The City has also pursued the following six natural resource conservation projects:

- Electric vehicle charging stations;
- Replacement of 90 gas vehicles in the City fleet with hybrids;
- Traffic demand management services for Bellevue businesses and residents;
- Retrofit of lighting fixtures at recreation facilities;

- Home energy reports for residents, in partnership with PSE and the C-7 New Energy Partnership;[2] and
- Sustainability web portal, an information and education tool.

4.2.4.2 City of Kirkland

The City of Kirkland addresses climate change and GHG emissions primarily by reducing emissions associated with government operations. Similar to Bellevue, the City of Kirkland also purchases green power from PSE for "a substantial percentage of its operations" and encourages its residents to do the same in partnership with PSE and the C-7 New Energy Partnership. The City also has a similar "Solarize Kirkland" program. The City recycles food waste, uses paper products with recycled content, and created a commute trip reduction program to meet GHG reduction goals.

4.2.4.3 City of Redmond

The City of Redmond ratified a climate action implementation plan in September 2014. The plan addresses climate change by reducing GHG emissions associated with transportation, heating or cooling buildings, reducing waste production, restoring natural resources, and educating the public about climate change and encouraging actions that reduce impacts on the environment. The plan suggests that comprehensive inventories and assessments of GHG emissions associated with government operations as well as emissions associated with the community are to be conducted (City of Redmond, 2013). GHG inventories were collected from 2008 through 2011 for different City operations and sectors of the community as a whole.

4.2.4.4 City of Renton

The City of Renton completed a GHG inventory in 2011. The City proposes the following actions to achieve the Mayors Climate Protection Agreement target (City of Renton, 2011)

- Conducting energy audits on all City buildings;
- Implementing energy efficiency management and performance monitoring systems;
- Targeting efficiency upgrades on energy-intensive buildings;
- Installing motion sensor-controlled lighting in all municipal building spaces;
- Decreasing the amount of water that needs to be treated (such as through low impact development techniques);
- Minimizing water demand through conservation measures;
- Increasing the efficiency of equipment to treat, store, and transport water;
- Purchasing the most fuel-efficient City vehicles; and

[2] In 2010, seven cities in King County, Washington — known as the C-7 New Energy Partnership — joined with PSE and energy management software company OPOWER to help nearly 100,000 residents reduce their home energy consumption. The C-7 New Energy Partnership includes the Cities of Bellevue, Issaquah, Kirkland, Mercer Island, Redmond, Renton and Sammamish.

- Creating policies for employees to limit idling and use the most fuel-efficient vehicles whenever possible.

Since 2011, the City has not updated its GHG inventory.

4.2.4.5 City of Sammamish

In 2011, the City of Sammamish published a sustainability strategy that suggested that reductions in GHG emissions could be achieved through the following:

- Reducing City energy use to 3 percent below 2007 consumption rates by 2012, in alignment with the U.S. Conference of Mayors Climate Protection Agreement;[3]
- Investigating municipal purchase of green power from *PSE's Green Power program* by applying savings from energy conservation to purchasing green power;
- Increasing use of transportation alternatives to single-occupancy and/or fossil-fueled vehicles for City staff commutes and work-related travel, and promoting use of transportation alternatives by the public;
- Reducing energy used by non-City building operations, including residential dwellings, businesses and industry; and

Since 2011, the City has not updated its GHG inventory.

4.2.5 Puget Sound Energy

In its Greenhouse Gas Policy Statement (2015), PSE identifies the following specific, near-term strategies that it continues to pursue:

1. Ongoing development and investment in PSE's customer energy efficiency program;
2. Pursuit of a diverse energy portfolio mix of resources including renewable generation that will lower PSE's GHG emissions consistent with least-cost planning principles;
3. Customer or community-based generation of renewable energy;
4. Opportunities to reduce GHG emissions with partners in the utility industry, local communities, and state and national governments;
5. Ongoing development and investment in PSE's green fleet and low emission vehicle programs;
6. Customer choice through the Green Power and Carbon Balance programs to reduce their carbon footprint while supporting local projects;
7. Transparency with PSE's GHG emissions footprint reporting; and
8. Coordination with customers to help them minimize their GHG emissions footprint.

