Appendix E: Air Quality and Greenhouse Gases Technical Resource Report

For Programmatic Environmental Impact Statement on Utility-Scale Solar Energy Facilities in Washington State

By

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For the

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Acronyms and Abbreviations List

BESS	battery energy storage system
CalEEMod	California Emissions Estimator Model
CETA	Clean Energy Transformation Act
CFR	*Code of Federal Regulations*
CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
Ecology	Washington State Department of Ecology
EFSEC	Energy Facility Site Evaluation Council
ESA	Environmental Science Associates
g CO_2e/kWh	gram of carbon dioxide equivalents per kilowatt hour
GHG	greenhouse gas(es)
GHGRP	Greenhouse Gas Reporting Program
GWP	global warming potential
kg CO_2e/MWh	kilogram of carbon dioxide equivalents per megawatt hour
LCA	life-cycle assessment
MACT	Maximum Achievable Control Technology
MOVES	Motor Vehicle Emission Simulator
MT CO_2e	metric tons of carbon dioxide equivalents
MW	megawatt
N_2O	nitrous oxide
NAAQS	National Ambient Air Quality Standards
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NO_2	nitrogen dioxide
NOC	Notice of Construction
NOx	nitrogen oxide
NREL	National Renewable Energy Laboratory
NSPS	New Source Performance Standards
PEIS	Programmatic Environmental Impact Statement
PM_{10}	particulate matter 10 microns or less in diameter
$PM_{2.5}$	fine particulate matter 2.5 microns or less in diameter
PSD	Prevention of Significant Deterioration
RCW	Revised Code of Washington
SIP	State Implementation Plan for air quality
SO_2	sulfur dioxide
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound
WAAQS	Washington Ambient Air Quality Standards
WAC	Washington Administrative Code

Summary

This technical resource report describes the conditions of air quality and greenhouse gas (GHG) resources in the study area. It also describes the regulatory context, potential impacts, and measures that could avoid or reduce impacts.

The operation of solar energy facilities would reduce overall GHG emissions compared to a fossil fuel power plant that would otherwise be in operation to supply the same amount of electricity. Overall, GHG emissions would be reduced if solar energy production replaces fossil fuel energy production over the next 20 years. Washington state law requires utilities to have net-zero GHG emissions by 2045.

Findings for air quality and GHG impacts described in this technical resource report are summarized as follows:

- Facility GHG life-cycle emissions could be up to 2,368 metric tons of carbon dioxide equivalents (MT CO_2e) a year. Facilities with a battery energy storage system could have total GHG emissions up to 4,192 MT CO_2e a year. These impacts are **less than significant** and offsets could be used to reduce the amount of GHGs in the atmosphere.
- Through compliance with laws and permits and with the implementation of measures that could avoid and reduce impacts, construction, operation, and decommissioning would likely result in **less than significant impacts** on air quality.

Compliance with existing laws is sufficient for there to be **no significant and unavoidable adverse impacts** to air quality and GHGs expected for any of the facilities evaluated. Site selection considerations could be used to reduce the air pollutants and GHGs emitted from the transport of materials and personnel. Measures that minimize the emissions from vehicle and equipment engines, such as using newer engines with the most up-to-date emissions performance technology and limiting engine idling time, would also reduce air quality and GHG impacts. Paving of roads and parking areas could also reduce air pollution from fugitive dust generated by vehicle traffic.

Crosswalk with Air Quality and Greenhouse Gases Technical Resource Report for Utility-Scale Onshore Wind Energy

Two Programmatic Environmental Impact Statements (PEISs) are being released at the same time, one for utility-scale solar energy facilities and one for utility-scale onshore wind energy facilities. This crosswalk identifies the areas with substantial differences between the air quality and greenhouse gases technical resource reports for each PEIS.

Utility-Scale Solar Energy PEIS (this document)	**Utility-Scale Onshore Wind Energy PEIS**
• Different specific air emission estimates • Differences in the estimates for GHG life-cycle assessments	• Different specific air emission estimates • Includes evaluation of air quality for repowering facilities instead of decommissioning • Differences in the estimates for GHG life-cycle assessments

1 Introduction

This technical resource report describes air quality and greenhouse gases (GHGs) within the study area and assesses potential impacts associated with the types of facilities evaluated (alternatives) and a No Action Alternative, which are described in Chapter 2 of the State Environmental Policy Act Programmatic Environmental Impact Statement (PEIS).

1.1 Resource description

The following resources could have impacts that overlap with impacts to air quality and GHGs. Impacts on these resources are reported in their respective technical resource reports:

- **Tribal rights, interests, and resources:** Analysis of air quality impacts and emissions on Tribal communities is included in the *Tribal Rights, Interests, and Resources Technical Report* (Appendix B).
- **Environmental justice:** Analysis of air quality and emissions impacts on people of color and low-income populations is included in the *Environmental Justice Technical Resource Report* (Appendix C).
- **Environmental health and safety and public services and utilities:** Impacts related to battery energy storage system (BESS) fires and explosions and subsequent risk of hazardous air emissions to emergency responders are included in the *Environmental Health and Safety Technical Resource Report* (Appendix I) and *Public Services and Utilities Technical Resource Report* (Appendix P)

1.1.1 Fundamentals of air quality

Air quality is a measure of how clean or polluted the air is. When air quality is good, the air appears clear and contains little to no chemical pollutants or particles. Poor air quality occurs when the air contains high levels of pollutants, which can be dangerous to both human health and the environment.

Air pollution arises from various sources, both human-made and natural. Although natural sources like windblown dust, wildfires, and volcanoes can be substantial contributors to poor air quality, they usually do not create long-term problems. Human-made mobile sources of air pollution include cars, buses, planes, trucks, and trains. Stationary sources of human-made air pollution include power plants, oil refineries, and other industrial facilities. Area sources of human-made air pollution are localized activities or processes that emit air pollutants that can collectively contribute to poor air quality such as agricultural activities, urban areas, and wood-burning fireplaces.

1.1.2 Fundamentals of greenhouse gases

“Global warming” and “climate change” are common terms used to describe the increase in the average temperature of the Earth’s near-surface air and oceans since the mid-20th century. Natural processes and human actions have been identified as impacting climate. Since the 19th century, increasing GHG concentrations resulting from human activity (such as fossil fuel combustion, deforestation, and other activities) have unequivocally caused global warming (IPCC 2023). GHGs in the atmosphere naturally trap heat by impeding the exit of solar radiation—a phenomenon sometimes referred to as the “greenhouse effect.” Some GHGs occur naturally and are necessary for keeping the Earth’s surface inhabitable. However, increases in the concentrations of these gases in the atmosphere during the last 100 years have trapped solar radiation and decreased the amount that is reflected back into space, intensifying the greenhouse effect and resulting in the increase of global average temperature and climate change.

Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are the principal GHGs. When concentrations of these gases exceed historical concentrations in the atmosphere, the greenhouse effect is intensified. CO_2 is the reference gas for climate change, because it is the GHG emitted in the highest volume. The effect that each of the GHGs has on global warming is the product of the mass of their emissions and their global warming potential (GWP). GWP indicates how much a gas is predicted to contribute to global warming relative to how much warming would be predicted to be caused by the same mass of CO_2. For example, CH_4 and N_2O are substantially more potent GHGs than CO_2, with GWPs of approximately 25 and approximately 298 times that of CO_2, which has a GWP of 1.

In emissions inventories, GHG emissions are typically reported as metric tons of carbon dioxide equivalents (MT CO_2e). CO_2e is 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 higher quantities and it accounts for the majority of GHG emissions in CO_2e, both from developments and human activity in general.

1.2 Regulatory context

1.2.1 Air quality

To protect public health and welfare nationwide, the federal Clean Air Act requires that the U.S. Environmental Protection Agency (USEPA) establish National Ambient Air Quality Standards (NAAQS) for certain common and widespread pollutants and revise them regularly based on the latest science.

Each state must submit to USEPA and the public its rules and programs that ensure that the NAAQS are attained in all areas of the state. These rules and programs comprise the Washington State Implementation Plan (SIP) for air quality (USEPA 2025).

USEPA sets primary and secondary NAAQS for seven common “criteria pollutants”:

- Particulate matter 10 microns or less in diameter (PM_{10})
- Particulate matter 2.5 microns or less in diameter ($PM_{2.5}$)
- Ozone
- Sulfur dioxide (SO_2)

- Nitrogen dioxide (NO_2)
- Carbon monoxide (CO)
- Lead

Most of the criteria pollutants are directly emitted. Ozone, however, is a secondary pollutant that is formed in the atmosphere by chemical reactions between nitrogen oxides (NOx) and volatile organic compounds (VOCs) in the presence of sunlight. $PM_{2.5}$ is also directly emitted and forms in the atmosphere through chemical reactions.

The NAAQS represent maximum ambient (outdoor air) concentration levels of the criteria pollutants. The NAAQS specify different averaging times as well as maximum concentrations. The health-based NAAQS are referred to as primary NAAQS. They are set at the levels protective of human health, with an adequate margin of safety to be protective of vulnerable populations. The welfare-based NAAQS, or secondary NAAQS, are set at the levels that protect ecosystems and built environments from detrimental effects of air pollution.

Washington State has adopted its own set of Washington Ambient Air Quality Standards (WAAQS), which are equal to the NAAQS for nearly all the criteria pollutants.

After USEPA sets a new or revises an existing NAAQS, it must review available air quality data and designate each area of the state as meeting or not meeting the standard. Areas that fail to meet the new or revised NAAQS are designated as "nonattainment" areas. There are no current nonattainment areas in Washington state at the time of writing this PEIS.

If an area is designated as nonattainment, the state must revise the SIP to include a plan for the area to resolve the nonattainment of the NAAQS as expeditiously as practicable, but no later than 5 years. In general, attainment plans for nonattainment areas outline specific measures to reduce ambient levels of that pollutant. Once the air quality in the nonattainment area is improved and the state demonstrated that the improvement is permanent, enforceable, and will be maintained in the future, USEPA redesignates the area to attainment and approves maintenance plans. Areas with approved maintenance plans are referred to as a "maintenance area." Oversight and air quality planning for the maintenance areas continues for at least 20 years, and afterwards, the approved maintenance strategy continues to apply in the area.

There are 15 maintenance areas in Washington as of the time of writing this PEIS. To identify if a project is located in a maintenance or nonattainment area, please refer to the Air Quality Nonattainment and Maintenance Areas map (Ecology 2025a).

Apart from the area designations for criteria pollutants, the federal Clean Air Act also categorizes certain geographic areas as Class I, Class II, and Class III areas.

- Class I areas: Under the Prevention of Significant Deterioration (PSD) program, all international parks, national wilderness areas and national memorial parks that exceed 5,000 acres, and national parks that exceed 6,000 acres are categorized as mandatory federal Class I areas. The state must prevent and remedy air quality impairments to the pristine air quality and visibility conditions (Ecology 2025b).

- Class II areas: All other areas that attain the NAAQS are initially designated as Class II.
- Class III areas: Compared to Class I and II areas, Class III areas are industrialized areas and may permit a greater degree of air quality deterioration; however, they still must attain the NAAQS. There are no Class III areas in Washington.

To protect air quality in pristine Class I areas, USEPA established the Regional Haze Program. Washington has a SIP-approved Regional Haze Plan outlining requirements for sources.

A new emissions source must demonstrate that it will operate in compliance with all applicable federal and state air quality requirements, including emissions standards, NAAQS/WAAQS, and the Washington SIP. The State of Washington has established rules through the Washington State Department of Ecology (Ecology) for permitting new sources in both attainment and nonattainment areas of the state, or requirements may be imposed by local air authorities. Local clean air agencies with jurisdiction within the study area include the Puget Sound Clean Air Agency, Southwest Clean Air Agency, Yakima Regional Clean Air Agency, Benton Clean Air Agency, and Spokane Regional Clean Air Agency. Washington Administrative Code (WAC) 463-62-070 requires that energy facilities meet all federal and state air quality laws and regulations mentioned above. In general, if potential emissions from stationary sources exceed certain thresholds, approval from the applicable permitting authority is required before beginning construction. In Washington, these permits are called Notice of Construction (NOC). New sources of air emissions in nonattainment areas must undergo more rigorous permitting than equivalently sized sources in attainment areas. Chapter 173-400 WAC establishes the requirements for review and issuance of NOC approvals for sources of air emissions.

New industrial stationary sources of pollution must receive an air quality permit (NOC) prior to operation. Chapter 173-400 WAC establishes the requirements for review and issuance of NOC approvals for new sources of air emissions. When there are no permanent sources of regulated pollutants, an NOC would not be required. Stationary emergency generator engines that do not exceed 500 brake-horsepower are exempt from permitting review, along with associated fuel tanks. There are other exemptions based on potential emissions below thresholds that are pollutant dependent. Construction activities are considered to be temporary sources and are exempt from permitting review. Construction may require the temporary use of portable concrete batch plants, which would either already be permitted using general orders by the owners/operators of the plants or require obtaining a new permit. The need for an air permit will be dependent upon the equipment that is being proposed for use at a given facility and cannot be determined on a programmatic basis.

While the ambient air quality standards place upper limits on levels of air pollution, the PSD permitting regulations administered by Ecology place limits on the total increase in ambient pollution levels above baseline levels in attainment areas from the operation of large stationary sources. By only allowing ambient concentration levels to increase by a limited amount, it prevents “polluting up to the standard” from new and modified stationary sources and the deterioration of air quality in an area. These allowable increases are called “increments” and are smallest in Class I areas, such as national parks or wilderness areas. The rest of the country is subject to larger Class II increments. The federal Clean Air Act established mandatory Class I areas for national parks larger than 6,000 acres and national wilderness areas larger than 5,000 acres. States can choose a less stringent set of Class III increments; however, none have done so. Major (larger than a certain threshold) new stationary sources and large modifications at existing major stationary sources must meet the requirements of the PSD regulations and be issued a permit from Ecology before construction can begin. The PSD regulations also require the use of best-performing pollution control technology and practices, a quantitative demonstration that a stationary source would not cause or contribute to a violation of the NAAQS, and coordination with Federal Land Managers of Class I areas located near a stationary source to evaluate whether there would be an adverse impact on any air quality related values of those areas such as scenic, cultural, biological, and recreational resources.

Stationary emission sources that are not major (larger than a certain threshold) are considered minor sources. Minor sources would not trigger the requirements of PSD permitting; however, air permits or other forms of registration may still be required. Local clean air agencies administer the minor source permitting programs within their jurisdictions. Ecology manages these programs in all other areas and for certain industry categories throughout the state, regardless of local air authority jurisdiction. The USEPA Region 10 issues air permits on Tribal lands. The jurisdictional areas of the local clean air agencies are as follows (Ecology 2024):

- Benton Clean Air Agency—Benton County
- Northwest Clean Air Agency—Island, Skagit, and Whatcom counties
- Olympic Region Clean Air Agency—Clallam, Grays Harbor, Jefferson, Mason, Pacific, and Thurston counties
- Puget Sound Clean Air Agency—King, Kitsap, Pierce, and Snohomish counties
- Southwest Clean Air Agency—Clark, Cowlitz, Lewis, Skamania, and Wahkiakum counties
- Spokane Regional Clean Air Agency—Spokane County
- Yakima Regional Clean Air Agency—Yakima County

Construction-related emissions are regulated separately under the federal Clean Air Act. WAC 173-400-110(4) exempts construction activities from permitting review when the activities do not result in new or modified stationary sources.