---

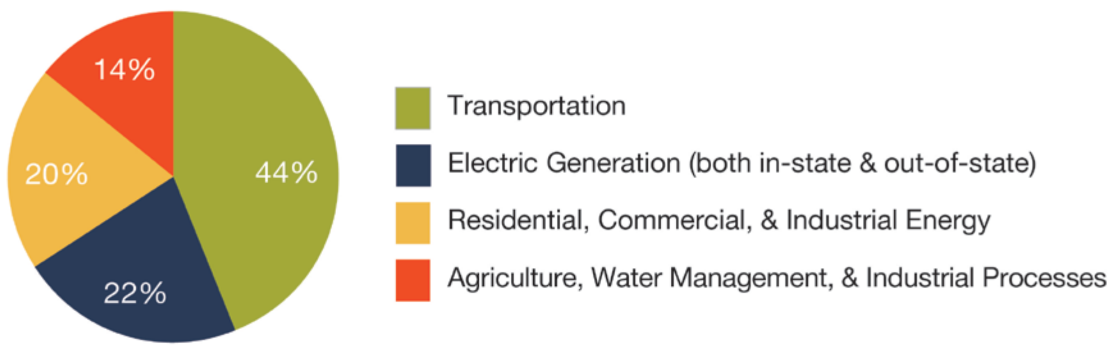
[3] The City of Sammamish is a signatory of the U.S. Conference of Mayors Climate Protection Agreement, which calls for reducing emissions by 7 percent less than 1990 levels by 2012. Because the City was not incorporated until 2000, this objective calls for reducing emissions by 3 percent of 2005 emissions levels (City of Sammamish, 2013).

The most recent (2014) inventory of PSE emissions indicates that emissions from all sources totaled approximately 14.4 million metric tons of CO_2; 2,980 metric tons of CH_4; 161 metric tons of N_2O; and 0.58 metric tons of SF_6. Most of the CO_2 emissions were from generated and purchased electricity (71.1 percent), while the remaining emissions were from natural gas supply to end users (28.9 percent). For CH_4, the majority of emissions were fugitive from natural gas operations (79.2 percent). Generated and purchased electricity also accounted for all N_2O emissions and all SF_6 emissions.

4.3 WHAT IS THE STATUS OF GREENHOUSE GAS EMISSIONS IN THE COMBINED STUDY AREA?

Ecology estimated that in 2010, Washington produced about 96 million gross metric tons (about 106 million U.S. tons) of CO_2e (Adelsman, 2014). Sources of GHG emissions in the state are shown in Figure 4-1.

Figure 4-1. Sources of GHG Emissions in Washington State



King County last inventoried countywide GHG emissions for the year 2012. Community consumption-based emissions (which include some lifecycle emissions associated with food consumption within the county but grown elsewhere) totaled 55 million metric tons of CO_2e (King County, 2015).

The City of Bellevue updates its GHG inventory yearly. Emissions remained virtually equal to 2007 levels across the whole community in 2012. As of 2013, municipal emissions from City operations were reduced 21 percent compared to 2007. The City has not reached its Mayors Climate Protection Agreement target (Resolution 7517) to reduce emissions to 7 percent below 1990 levels by 2012 (City of Bellevue, 2015).

In 2009, the Renton community generated an estimated 1,216,300 metric tons of CO_2e. Transportation contributed the largest share of these GHG emissions (49 percent), followed by commercial (21 percent) and residential (20 percent). Solid waste accounted for a small portion (0.3 percent) of total community GHG emissions. It is unknown whether the City achieved the goals in the Mayors Climate Protection Agreement.

The City of Kirkland updates its GHG inventory for government operations annually and those associated with the city as a whole every 3 years. A community inventory is not available at this time (City of Kirkland, 2013). As of 2012, municipal emissions from City operations were reduced 10 percent compared to 2005; however, the City has not reached its Mayors Climate Protection Agreement target (Resolution 7517) to reduce emissions to 7 percent below 1990 levels by 2012.

None of the other cities in the combined study area have publicly available GHG inventory estimates.

The Climate Registry is a nonprofit collaboration between North American states, provinces, territories, and Native Sovereign Nations to record and track the greenhouse gas emissions of businesses, municipalities and other organizations. The Climate Registry's Board of Directors is made up of 31 states of the USA, 13 provinces/territories of Canada, six states of Mexico, and three Native Sovereign Nations.[1] The data is to be independently verified to ensure accuracy, however participation by organizations is voluntary.