Washington State regulates what are known as “fugitive” air emissions, which consist of any pollutants that are not emitted through a chimney, smokestack, or similar facility. For example, blowing dust from construction sites, unpaved roads, and tilled agricultural fields are common sources of fugitive particulate matter emissions, referred to as fugitive dust. Solar energy plants are not included among the facilities for which review and permitting of fugitive emissions are required (WAC 173-400-040). Nevertheless, WAC 173-400-040(9)(a) requires owners and operators of fugitive dust sources to take reasonable measures to prevent dust from becoming airborne and to minimize emissions.

Other Washington state regulations that apply to nuisance emissions, including fugitive dust and various equipment used during construction, include the following:

- **WAC 173-400-040(3), Fallout.** No person shall cause or allow the emission of particulate matter from any source to be deposited beyond the property under direct control of the owner or operator of the source in sufficient quantity to interfere unreasonably with the use and enjoyment of the property upon which the material is deposited.
- **WAC 173-400-040(4)(a), Fugitive Emissions.** The owner or operator of any emissions unit engaging in materials handling, construction, demolition, or other operation that is a source of fugitive emissions, if located in an attainment area and not impacting any nonattainment area, shall take reasonable precautions to prevent the release of air contaminants from the operation.
- **WAC 173-400-040(5), Odors.** Any person who causes or allow the generation of any odor from any source that may unreasonably interfere with any other property owner's use and enjoyment of their property must use recognized good practice and procedures to reduce the odor to a reasonable minimum.
- **WAC 173-400-040(9), Fugitive Dust**. The owner or operator of a source or activity that generates fugitive dust must take reasonable precautions to prevent that fugitive dust from becoming airborne and must maintain and operate the source to minimize emissions.

1.2.2 Greenhouse gases

In March 2008, the Washington Legislature enacted House Bill 2815, which directed Ecology to develop rules for the mandatory reporting of GHG emissions by sources that emit more than certain specified threshold amounts. These rules are codified in Chapter 173-441 WAC. According to WAC 173-441-030(1)(a), any source that emits 10,000 MT CO_2e per calendar year, and that is a source type identified in WAC 173-441-120, is required to report its GHG emissions to Ecology. For facilities emitting more than 25,000 metric tons per year, a quantitative disclosure of GHGs is required under 40 *Code of Federal Regulations* 98.

In 2020, the Washington Legislature set new GHG emission limits (Revised Code of Washington 70A.45.020) to combat climate change. Under the law, the state is required to reduce emissions levels as follows:

- 2020—reduce to 1990 levels
- 2030—45% below 1990 levels
- 2040—70% below 1990 levels
- 2050—95% below 1990 levels and achieve net zero emissions

The 2019 Clean Energy Transformation Act (CETA) requires all electric utilities in Washington to transition to carbon-neutral electricity by 2030 and that 100% of electricity be generated from renewable or nonemitting resources by 2045. The Washington Department of Commerce and the Washington Utilities and Transportation Commission are leading the implementation efforts.

Table 1. Applicable laws, plans, and policies

Regulation, statute, guideline	Description
Federal	
42 *United States Code* 7401 et seq., Clean Air Act	The Clean Air Act is the law that defines the U.S. Environmental Protection Agency's (USEPA's) responsibilities for protecting and improving the nation's air quality and the stratospheric ozone layer.
40 *Code of Federal Regulations* (CFR) 50, National Ambient Air Quality Standards (NAAQS)	National primary and secondary ambient air quality standards. The primary standards define levels of air quality that USEPA judges are necessary, with an adequate margin of safety, to protect public health. The secondary air quality standards define levels that USEPA judges necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant.
40 CFR 52.21, Prevention of Significant Deterioration (PSD) of Air Quality	If a facility would be a major source of air pollutant emissions, a PSD air permit would be required prior to construction. The Washington State Department of Ecology (Ecology) administers the PSD program in Washington, except for on Tribal lands or for sources under the jurisdiction of the Energy Facility Site Evaluation Council. Although this program is administered by Ecology, it requires coordination with federal partners such as USEPA.
40 CFR 60, New Source Performance Standards (NSPS)	Federal emissions standards that apply to specific categories of stationary sources. The NSPS represent the minimum level of control that is required on a new or modified source. Generator engines or combustion heating equipment may be subject to the NSPS. Ecology and often local clean air agencies administer the NSPS.
40 CFR 63, National Emissions Standards for Hazardous Air Pollutants (NESHAP)	Federal emissions standards for hazardous air pollutants from specific source categories. They generally specify the Maximum Achievable Control Technology (MACT) that must be applied for a given source category; therefore, they are also referred to as MACT standards. Generator engines or combustion heating equipment may be subject to NESHAP. Ecology and often local clean air agencies administer the NESHAP.
40 CFR 98, Mandatory Greenhouse Gas (GHG) Reporting	The Greenhouse Gas Reporting Program (GHGRP) requires reporting of GHG data and other relevant information from large GHG emission sources. A total of 41 categories of emission sources are covered by the GHGRP. Facilities are generally required to submit annual reports under 40 CFR 98 under the following circumstances: 1) direct GHG emissions from covered sources exceed 25,000 metric tons of carbon dioxide equivalents (MT CO_2e per year); 2) stationary fuel combustion units at the facility have a combined maximum rated heat input capacity of 30 million British thermal units per hour or greater; or 3) supply of certain products would result in over 25,000 MT CO_2e of GHG emissions if those products were released, combusted, or oxidized.
40 CFR 51(W) and 40 CFR 93, General Conformity Analysis	General Conformity requires that federal agencies not take actions that cause or contribute to violations of ambient air quality standards or interfere with goals outlined in a state or Tribal implementation plan for achieving attainment.

Regulation, statute, guideline	Description
State	
Chapter 70A.15 Revised Code of Washington (RCW), Washington Clean Air Act	This regulation defines Ecology's and local air pollution control agencies' responsibility for protecting and improving air quality in Washington.
Chapter 70A.45 RCW, Limiting GHG Emissions	This regulation establishes GHG emission limits and reporting requirements in Washington.
Chapter 70A.65 RCW, GHG Emissions	This regulation establishes the cap and invest program in Washington.
Chapter 173-400 Washington Administrative Code (WAC), General Regulations for Air Pollution Sources	This chapter establishes technically feasible and reasonably attainable emissions standards and establishes rules generally applicable to the control and/or prevention of the emission of air contaminants.
WAC 173-400-040, General Standards for Maximum Emissions	This chapter outlines some general emissions standards that apply to all sources and emissions units.
WAC 173-400-110, New Source Review for Sources and Portable Sources	A source must apply for and be issued a Notice of Construction (NOC) for sources of air emissions unless exempted. Exemptions are described in the rule. A local clean air agency often implements its own approved version of this program.
WAC 173-400-99 through 173.400.105, Registration Program	Many sources of air emissions that do not require an NOC instead require registration. A local clean air agency often implements its own approved version of this program.
WAC 173-400-720, PSD	These are the state rules for administering the PSD permitting program. If a facility would be a major source of air pollutant emissions, a PSD air permit would be required prior to construction.
Chapter 173-401 WAC, Operating Permit Regulation	Title V major sources require an Air Operating Permit.
Chapter 173-460 WAC, Controls for New Sources of Toxic Air Pollutants	Sources of toxic air pollutants must comply with these regulations.
Chapter 173-441 WAC, Mandatory GHG Reporting	Facilities with stationary fuel combustion units emitting ≥10,000 MT CO_2e per year must report GHG emissions.
Chapter 173-446 WAC, Washington Climate Commitment Act	Implements the provisions of the GHG emissions cap and invest program.
Chapter 173-444 WAC, Washington Clean Energy Transformation Act (CETA)	Establishes rules that electric utilities shall use to comply with parts of the Washington CETA.
Chapter 173-476 WAC, Ambient Air Quality Standards	Establishes maximum acceptable levels in the ambient air for particulate matter, lead, sulfur dioxide, nitrogen oxides, ozone, and carbon monoxide.
Chapter 463-62-070 WAC, Construction and Operation Standards for Energy Facilities – Air Quality	States that air emissions from energy facilities shall meet the requirements of applicable state air quality laws and regulations.

Regulation, statute, guideline	Description
Chapter 463-78 WAC, General and Operating Permit Regulations for Air Pollution Sources	Establishes maximum permissible air emissions standards and reporting requirements for emissions sources under the jurisdiction of the Washington Energy Facility Site Evaluation Council.
Local	
Local New Source Review/Air Permitting program	An NOC may be required for sources of air emissions. Local clean air agencies often have their own approved programs rather than being administered by Ecology. The Puget Sound Clean Air Agency, Southwest Clean Air Agency, Yakima Regional Clean Air Agency, Benton Clean Air Agency, and Spokane Regional Clean Air Agency are located within the study area.
Local Registration Program	Sources of air emissions that do not require an NOC may instead require registration. Local clean air agencies often have their own approved programs rather than being administered by Ecology.
Regulations from cities, counties	Facilities would also need to comply with city and county regulations, ordinances, and plans related to air quality and GHG emissions.

2 Methodology

2.1 Study area

The study area for air quality resources encompasses the overall solar geographic study area (Figure 1) and surrounding areas, which could include facilities and activities with air emissions.

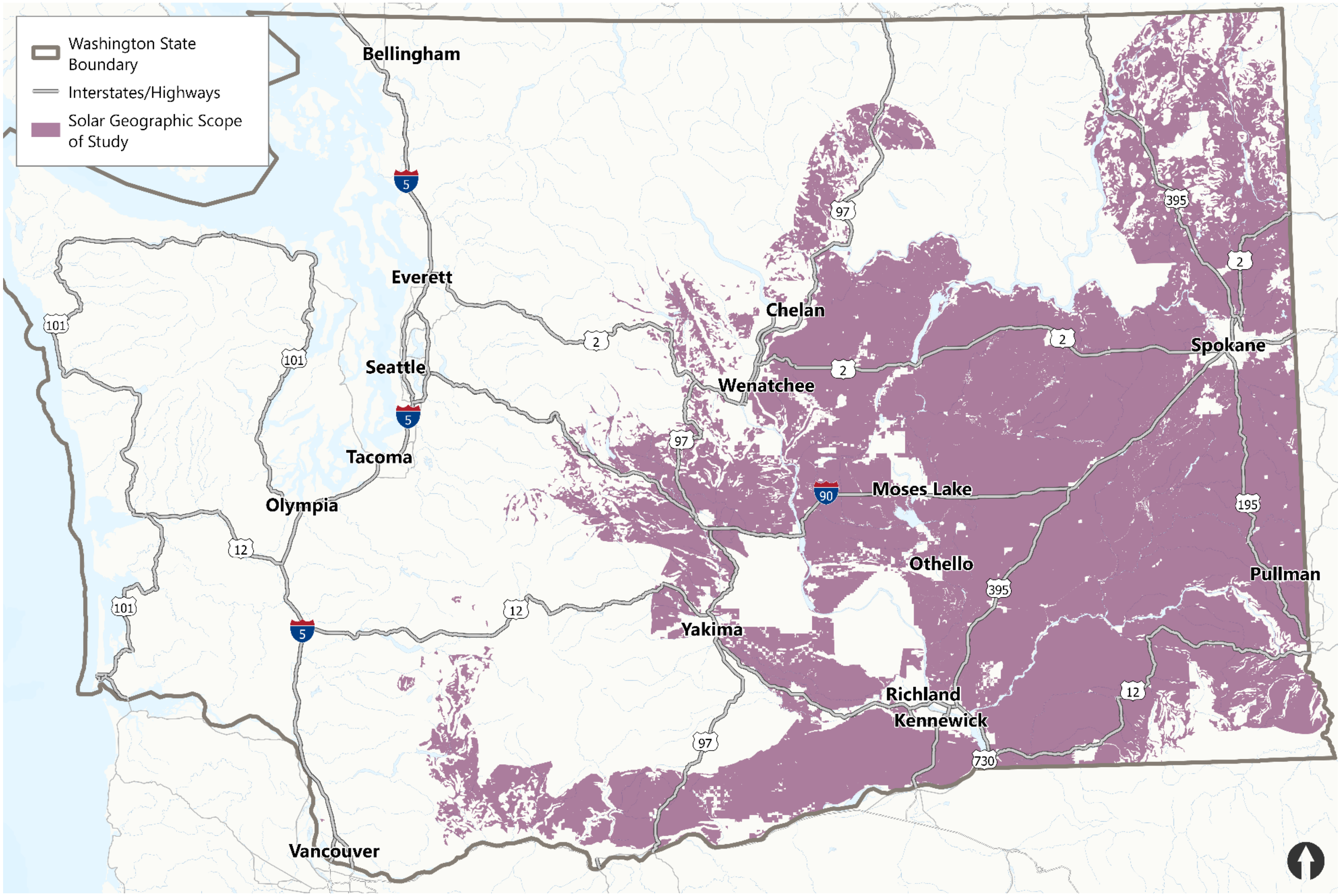

Figure 1. Solar Energy Facilities PEIS – geographic scope of study

2.2 Technical approach

This section describes the technical approach for analyzing air pollution and GHG emissions:

- Tabulate construction and decommissioning of solar energy generation facilities, including the operation of non-road equipment (equipment that does not regularly use roads such as construction machinery and generators) and on-road vehicle traffic, which would emit criteria air pollutants and GHG from the combustion of fuel in internal combustion engines, as well as particulate dust emissions from land-clearing activities and vehicle travel on paved and unpaved roadways. If required, blasting would also generate air emissions and GHGs.
  - Criteria air pollutant emissions were tabulated through a meta-analysis of solar facility emission inventories and their emission rates per megawatt (MW) of facility developed.
  - GHG emissions resulting directly from construction and decommissioning were similarly estimated.
- Operational emissions were tabulated for generator and vehicle use associated with maintenance activities. The solar modules are not direct sources of air emissions or GHG emissions during operation. However, installations may use backup generator engines to supply power when normal sources of electricity are unavailable. The facilities may not be staffed, or would be staffed in low numbers, and therefore would experience few daily worker commutes by vehicle. Periodic site visits would also be required for maintenance activities.
  - Similar to construction, criteria air pollutant emissions were tabulated through a meta-analysis of solar facility emission inventories and their emission rates per MW of facility developed.
  - GHG emissions resulting directly from operations were similarly estimated.
  - Overall emissions were then tabulated using the emissions per MW and the upper end of the considered facility design sizes.