4.4 HOW WERE POTENTIAL IMPACTS TO GREENHOUSE GAS EMISSIONS ASSESSED?

The potential loss of carbon sequestration from tree removal is based on sequestration rates of the Climate Registry. This analysis compares the associated change in GHG emissions for each alternative to the State of Washington GHG reporting thresholds. A qualitative discussion of lifecycle emissions associated with each project alternative is also included. Lifecycle GHG emissions are roughly estimated based on publically available research data. Emissions from the operation of construction equipment are also qualitatively discussed relative to each of the other project alternatives.

4.5 WHAT ARE THE LIKELY CONSTRUCTION IMPACTS RELATED TO GREENHOUSE GAS EMISSIONS?

4.5.1 Construction Impacts Considered

The alternatives could generate GHG emissions from the operation of vehicles and equipment (off-road equipment, vendor and hauling truck trips, and construction worker trips), lifecycle emissions from construction materials (e.g., GHGs generated at the batch plant during production of concrete used in foundations or street work), and from release of sequestered GHGs as a result of tree removal. While vegetation could be replanted in cleared *transmission* alignment corridors, replanting was not included in the assessment of sequestration impacts in order to provide a worst-case estimate. Additionally, construction materials would have lifecycle emissions associated with their procurement. Project-related GHG emissions from construction would be temporary and would not represent a continuing burden on the statewide inventory. Both GHG emissions from construction equipment and lifecycle emissions are somewhat speculative at the programmatic level so a general qualitative comparison among the alternatives and options is provided.

This chapter conservatively quantifies and assesses impacts from losses of carbon sequestration according to the following criteria:

Minor – Project would result in construction-related GHG emissions below the State of Washington reporting threshold[4] of 10,000 metric tons.

Moderate – If the project would result in construction-related GHG emissions at or above the State of Washington reporting threshold of 10,000 metric tons in a given year but would implement best management practices[5] to reduce GHG emissions.

Significant – If the project would result in construction-related GHG emissions at or above the State of Washington reporting threshold of 10,000 metric tons in a given year and would not implement best management practices to reduce GHG emissions, or would result in construction-related GHG emissions at or above 25,000 metric tons in a given year even if BMPs are implemented.

4.5.2 No Action Alternative

The No Action Alternative would not result in construction activities or changes to maintenance activities. While conductor replacement could occur under the No Action Alternative, GHG emissions associated with truck operations and fabrication of new conductors would be negligible. Similarly, there would be no change in energy efficiency improvements implemented to achieve PSE's conservation goals, which involves a negligible amount of construction.

4.5.3 Alternative 1: New Substation and 230 kV Transmission Lines

Construction impacts are discussed below for each transmission line option. Construction of the substation would be the same under each option and occur simultaneously. Therefore, substation construction is considered as part of each option.

4.5.3.1 Option A: New Overhead Transmission Lines

4.5.3.1.1 GHG Emissions from Construction Vehicles and Equipment

Construction truck trips, off-road equipment, and worker trips would generate GHG emissions. The equipment likely to be used for construction under Alternative 1, Option A is presented in Appendix B. Most of this equipment would operate on diesel fuel which has an emission factor of 10.15 kilograms of CO_2 per gallon.

Of all the options under Alternative 1, Option A would potentially have the shortest construction period (approximately 12 to 18 months). Installing transformers under Option A would be performed concurrently with the transmission line and poles. Consequently, although Option A would involve a relatively large amount of construction equipment as

[4] In practice, the reporting threshold applies to emissions from a facility and not to temporary construction activities. However it is being applied in this EIS to assessment of construction impacts as a tool for determining relative significance.

[5] Best management practices to minimize GHG emissions could take the form of a number of measures, depending on whether it is a construction-related emission or an operational emission source.

indicated in Appendix B, its relatively short duration would result in lower direct construction GHG emissions than those associated with Option C, and emissions would likely be similar to Options B and D.