To identify life-cycle GHG emissions from the development of solar facilities, the following methods were used:

- Review life-cycle assessment (LCA) studies to identify potential life-cycle GHG emissions factors and provide a comprehensive understanding of the GHG impacts throughout the facility's entire life cycle:
  - A review conducted by the National Renewable Energy Laboratory (NREL; NREL 2012) identified LCA emission allocations for solar facilities by emissions scope (i.e., upstream processes, operational processes, and downstream processes).
  - The operational emissions were tabulated as part of the meta-analysis and these estimates were used to approximate the upstream and downstream LCA emissions based on the NREL allocations.
  - Overall LCA emissions were tabulated as a sum of the different estimates by GHG scope

2.3 Impact assessment approach

The PEIS analyzes a timeframe of up to 20 years of potential facility construction and up to 30 years of potential facility operations (totaling up to 50 years into the future).Air pollutant and GHG emissions level ranges have been estimated for the types of facilities based on the predicted level of non-road equipment and on-road vehicle use required during construction and operation. This analysis evaluates impacts relative to the effects of site characterization, construction, operation, and decommissioning of facilities.

The actual circumstances of each facility could vary; therefore, this analysis broadly assumes that a facility would result in a potentially significant impact in any one of the following occurs:

- Emissions that may trigger air permitting requirements (100 tons per year of VOCs, NOx, SO_2, CO, PM_{10}, or $PM_{2.5}$ within a calendar year unless the area is in a nonattainment area, in which case the threshold would be the matching general conformity de minimis limit for that region)
- Fugitive dust that may impact biological resources or water quality

Although GHG concentrations are global and not localized, all of the types of facilities evaluated would result in GHG emissions. An LCA does not consider any offsetting of impacts from replacing one energy source with another, i.e., it does not account for CO_2e emissions reduced by replacing fossil fuel energy generation with a clean energy source. The life-cycle GHG emissions and state GHG requirements for utilities were considered in determining significance.

3 Technical Analysis and Results

3.1 Overview

This section describes the potential significant adverse air quality and GHG impacts that might occur for a given solar energy facility type. In general, the extent of the impact depends on the size of the power range and size of the facility. This section also includes measures to avoid, minimize, and mitigate impacts.

3.2 Affected environment

The affected environment represents existing conditions at the time this study was prepared. Given the substantial geographic extent of the solar study area, the existing air pollutant concentration levels can vary from one site to another. At the time of this PEIS, all areas in Washington state meet the NAAQS set by USEPA for criteria pollutants.

There are 15 former nonattainment areas in Washington. Each area has an approved maintenance plan for air quality that includes specific requirements for the area. Most of the 15 areas have demonstrated attainment of the standard for which they were designated nonattainment for more than 20 years. This is an important threshold signifying successful maintenance strategies that no longer need to be reviewed or revised. At the end of 2025, there will be only two maintenance areas that are still within the 20-year planning period. These areas (Tacoma and Ferndale) are outside of the geographic scope of study.

There are some areas of concern for particulate matter and ozone within the study area. The Tri-Cities area (Kennewick, Pasco, and Richland) is an area of concern for ozone. Sunnyside, Toppenish, and Yakima to the west are areas of concern for particulate matter, along with Omak in the north and Colville in the northeast.

Any location may experience occasional severe deterioration of air quality due to wildfires (usually July through September), depending on wind patterns and the location of the fire(s). In addition, seasonal dust storms (usually during dry periods in spring and summer), particularly in eastern and central Washington, can increase levels of particulate matter in the air, which increases inhalation health risks and can cause reduced atmospheric visibility.

To make sure the air continues to meet air quality standards, Ecology and its partners monitor the air using Washington's Air Monitoring Network. As previously described, regulatory programs such as PSD and Chapter 173-400 WAC are in place to ensure that air pollution levels do not increase to concentrations that threaten ambient air quality standards. Any new industrial sources of air pollution must receive an air quality permit prior to operation. The permitting programs are designed to ensure that not only are ambient air quality standards protected, but that the current levels of air quality are not substantially degraded by industrial growth.

Per Ecology's estimates, in 2019, Washington produced about 102.1 million MT CO_2e (Ecology 2022). Ecology found that transportation is the largest source, at 40% of the state's GHG emissions, followed by residential, commercial, and industrial energy use at 31%, and electricity consumption (both in-state and out-of-state) at 21%.[1] The sources of the remaining 8% of emissions are agriculture, waste management, and industrial processes.[2]

3.3 Potentially required permits and approvals

The following permits related to air quality would potentially be required for construction, operation, or decommissioning:

- **Air Quality Permits (Ecology, Energy Facility Site Evaluation Council [EFSEC], local agency):** These permits are required to control and manage emissions from construction and operation activities. New or modified industrial stationary sources of pollution must receive an air quality permit (NOC Approval) prior to operation. Chapter 173-400 WAC establishes the requirements for review and issuance of NOC Approvals for new or modified sources of air emissions. A fugitive dust plan may be required to demonstrate compliance with WAC 173-400-040(3) and 173-400-040(8)(a).

3.4 Utility-scale solar facilities

3.4.1 Air quality impacts from construction and decommissioning

Site characterization, construction, and decommissioning would generate air and GHG emissions from the following:

- Non-road equipment used for site characterization, site preparation, construction, take down, and site clearance activities
- On-road vehicle traffic associated with site characterization, construction activities, off haul trucks, vendors, and workers

Site characterization and construction-related air emissions would be generated by non-road construction equipment, haul-truck trips, on-road worker trips, vehicle travel on paved and unpaved surfaces, and fugitive dust from material handling activities. Site characterization and construction of large utility-scale solar energy facilities would generate more emissions than those of small to medium utility-scale facilities due to the larger proposed facilities, which

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[1] Transportation sources include on-road vehicles, marine vessels, jet fuel and aviation gasoline, rail operations, and natural gas for transportation. Washington GHG emissions from the transportation sector have been fairly constant for several years, with on-road gasoline continuing to contribute over 50% of transportation sector emissions. Marine vessel emissions include emissions from recreational, commercial, and ocean-going vessels, but exclude marine bunker fuels consumed in international waters.

[2] The industrial sector includes fugitive GHG emissions that are released during the production, processing, transmission, and distribution of fossil fuels. These emissions are typically fugitive methane due to leakage and venting from natural gas pipelines, and petroleum systems.

would require more construction equipment and more on-road vehicles than small to medium facilities. Construction emissions were estimated by reviewing emissions data from similar solar projects both in Washington and California and deriving a scaled emissions rate in tons per MW to apply to this analysis. Emissions from the reviewed projects were calculated using both the USEPA's Motor Vehicle Emission Simulator (MOVES; USEPA 2023) emissions factor modeling system and the California Emissions Estimator Model (CalEEMod; CAPCOA 2022). The pollutant rates were applied to this programmatic analysis to calculate construction emissions using the most conservative proposed wattage of the facility. Emissions shown in Table 2 were estimated for the construction for a 600-MW and 1,200-MW solar energy facility.

Table 2. Estimated construction emissions for types of facilities analyzed in this PEIS (tons)

Emission type	600-MW facility	1,200-MW facility	Threshold (tons per year)
VOCs	5.8	11.7	100
NOx	42.0	84.0	100
CO	37.2	74.3	100
PM_{10}	11.6	23.1	100
$PM_{2.5}$	3.4	6.8	100
SO_2	0.2	0.3	100

Source: Prepared by Environmental Science Associates (ESA) based on emissions per MW of development from published Environmental Impact Statements produced at the project-specific level. Evaluated projects were: Bluebird Solar Energy (Tetra Tech 2023), Crimson Solar (BLM 2021), Little Bear Solar (ESA 2018), Horse Heaven Wind Farm (EFSEC 2023), and Vikings Solar Energy (McIntyre 2022).

A significant air quality impact would occur if emissions generated exceeded the annual threshold presented in Table 2. As shown in Table 2, construction emissions from a utility-scale solar energy facility are not anticipated to be exceeded for any criteria pollutant. Through compliance with laws and permits and with the implementation of measures that could avoid and reduce impacts, construction and decommissioning would likely result in **less than significant impacts** on air quality.

3.4.2 Air quality impacts from operation

Operation of a utility-scale solar energy facility would generate air and GHG emissions from:

- On-road vehicle traffic associated with maintenance activities

Operations would generate exhaust and fugitive dust emissions from on-road vehicles required for solar panel maintenance and cleaning. This would involve both light and heavy-duty vehicles. Operations of a large utility-scale solar energy facility are assumed to require more maintenance and would generate more emissions than those smaller facilities. Operational emissions were estimated by reviewing emissions data from similar solar projects both in Washington and California and deriving a scaled emissions rate in tons per MW to apply to this programmatic analysis. Emissions from the reviewed projects were calculated using both the

USEPA's MOVES emissions factor modeling system and California's CalEEMod. The pollutant rates were applied to this programmatic analysis to calculate operational emissions using the most conservative proposed wattage of the facility. Emissions shown in Table 3 were estimated for the operations of a 600-MW and 1,200-MW solar energy facility.

Table 3. Estimated operations emissions for types of facilities analyzed in this PEIS (tons)

Emission type	600-MW facility	1,200-MW facility	Threshold (tons per year)
VOCs	2.7	5.3	100
NOx	17.8	35.7	100
CO	14.9	29.8	100
PM_{10}	3.3	6.6	100
$PM_{2.5}$	1.4	2.9	100
SO_2	<0.01	<0.01	100

Source: Prepared by ESA based on emissions per MW of development from published Environmental Impact Statements produced at the project-specific level. Evaluated projects were: Bluebird Solar Energy (Tetra Tech 2023), Crimson Solar (BLM 2021), Little Bear Solar (ESA 2018), Horse Heaven Wind Farm (EFSEC 2023), and Vikings Solar Energy (McIntyre 2022).

A significant air quality impact would occur if emissions generated exceeded the annual threshold presented in Table 3. As shown in Table 3, operations of a utility-scale solar energy facility would not be anticipated to exceed any criteria pollutant thresholds. Through compliance with laws and permits and with the implementation of measures that could avoid and reduce impacts, operation would likely result in **less than significant impacts** on air quality.

3.4.3 GHG emissions over the lifetime of the solar energy facility

NREL has developed LCAs for various electricity generation technologies. The LCA covers the full lifespan of the product from raw material extraction to construction and operation, and ultimately decommissioning and disposal. According to the NREL LCA, solar energy technology has life-cycle GHG emissions equal to approximately 40 grams of carbon dioxide equivalents per kilowatt hour (g CO_2e/kWh) with a system lifetime of 30 years (NREL 2012). Table 4 summarizes where the GHG emissions are generated during the lifespan of a solar installation and compares them to LCA values for coal-fired and natural gas electricity generation facilities.

Table 4. LCA comparison for utility-scale facilities

Facility type and energy comparison	Upstream processes	Operational processes	Downstream processes
Solar	• Raw materials extraction • Materials production • Module manufacture • System/plant component manufacture • Installation/plant construction	• Power generation • System/plant operation and maintenance	• System/plant decommissioning • Disposal
40 g CO_2e/kWh	~60% to 70%	~21% to 26%	~5% to 20%
Coal	• Raw materials extraction • Construction materials manufacture • Power plant construction	• Coal mining • Coal preparation • Coal transport • Coal combustion • Power plant operation and maintenance	• Power plant decommissioning • Waste disposal • Coal mine land rehabilitation
1,030 g CO_2e/kWh	<1%	>99%	<1%
Natural Gas	• Raw materials extraction • Gas processing • Pipeline transport	• Combustion of fuels • Maintenance • Operation	• Decommissioning • Disposal and recycling
460 g CO_2e/kWh	<1%	>99%	<1%

Source: NREL 2012.

The NREL LCA information provides the proportion of the GHG emissions produced from a technology's life cycle during upstream processes, operational processes, and downstream processes. Upstream processes include the raw material extraction and construction of photovoltaics and associated components, along with the construction of the solar plant. Operational processes are addressed in Section 3.4.2 and include solar panel maintenance and cleaning and involve mostly vehicle exhaust emissions from the maintenance activities. Downstream processes are the decommissioning and disposal of the solar installation. The estimates for annual operational GHG emissions for a 600-MW facility have been used to determine the total operational GHG emissions for a 30-year life cycle, consistent with the LCA performed by NREL. The upstream and downstream life-cycle GHG emissions are then calculated from the proportions provided by NREL's photovoltaic LCA. Table 5 summarizes the life-cycle GHG emissions for a 600-MW and 1,200-MW solar energy facility, as well as an amortized GHG estimate based on the life-cycle GHG emissions, and compares them to those for coal-fired and natural gas electricity generation facilities.

Table 5. Life-cycle GHG emissions comparison for 600-MW and 1,200-MW facilities

Life-cycle GHG emissions	Upstream processes (MT CO_2e)	Operational processes (MT CO_2e)	Downstream processes (MT CO_2e)	Total life-cycle emissions (MT CO_2e)	Amortized GHG emissions (MT CO_2e/year)
Solar					
NREL proportions (average)	65%	23%	12%	100%	--
600-MW solar facility	23,088	8,170	4,262	35,520	1,184
1,200-MW solar facility	46,176	16,339	8,525	71,040	2,368
Coal					
NREL proportions (average)	<1%	>99%	<1%	100%	--
600-MW coal facility	22,313	4,551,750	22,313	4,596,375	153,213
1,200-MW coal facility	44,625	9,103,500	44,625	9,192,750	306,425
Natural Gas					
NREL proportions (average)	<1%	>99%	<1%	100%	--
600-MW natural gas facility	3,564	2,049,097	89	2,052,750	68,425
1,200-MW natural gas facility	7,127	4,098,195	178	4,105,500	136,850

Source: Prepared by ESA based on NREL 2012.
Notes: Coal and natural gas facility estimates are based on the direct facility size, assuming 8,760 hours per year at a capacity factor of 85%. The solar facility estimate is derived from environmental review documentation estimates of operational GHG emissions. These operational emissions were then used with the NREL LCA percentages to estimate the upstream and downstream contributions.

The operation of solar energy facilities would reduce overall GHG emissions compared to a fossil fuel power plant that would otherwise be in operation to supply the same amount of electricity. Overall, GHG emissions would be reduced if solar energy production replaces fossil fuel energy production over the next 20 years. CETA requires utilities to have net-zero GHG emissions by 2045.

GHG life-cycle emissions for a utility-scale solar facility would be up to 2,368 MT CO_2e a year. These impacts are **less than significant** and offsets could be used to reduce the amount of GHGs in the atmosphere.