4.5.3.1.2 Lifecycle GHGs

The primary material resources required for Alternative 1, Option A are concrete for pier and transformer foundations, steel or laminated wood poles for towers, and conductors. Of these materials, concrete is likely the most GHG-intensive to produce. Production of 1 cubic meter of concrete generates approximately 101 kilograms (222 pounds) of CO_2 (Kjellsen et al., 2005) which accounts for cement production, aggregate production, water, and transport. With an alignment of approximately 18 miles and a typical spacing between poles of 1,000 feet, approximately 100 pole foundations would need to be installed. Assuming caisson foundations 35 feet deep and 6 feet in diameter, each foundation would require approximately 6 cubic meters of concrete, yielding a minimum GHG estimate for all towers of 60.6 metric tons of CO_2. This value is a rough estimate for comparative purposes only and is not intended for use as a component of a GHG emission inventory.

4.5.3.1.3 Loss of Sequestered CO_2 (Tree Removal)

Removal of existing vegetation would result in the loss of sequestered (stored) CO_2 as well as the loss of continued sequestration in the future by this vegetation. If a new corridor is used, there would be more intensive vegetation removal than other options. The amount of sequestered CO_2 per unit area (expressed as metric tons of CO_2 per acre) depends on the specific vegetation type. Table 4-1 presents CO_2 sequestration values from the California Climate Action Registry (now known as the Climate Action Registry).[6] As shown in the table, trees can sequester the largest amount of CO_2 per acre compared to other types of vegetation.

Table 4-1. CO_2 Sequestration by Vegetation Type

Land Use	Sub-Category	CO_2 Sequestration (metric tons CO_2/ acre)
Forest Land	Scrub	14.3
	Trees	111
Cropland	--	6.20
Grassland	--	4.31

Source: CAPCOA, 2013

Using an existing 115 kV corridor for Alternative 1, Option A could require up to an additional 50 feet of lateral clearing along the length of the alignment. This would result in removal of up to 44 acres of forested land under a worst-case scenario which could result in up to 4,900 metric tons of CO_2 sequestration losses (loss of active CO_2 intake by trees acting

[6] Data from the CAR Forest Protocol and Urban Forest Research Tree Carbon Calculator are not used since their main focus is annual emissions for carbon offset considerations. As such they are designed to work with very specific details of the vegetation that are not available at a SEPA level of analysis.

as a carbon sink). This would not exceed the state's GHG reporting threshold and would be a minor impact with respect to GHG emissions.

Assuming a new right-of-way alignment of approximately 18 miles and a maximum 150-foot-wide clear zone under a worst-case scenario, up to 327 acres could be cleared under Option A if the corridor had 100% tree coverage. Because most likely corridors include existing rights of way or other utility corridors, an average tree coverage of 40 percent throughout the project alignment was considered a conservative assumption (see Chapter 6). With this assumption a worst-case estimate of up to approximately 131 acres of forested land could be removed under Option A, which could result in up to 14,500 metric tons of CO_2 sequestration losses (loss of active CO_2 intake by trees acting as a carbon sink). This estimate exceeds that of Alternative 1, Option C (Underground Transmission Lines), below, due to the substantially wider corridor needed for overhead lines. This impact would exceed the state's GHG reporting threshold and, without best management practices or mitigation, it would be a significant adverse impact with respect to GHG emissions. Installation of the new transformer at a new or expanded substation would be unlikely to meaningfully contribute to further loss of CO_2 sequestration. It should be noted that, unlike Option C, trees could be replanted along the corridor under Option A after construction of the utility lines.

4.5.3.2 Option B: Existing Seattle City Light 230 kV Transmission Corridor

4.5.3.2.1 GHG Emissions from Construction Vehicles and Equipment and Lifecycle GHGs

Alternative 1, Option B would require a complete rebuild of the Seattle City Light lines, including replacing most of the existing structures. However, some of the existing structures may be adequate and not require replacement, thus reducing the amount of construction equipment and materials needed. Construction duration would be somewhat longer than Option A: up to 24 months for overhead lines with concurrent substation construction. Construction-related GHG impacts would likely be somewhat higher than those described above for Option A.

4.5.3.2.2 Loss of Sequestered CO_2 (Tree Removal)

While Alternative 1, Option B could require a complete rebuild of the Seattle City Light lines, including replacing most of the existing structure, the land for these structures within the SCL right-of-way would already have largely been cleared. Therefore, the impacts from loss of sequestration described for Option A would not occur, or would be substantially less. However, this option would require a segment of new transmission to connect the SCL line to the Lakeside substation. The exact length of that alignment is not known, but the proximity of the Lakeside substation to the line suggests it would be approximately 1 mile or less, meaning the impact would be approximately 800 metric tons of CO_2 sequestration losses. This would be a minor impact with respect to GHG emissions.