3.4.4 Measures to avoid, reduce, and mitigate impacts

The PEIS identifies a variety of measures to avoid, reduce, and mitigate impacts. These measures are grouped into five categories:

- **General measures:** The general measures apply to all projects using the PEIS.
- **Recommended measures for siting and design:** These measures are recommended for siting and design in the pre-application phase of a project.
- **Required measures:** These measures must be implemented, as applicable, to use the PEIS. These include permits and approvals, plans, and other required measures.
- **Recommended measures for construction, operation, and decommissioning:** These measures are recommended for the construction, operation, and decommissioning phases of a project.
- **Mitigation measures for potential significant impacts:** These measures are provided only in sections for which potential significant impacts have been identified.

3.4.4.1 General measures

- **Laws, regulations, and permits:** Obtain required approvals and permits and ensure that a project adheres to relevant federal, state, and local laws and regulations.

  Rationale: Laws, regulations, and permits provide standards and requirements for the protection of resources. The PEIS impact analysis and significance findings assume that developers would comply with all relevant laws and regulations and obtain required approvals.

- **Coordination with agencies, Tribes, and communities:** Coordinate with agencies, Tribes, and communities prior to submitting an application and throughout the life of the project to discuss project siting and design, construction, operations, and decommissioning impacts, and measures to avoid, reduce, and mitigate impacts. Developers should also seek feedback from agencies, Tribes, and communities when developing and implementing the resource protection plans and mitigation plans identified in the PEIS.

  ***Rationale*:** Early coordination provides the opportunity to discuss potential project impacts and measures to avoid, reduce, and mitigate impacts. Continued coordination provides opportunities for adaptive management throughout the life of the project.

- **Land use:** Consider the following when siting and designing a project:
  - Existing land uses
  - Land ownership/land leases (e.g., grazing, farmland, forestry)
  - Local comprehensive plans and zoning
  - Designated flood zones, shorelines, natural resource lands, conservation lands, priority habitats, and other critical areas and lands prioritized for resource protection
  - Military testing, training, and operation areas

    - State-designated harbors
    - Air quality nonattainment areas

  ***Rationale*:** Considering these factors early in the siting and design process avoids and minimizes the potential for land use conflicts. Project-specific analysis is needed to determine land use consistency.

- **Choose a project site and a project layout to avoid and minimize disturbance:** Select the project location and design the facility to avoid potential impacts to resources. Examples include the following:
    - Minimizing the need for extensive grading and excavation and reducing soil disturbance, potential erosion, compaction, and waterlogging by considering soil characteristics
    - Minimizing facility footprint and land disturbances, including limiting clearing and alterations to natural topography and landforms and maintaining existing vegetation
    - Minimizing the number of structures required and co-locating structures to share pads, fences, access roads, lighting, etc.

  ***Rationale*:** Project sites and layouts may differ substantially in their potential for environmental impacts. Thoughtful selection of a project site and careful design of a facility layout can avoid and reduce environmental impacts.

- **Use existing infrastructure and disturbed lands, and co-locate facilities:** During siting and design, avoid and minimize impacts by:
    - Using existing infrastructure and disturbed lands, including roads, parking areas, staging areas, aggregate resources, and electrical and utility infrastructure
    - Co-locating facilities within existing rights-of-way or easements
    - Considering limitations of existing infrastructure, such as water and energy resources

  ***Rationale*:** Using existing infrastructure and disturbed lands and co-locating facilities reduces impacts to resources that would otherwise result from new ground disturbance and placement of facilities in previously undisturbed areas.

- **Conduct studies and surveys early:** Conduct studies and surveys early in the process and at the appropriate time of year to gather data to inform siting and design. Examples include the following:
    - Geotechnical study
    - Habitat and vegetation study
    - Cultural resource survey
    - Wetland delineation

  ***Rationale*:** Conducting studies and surveys early in the process and at the appropriate time of year provides data to inform siting and design choices that avoid and reduce impacts. This can reduce the overall timeline as well by providing information to agencies as part of a complete application for environmental reviews and permits.

- **Restoration and decommissioning:** Implement a Site Restoration Plan for interim reclamation following temporary construction and operations disturbance. Implement a Decommissioning Plan for site reclamation at the end of a project. Coordinate with state and local authorities, such as the Washington Department of Fish and Wildlife, county extension services, weed boards, or land management agencies on soil and revegetation measures, including approved seed mixes. Such plans address:
    - Documentation of pre-construction conditions and as-built construction drawings
    - Measures to salvage topsoil and revegetate disturbed areas with native and pollinator-supporting plants
    - Management of hazardous and solid wastes
    - Timelines for restoration and decommissioning actions
    - Monitoring of restoration actions
    - Adaptive management measures

    ***Rationale*:** Restoration and decommissioning actions return disturbed areas to pre-construction conditions, promote soil health and revegetation of native plants, remove project infrastructure from the landscape, and ensure that project components are disposed of or recycled in compliance with all applicable laws and regulations.

- **Cumulative impact assessment:** Assess cumulative impacts on resources based on reasonably foreseeable past, present, and future projects. Identify measures to avoid, reduce, and mitigate cumulative impacts. Consider local studies and plans, such as comprehensive plans.

    ***Rationale*:** Cumulative impacts can result from incremental, but collectively significant, actions that occur over time. The purpose of the cumulative impacts analysis is to make sure that decision-makers consider the full range of consequences under anticipated future conditions.

3.4.4.2 Recommendations for siting and design

- Conduct an LCA of potential greenhouse gas emissions and design the facility and incorporate into project planning ways to minimize use of fossil fuels to reduce greenhouse gases and other air emissions.
- Consider options to reduce embodied carbon when selecting construction and operations materials and equipment.

3.4.4.3 Required measures

This section lists permits and approvals, plans, and other required measures for use of the PEIS, as applicable. See Section 3.3 for more detailed information on potentially required permits and approvals.

- Air Quality Permits (Ecology, EFSEC, local agency)

3.4.4.4 Recommended measures for construction, operation, and decommissioning

- Surface access roads, on-site roads, and parking lots with aggregate with hardness sufficient to prevent vehicles from crushing the aggregate and causing excessive dust.
- Minimize vehicle and equipment exhaust emissions by:
  - Using efficient transportation routing
  - Using hybrid or zero-emission equipment, electric maintenance trucks or service vehicles, and/or latest-model-year vehicles and equipment
  - Maintaining vehicles and equipment in good condition
  - Limiting engine idling time and shutting down equipment when not in use
  - Encouraging carpooling among construction workers to minimize construction-related traffic and associated emissions
  - Using ultra-low-sulfur diesel fuel with a sulfur content of 15 parts per million or less for all diesel engines.
  - Applying add-on pollution control technologies to construction generators
- Implement best management practices identified in the "Guide to Handling Fugitive Dust from Construction Projects," as published by the Associated General Contractors of Washington (AGC 2009) or updated guidance recommended by the local air agency. Example measures to minimize fugitive dust emissions include:
  - Monitor wind speeds and suspend all soil disturbance activities and travel on unpaved roads during periods of high winds.
  - Use water, water-based environmentally safe dust suppression materials, or other fugitive dust-abatement measures for dust control in compliance with state and local regulations.
  - Cover construction materials that could be a source of fugitive dust during transportation or storage.
  - Limit traffic speeds on unpaved roads.
- Use offsets to reduce the amount of greenhouse gases in the atmosphere. Offset projects are intended to result in greenhouse gas reductions that are real, permanent, quantifiable, verifiable, and enforceable.

3.4.4.5 Mitigation measures

- No potential significant impacts identified.

3.4.5 Unavoidable significant adverse impacts

Through compliance with laws and permits and with the implementation of measures to avoid and mitigate significant impacts, construction, operation, or decommissioning would result in **no significant and unavoidable adverse impacts** related to air quality or GHGs.