4.5.3.3 Option C: Underground Transmission Lines

4.5.3.3.1 GHG Emissions from Construction Vehicles and Equipment

The equipment involved for construction under Alternative 1, Option C is presented in Appendix B. Most of this equipment would operate on diesel fuel which has an emission factor of 10.15 kilograms of CO_2 per gallon.

Of all the options under Alterative 1, underground transmission line construction would have the longest construction period (approximately 28 to 36 months). Construction for the transformer installations under Option C would be performed concurrently with the transmission line. Additionally, excavation and removal of soils throughout the construction route would require many more truck trips than the other options. Consequently, direct construction-related GHG emissions of Option C would be the greatest of all the options.

4.5.3.3.2 Lifecycle GHGs

The primary material required for Alternative 1, Option C would be concrete to construct an outermost barrier in the excavated trench and for access vaults. With an alignment corridor length of 18 miles and assuming a trench width of 5 feet, and a concrete layer of 3 feet encasing the lines, approximately 40,400 cubic meters of concrete would be required, yielding approximately 4,080 metric tons of CO_2. This value is a rough estimate to be used for comparative purposes only, not as a component of a GHG emission inventory.

4.5.3.3.3 Loss of Sequestered CO_2 (Tree Removal)

With an alignment corridor length of 18 miles and a cleared work area of 30 feet for a new corridor under a worst-case scenario, Alternative 1, Option C could require a clearance area up to 66 acres in total, assuming tree coverage of 40 percent throughout the project alignment. The reduced width of the cleared work area compared with Option A results in a relatively lower loss of sequestered CO_2. Conservatively assuming that lost sequestration would entirely be in the form of forestland (trees), Option C could result in over 7,300 metric tons of lost CO_2 sequestration. This projected loss would not exceed the State's GHG reporting threshold and would be considered a minor impact with respect to GHG emissions. However, unlike Option A, replacement trees could not be planted in the corridor after construction due to the buried utilities. If an existing utility or roadway corridor were used, there may be no clearing necessary and thus no CO_2 sequestration losses, although there could be some losses of street trees. It is also possible that only a portion of the line would be placed underground, and the rest would be as described for Option A or B. On a per mile basis, Option B would have less CO_2 sequestration losses than Option A, while use of the SCL corridor under Option B would have lower CO_2 sequestration losses than Option C.

4.5.3.4 Option D: Underwater Transmission Lines

4.5.3.4.1 GHG Emissions from Construction Vehicles and Equipment

The types of construction equipment likely to be needed under Alternative 1, Option D are presented in Appendix B. Most of this equipment would operate on diesel fuel which has an emission factor of 10.15 kilograms of CO_2 per gallon. Installing underwater transmission lines would have the shortest construction period of approximately 8 months. Consequently, although Option D would involve a relatively large amount of construction equipment as indicated in Appendix B, its relatively short duration would result in direct construction GHG emissions less than those associated with Option A, Option B or Option C.

4.5.3.4.2 Lifecycle GHGs

The primary material required for Alternative 1, Option D would be concrete for cable landings and for foundations of any poles needed for transition to on-land transmission. There would be two cable landing points requiring a modest amount of concrete for the landing vaults. An estimate of concrete volume is speculative at this programmatic review, but Option D is likely to have the lowest lifecycle emissions of the four Alternative 1 options or any of the other alternatives.

4.5.3.4.3 Loss of Sequestered CO_2 (Tree Removal)

East-west connections to Talbot Hill or Lakeside substation and to Sammamish substation necessary under Alternative 1, Option D would require vegetation removal and associated loss of sequestration impacts. Assuming new right-of-way would be necessary for all three connections, with a combined alignment of approximately 7.8 miles and a maximum 150-foot-wide clear zone (worst-case), up to 143 acres could be cleared under Option D. Conservatively assuming an average tree coverage of 40 percent throughout the project alignment (see Chapter 6), a worst-case estimate of up to 57 acres of forested land could be removed under Option D.

Option D could result in a loss of up to 6,330 metric tons of CO_2 sequestration. This would not exceed the state's GHG reporting threshold. Installation of the new transformer at a new or expanded substation would be unlikely to meaningfully contribute to further loss of CO_2 sequestration.

Installation of cable landing points may require clearing of wetlands on the lake shore, but this would be unlikely to contribute meaningfully to loss of sequestration and would be considered a minor impact with respect to GHG emissions.

4.5.4 Alternative 2: Integrated Resource Approach

4.5.4.1 Energy Efficiency Component

Energy efficiency improvements would entail implementing accelerated measures and incentives to reduce demand. This component would not involve infrastructure improvements, changes to maintenance activities, or construction of new or relocated maintenance yards. Consequently, energy efficiency improvements would have no impact with regard to direct GHG emissions, lifecycle GHG emissions, or sequestration loss.

4.5.4.2 Demand Response Component

Demand response measures would entail implementing measures to reduce and/or shift electrical demand and would not involve infrastructure improvements, changes to maintenance activities, or construction of new or relocated maintenance yards. Consequently, implementation of demand response systems would have no impact with regard to direct GHG emissions, lifecycle GHG emissions, or sequestration loss.

4.5.4.3 Distributed Generation Component

4.5.4.3.1 GHG Emissions from Construction Vehicles and Equipment

Construction of distributed generation facilities could result in direct GHG emissions, such as from gas turbines or diesel reciprocating engines. The amount of GHG released would vary with the type and number of facilities constructed, making it speculative to quantify direct construction emissions at this programmatic level of analysis. In addition, the number of hours that such facilities would need to operate in direct response to the need identified by PSE for the Energize Eastside Project would be relatively small (see Chapter 7 for additional discussion of energy consumption). Therefore, the quantities of GHG generated to address the project need would be negligible.

4.5.4.3.2 Lifecycle GHGs

The lifecycle emissions for distributed generation facilities would be speculative to quantify without a precise estimate of the number and size of facilities to be constructed. However, lifecycle emissions could be greater than those associated with either Option A, Option B, or Option D of Alternative 1 primarily due to the potential for ongoing combustion of natural gas associated with peak generation plants or other combustion turbines or engines.

4.5.4.3.3 Loss of Sequestered CO_2 (Tree Removal)

Loss of sequestration would depend on the condition of sites selected for distributed generation facilities (i.e., whether the sites are currently vegetated and the type of vegetation present). Since most of this equipment is anticipated to be on or adjacent to buildings, the amount of vegetation removed would be negligible.

4.5.4.4 Energy Storage Component

4.5.4.4.1 GHG Emissions from Construction Vehicles and Equipment

Like the distributed generation component, construction of the energy storage component would generate GHG emissions that are not possible to quantify at this programmatic level of analysis. However, given that a battery storage facility would resemble an open yard of containers, a surface parking lot represents a reasonable approximation of such a land use. Construction of a 10-acre surface parking lot could generate an estimated 302 metric tons of CO_2. This assumes a 6-month construction period, no demolition, and cut and fill balanced on-site[7]. This would be considered a minor impact with respect to GHG emissions.

4.5.4.4.2 Lifecycle GHGs

Lifecycle GHG emissions associated with battery storage technologies can be high because some of the materials used in their manufacture are scarce. For example, the energy demand for the manufacture of new lithium-ion batteries for plug-in hybrid motor vehicles has been estimated to be 1,700 megajoules of primary energy to produce 1 kilowatt-hour of lithium-ion battery capacity (Samaras et al., 2008). This energy demand would also have lifecycle emissions that would be in addition to the materials used for construction of any required structures. However, battery lifecycle emissions can be reduced by as much as 70 percent

---

[7] Calculated using the California Emissions Estimator Model Version 2013.2.2.

with recycling techniques that would be reflected in operational emissions as batteries are replaced.

4.5.4.1 Peak Power Generation Component

This component would involve installing three 20 MW generators at existing substations within the Eastside. These could be any type of generator but the most likely type would be a simple-cycle gas-fired generator. Construction of three gas-fired simple-cycle generators would be similar to a substation, including trenching to access upgraded natural gas, water, and wastewater utility lines. Construction would occur within or adjacent to existing PSE substations over 12 months. Construction emissions would be similar to those identified above for the battery storage component, approximately 750 metric tons of CO_2.