3.5 Solar facilities with battery energy storage systems

3.5.1 Air quality impacts from construction and decommissioning

Site characterization, construction, and decommissioning-related air emissions for utility-scale solar energy facilities with co-located BESSs would be generated by activities for both a solar energy facility (as discussed in Section 3.4) as well as up to two BESSs at 500 MW each. This would require more equipment and on-road vehicles than required for utility-scale facilities without a BESS. Emissions shown in Table 6 were estimated for the construction of a 1,200-MW facility and two 500-MW BESSs.

Table 6. Construction emissions for a 1,200-MW solar energy facility and two 500-MW co-located battery energy storage systems

	Estimated emissions (tons)					
	VOC	NOx	CO	PM_{10}	$PM_{2.5}$	SO_2
BESS construction	1.7	14.7	7.3	0.5	0.5	<0.01
Facility construction (excluding BESS)	11.7	84.0	74.3	23.1	6.8	0.3
Facility construction total (including BESS)	13.4	98.7	81.6	23.6	7.3	0.3
Threshold (tons per year)	100	100	100	100	100	100
Exceed threshold?	**No**	**No**	**No**	**No**	**No**	**No**

Source: Prepared by ESA based on emissions per MW of development from published Environmental Impact Statements produced at the project-specific level. Evaluated projects were: Bluebird Solar Energy (Tetra Tech 2023), Crimson Solar (BLM) 2021, Little Bear Solar (ESA 2018), Horse Heaven Wind Farm (EFSEC 2023), and Vikings Solar Energy (McIntyre 2022).

A significant air quality impact would occur if emissions generated exceeded the annual threshold presented in Table 6. As shown in Table 6, construction emissions from a 1,200-MW solar energy facility and two 500-MW BESSs are not anticipated to exceed any criteria pollutant thresholds. Impacts to air quality from construction would be the same as described in Section 3.4.

3.5.2 Impacts from operation

Operation of a solar energy facility and two BESSs would generate similar emissions as those analyzed previously for a utility-scale facility without a BESS. Accidental leakage of refrigerants in air conditioning systems used for BESSs could result in minimal hazardous or toxic air pollutant emissions, which include emissions of chlorofluorocarbons, hydrofluorocarbons, perfluorinated chemicals, or sulfur hexafluoride. Potential for hazardous air pollutant and toxic air pollutant emissions from refrigerant leakage would be dependent on the size and number of cooling systems, maintenance practices, and the exact types and quantities of refrigerants used in cooling systems. The measures listed in Section 3.4.4 would be followed to reduce the potential for refrigerant leaks.

If a thermal runaway event due to damage or a battery management system failure were to occur for facilities with lithium-ion BESS, there could be risk of hazardous air emissions to emergency responders that include toxic gases. Impacts related to fires and explosions are included the *Environmental Health and Safety Technical Resource Report* and *Public Services and Utilities Technical Resource Report*.

Impacts to air quality from operation would be the same as described in Section 3.4.

3.5.3 GHG impacts from the entire lifetime of the solar energy facility

The GHG emissions for utility-scale solar energy facilities and co-located BESSs would be greater than the range described previously for utility-scale solar energy facilities without a BESS due to the addition to upstream and downstream LCA emissions from the BESS.

GHG life-cycle emissions have been previously modeled using OpenLCA software for the addition of 500-MW BESS systems for a case study in Texas (Das et al. 2024). The study indicated that the addition of a 500-MW BESS increases the LCA footprint by 7.58 kilograms of carbon dioxide equivalents per megawatt hour (kg CO_2e/MWh) for either solar or wind applications, and the addition of two 500-MW BESSs increases the LCA footprint by 15.16 kg CO_2e/MWh. Relative to the solar facilities evaluated in the Texas case study (1,435-MW solar facility), two 500-MW BESS installations increased the LCA of the entire facility by 77%. Applying this percentage increase to estimated annual emissions for small to large facilities, overall emissions including the two 500-MW co-located BESS installations would range from 2,096 to 4,192 MT CO_2e a year. These impacts are **less than significant** and offsets could be used to reduce the amount of GHGs in the atmosphere.

3.5.4 Measures to avoid, reduce, and mitigate impacts

Measures to avoid, reduce, and mitigate impacts for utility-scale solar energy facilities and co-located BESSs are the same as those identified in Section 3.4.4.

3.5.5 Unavoidable significant adverse impacts

Through compliance with laws and with the implementation of measures to avoid and reduce impacts, construction, operation, or decommissioning of facilities and co-located BESSs would result in **no significant and unavoidable adverse impacts** related to air quality or GHGs.

3.6 Solar facilities that include agricultural uses

3.6.1 Air quality impacts from construction and decommissioning

Site characterization and construction- and decommissioning-related air emissions for utility-scale solar energy facilities that include agricultural land use (agrivoltaic) would be similar to those generated for utility-scale facilities that do not include agricultural land use. Facilities with co-located agricultural use may include locating a solar facility on lands where there is already existing agricultural activity, with or without changing the type of agricultural activity, or a facility could add a new agricultural use to a site.

Construction and decommissioning methods for agrivoltaic facilities would be similar to those for facilities without agrivoltaics, and criteria pollutants would be generated by non-road construction equipment and on-road vehicles. Impacts to air quality from construction and decommissioning would be the same as described in Section 3.4.

3.6.2 Air quality impacts from operation

Operation of agrivoltaic facilities would generate similar emissions as those analyzed previously for utility-scale facilities that do not include agricultural land use. Emissions from agricultural diesel-powered equipment would vary depending on the type of crops planted, level of activity, and the size and age of equipment, but are not anticipated to generate emissions above and beyond those of existing agricultural practices. If the facility includes new agricultural uses, there could be additional air quality emissions, which would vary based on the type and scale of use for each project. The overall emissions footprint of an agricultural operation is highly dependent on the types of crops, number of tilling operations per year, age of equipment being used, and many other variables. If new agricultural uses require air permits, the facility would be required to meet air quality standards. Impacts to air quality from operation would be the same as described in Section 3.4.

3.6.3 GHG impacts from the entire lifetime of the solar energy facility

The GHG emissions for agrivoltaic facilities would likely be similar to the range described for facilities that do not include agricultural land use but would vary based on the type of land use and amount of land. Impacts would be **less than significant** and offsets could be used to reduce the amount of GHGs in the atmosphere. An LCA would need to be conducted to estimate GHGs for each project based on its specific design.

3.6.4 Measures to avoid, reduce, and mitigate impacts

Measures to avoid, reduce, and mitigate impacts to air and GHG for agrivoltaic facilities are the same as those in Section 3.4.4, with the following additional measures.

3.6.4.1 Recommended measures for construction, operations, and decommissioning

- During operations in high wind and dry conditions, limit the amount of soil or unpaved surface disturbances and use wind barriers or covers to minimize windblown dust.
- Consider ways to reduce air emissions during agricultural operations, such as through maintaining equipment in good condition, reducing the number of passes by equipment, and integrating advanced technologies to reduce equipment operation overlap.

3.6.5 Unavoidable significant adverse impacts

Through compliance with laws and with the implementation of measures to avoid and reduce impacts described in Section 3.4.4, construction, operation, or decommissioning of agrivoltaic facilities would result in **no significant and unavoidable adverse impacts** related to air quality or GHGs.

3.7 No Action Alternative

Under the No Action Alternative, agencies would continue to conduct environmental review and permitting for utility-scale solar energy facilities under existing state and local laws on a project-by-project basis.

The potential impacts would be similar to the impacts for the types of facilities described above for construction, operation, and decommissioning, depending on facility size and design, and would likely result in **less than significant** impacts.

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