4.5.5 Alternative 3: New 115 kV Lines and Transformers

4.5.5.1 GHG Emissions from Construction Vehicles and Equipment and Lifecycle GHGs

Alternative 3 would develop 115 kV transmission lines that would require a more narrow clearing area than a 230 kV alignment, from 40 feet up to 100 feet wide under a worst-case scenario, compared with 150 feet for the 230 kV corridor. However, the 115 kV alternative would require up to 60 miles of transmission alignment, resulting in more vegetation removal. Alternative 3 construction would have the second longest construction period (approximately 24 to 28 months). Substation improvements would occur simultaneously with construction along the alignment. GHG emissions from construction equipment and potentially loss of sequestration would incrementally increase, but these contributions would be negligible compared to work for the alignment. Consequently, the longer construction duration for Alternative 3 would result in higher direct construction GHG emissions than those associated with Alternative 1. Additionally the increased number of support towers would require more concrete, and lifecycle emissions would also be greater than Alternative 1.

4.5.5.2 Loss of Sequestered CO_2 (Tree Removal)

Assuming a new right-of-way alignment of approximately 60 miles and a 40-foot-wide clear zone under a worst-case scenario, Alternative 3 could require clearing up to 291 acres. Conservatively assuming an average tree coverage of 40 percent throughout the project alignment (see Chapter 6), a worst-case estimate of up to 116 acres of forested land could be removed under Alternative 3, resulting in up to 12,900 metric tons of CO_2 sequestration losses (loss of active CO_2 intake by trees acting as a carbon sink). This is a worst-case estimate because it conservatively assumes that additional clearance would be required over the entirety of the existing alignment. This impact would exceed the state's GHG reporting threshold and, without best management practices or mitigation, would be a significant adverse impact with respect to GHG emissions.

4.6 HOW COULD OPERATION OF THE PROJECT AFFECT GREENHOUSE GAS EMISSIONS?

4.6.1 Operation Impacts Considered

Operational GHG impacts would result primarily from employee vehicle trips to maintain the new facilities. However, some distributed energy components and peak generation plants would have operational emissions associated with fuel combustion.

4.6.2 No Action Alternative

Demand response programs, the primary component of the No Action Alternative, would implement operational measures to reduce and/or shift electrical demand. No infrastructure improvements, changes to maintenance activities, or new or relocated maintenance yards would be required. No new employee vehicle trips are envisioned under the No Action Alternative. Consequently there would be no operational GHG impacts associated with the No Action Alternative.

4.6.3 Alternative 1: New Substation and 230 kV Transmission Lines

Potential operational GHG impacts associated with all of the Alternative 1 options would result from vehicle travel associated with occasional maintenance of the electrical facilities. Such trips would be infrequent and would not result in appreciable GHG emissions. Therefore, Alterative 1 would have a minor impact with regard to operational GHG emissions.

4.6.4 Alternative 2: Integrated Resource Approach

4.6.4.1 Energy Efficiency and Demand Response Components

Energy efficiency and demand response components would not involve infrastructure improvements, changes to maintenance activities, or new or relocated transformers, substations, or maintenance yards. These components would have no impact with regard to operational GHG emissions. There may be an indirect beneficial impact because conservation measures would reduce energy demand and associated GHG emissions associated with the mix of energy generation.

4.6.4.2 Distributed Generation Component

Distributed generation facilities could result in operational GHG impacts that would vary with the type and magnitude of facility. Because of the limitations of distributed generation systems described in Chapter 2, the Phase 1 evaluation assumed that these sources would contribute minimally to addressing the identified deficiency in capacity by 2024.

Certain types of distributed generation facilities, specifically gas turbines and reciprocating engines, have the potential to generate operational GHG emissions associated with fuel combustion, which would vary depending on the frequency of operation, size of engine, and type of fuel used. For this analysis, it is assumed that distributed generation facilities could result in negligible to moderate adverse impacts.

4.6.4.3 Energy Storage Component

Operation of a battery storage facility would be similar to that of a small office building, with worker vehicle trips and vendor trips to perform periodic replacement of degraded cells. Such trips would be infrequent and not result in appreciable GHG emissions. Lifecycle GHG Emissions associated with battery storage technologies can be high because some of the materials used in their manufacture are scarce. For example, the energy demand for the manufacture of new lithium-ion batteries for plug-in hybrid motor vehicles has been estimated to be 1,700 megajoules of primary energy to produce 1 kilowatt-hour of lithium-ion battery capacity (Samaras et al., 2008). This energy demand would have lifecycle emissions. However, battery lifecycle emissions can be reduced by as much as 70 percent with recycling techniques that would be reflected in operational emissions as batteries are replaced. Therefore, the energy storage component would have a minor impact with regard to operational GHG emissions.

4.6.4.4 Peak Power Generation Component

This component would involve operation of three 20 MW generators at existing substations within the Eastside, likely simple-cycle gas-fired generators called peak generation plants. In 2013, the overall mix of fuels used by PSE to provide all electricity to all of its customers was led by hydropower (32 percent), followed closely by coal, natural gas, and wind energy (PSE, 2015). While hydropower is considered to be renewable and to have negligible GHG emissions, coal is a relatively carbon-intensive energy source, producing between 205 and 230 pounds of CO_2 per million British thermal units (Btus). Natural gas is relatively less carbon intensive, producing 117 pounds of CO_2 per million Btu. Because peak generation plants would be powered by natural gas, their operational GHG emissions would be similar to the average of overall carbon intensity of PSE's current mix of resources.

Peak generation plants would be operated to provide power at peak demand times to reduce the demands on the transmission system. These plants would also need to be operated for maintenance purposes at least monthly (typically permitted for weekly operation of an hour, or 50 hours per year). Because operational GHG emissions would be a function of operational frequency (including peak power demand situations), quantitative estimates of operational GHG emissions would be speculative, but they are likely to be the highest of any distributed generation source. Such power plants can be required to report GHG emissions pursuant to Chapter 173-441 Washington Administrative Code – Reporting of Emissions of Greenhouse Gases. This could be considered a moderate GHG impact, warranting mitigation.

4.6.5 Alternative 3: New 115 kV Lines and Transformers

Potential operational impacts of 115 kV overhead power lines would be the same as those identified above for maintenance-related vehicle trips for 230 kV power lines. Such trips would be infrequent and not result in appreciable GHG emissions. Therefore, Alterative 3 would have a minor impact with regard to operational GHG emissions.

4.7 WHAT MITIGATION MEASURES ARE AVAILABLE FOR POTENTIAL IMPACTS TO GREENHOUSE GAS EMISSIONS?

If gas turbines or reciprocating engines are selected as distributed energy components, air quality permits may require installation of a fuel flow meter to restrict the use of fuel and associated GHG emissions over a given time period. A vegetation replacement program could be implemented to reduce sequestration losses under Alternative 1, Option A, and Alternative 3 to a moderate level. Alternative 1, Options B and C would also involve vegetation clearing for alignments, although to a lesser extent. Additionally, carbon credits may be purchased to offset operational emissions generated by permitted sources.

4.8 ARE THERE ANY CUMULATIVE IMPACTS TO GREENHOUSE GAS EMISSIONS AND CAN THEY BE MITIGATED?

By definition, GHG impacts are cumulative impacts. The sum of all emission sources throughout the globe drives planet-wide GHG concentrations that result in climate change. Emission sources exceeding 10,000 metric tons per year of CO_2e are required to report their emissions to the state; they could be considered cumulatively considerable contributions and may require mitigation. There are two project elements that could potentially result in GHG emissions of this magnitude. The first is operational emissions from gas turbines or reciprocating engines, if they are selected as distributed energy components.

The second potentially significant adverse GHG impact would involve the substantial loss of sequestration associated with clearing for transmission alignments that could accompany Alternative 1, Option A, and Alternative 3. Given the substantial size of areas to be cleared and the relatively high tree canopy cover in the area, loss of sequestration could exceed 10,000 metric tons annually. A vegetation replacement program could be implemented to reduce sequestration losses to a moderate level.

4.9 ARE THERE ANY SIGNIFICANT UNAVOIDABLE ADVERSE IMPACTS TO GREENHOUSE GAS EMISSIONS?

There would be no significant and unavoidable adverse impacts related to GHG emissions associated with any of the project alternatives, with implementation of mitigation measures. Potential significant impacts from operational GHG emissions of gas turbines or reciprocating engines, if they are selected as distributed energy components, could be mitigated by a combination of engineering controls and the purchase of offsets. Significant impacts related to sequestration losses associated with clearing activities for transmission alignments that could accompany Alternative 1, Option A, and Alternative 3 could be mitigated to a less-than-significant level through vegetation replacement or offset acquisition.