Appendix H: Energy and Natural Resources Technical Report

For Programmatic Environmental Impact Statement on Onshore Wind Energy Facilities in Washington State

By

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For the

Shorelands and Environmental Assistance Program

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Acronyms and Abbreviations List

BESS	battery energy storage system
BMP	best management practice
DNR	Washington State Department of Natural Resources
gen-tie line	generation-tie transmission line
kWh	kilowatt-hour
mi/gal	mile per gallon
MW	megawatt
MWh	megawatt-hour
PEIS	Programmatic Environmental Impact Statement
RCW	Revised Code of Washington
USC	*United States Code*

Summary

This technical resource report describes the conditions of energy and natural resources in the study area. It also describes the regulatory context, potential impacts, and measures to avoid, reduce, and mitigate impacts.

The key resources that are applicable to utility-scale onshore wind energy projects and evaluated in this Programmatic Environmental Impact Statement (PEIS) include the following:

- Wind available for adjacent facilities
- Electricity that is generated from renewable and non-renewable sources
- Fuels for transportation and equipment, including gasoline and diesel
- Construction aggregate (the collective term for sand, gravel, and crushed stone)

The analysis of onshore wind energy projects found the following:

- Through compliance with laws and permits and with the implementation of measures to avoid and reduce impacts, construction, operation, and decommissioning would likely result in **less than significant impacts** on energy and natural resources.
- **No significant and unavoidable adverse impacts** on energy and natural resources would occur.

Crosswalk with Energy and Natural Resources Technical Report for Utility-Scale Solar Energy

Two 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 energy and natural resources technical reports for each PEIS.

Utility-Scale Solar Energy PEIS	Utility-Scale Onshore Wind Energy PEIS (this document)
• Different specific energy and natural resource use estimates and resulting different ranges of potential impacts • Some differences in measures to avoid and reduce impacts	• Includes analysis of wind as a primary energy resource and the potential for facilities to affect adjacent wind resource availability • Different specific energy and natural resource use estimates and resulting different ranges of potential impacts • Some differences in measures to avoid and reduce impacts

1 Introduction

This technical resource report describes energy and natural resources within the study area and assesses probable impacts associated with types of facilities (alternatives), and a No Action Alternative. Chapter 2 of the State Environmental Policy Act Programmatic Environmental Impact Statement (PEIS) provides a description of the types of facilities analyzed (alternatives).

This section provides an overview of the aspects of energy and natural resources and lists relevant regulations that contribute to the evaluation of potential impacts.

1.1 Resource description

The energy resource is considered in two components: the primary energy resource and secondary energy resource, as follows:

- Primary energy means energy as a found, natural resource (wood and wind are examples).
- Secondary energy means an energy commodity that is derived by processing a primary energy source (electricity and gasoline are examples of secondary energy). Much of the secondary energy available inside the study area was produced outside the study area and imported as electricity or liquid fuels.

The non-energy natural resource considered in this technical resource report is mineral resources. Of mineral resources in the study area, only construction aggregate (crushed rock, gravel, and sand) is relevant to construction, operation, or decommissioning onshore wind energy projects.

In the study area, the following resources could have impacts that overlap with impacts to energy and natural resources. Impacts on these resources are reported in their respective technical resource reports:

- **Air quality and greenhouse gases:** Emissions that may be associated with use of energy and natural resources are analyzed in the *Air Quality and Greenhouse Gases Technical Resource Report* (Appendix E).
- **Transportation:** Information on worker numbers and truck trips that were used to inform this report are described in the *Transportation Resources Technical Report* (Appendix O).
- **Public services and utilities:** Impacts on public service or utility providers are analyzed in the *Public Services and Utilities Technical Resource Report* (Appendix P).

1.2 Regulatory context

Potentially applicable federal, state, and local laws and regulations are listed in Table 1, which contribute to the evaluation of energy or natural resources impacts. For local regulations,

Table 1 lists categories of laws, plans, and policies that could apply depending on the local jurisdiction in which a project is proposed.

Table 1. Applicable laws, plans, and policies

Regulation, statute, guideline	Description
State	
Chapter 194-40 Washington Administrative Code, Clean Energy Transformation Act	Commits Washington to an electricity supply free of greenhouse gas emissions by 2045 and requires utilities to phase out coal-fired electricity by 2025 and be greenhouse gas emissions neutral by 2030.
Chapter 43.21F Revised Code of Washington (RCW), State Energy Office	Requires development of a State Energy Strategy at least once per 8 years. The State Energy Strategy provides estimates of electricity needs in the future.
Chapter 70A.535 RCW, Clean Fuels Program	Implements a low carbon fuel standard for vehicle fuels delivered in Washington state.

2 Methodology

This section provides an overview of the process for evaluating potential impacts and the criteria for determining the occurrence and degree of impact. Details about the technical approach and impact assessment are included in Section 2.2 and 2.3.

2.1 Study area

The study area for the energy and natural resources element includes the overall onshore wind geographic scope of study (Figure 1) and surrounding areas that are relevant to this analysis.

The PEIS geographic scope of study includes various federal, state, and locally managed lands; however, Tribal reservation lands; national parks, wilderness areas, and wildlife refuges; state parks; and areas within cities and urban growth areas were excluded. Some of these areas adjacent to the PEIS geographic scope of study are considered in the study area if they contain energy or natural resources that may be impacted by projects.

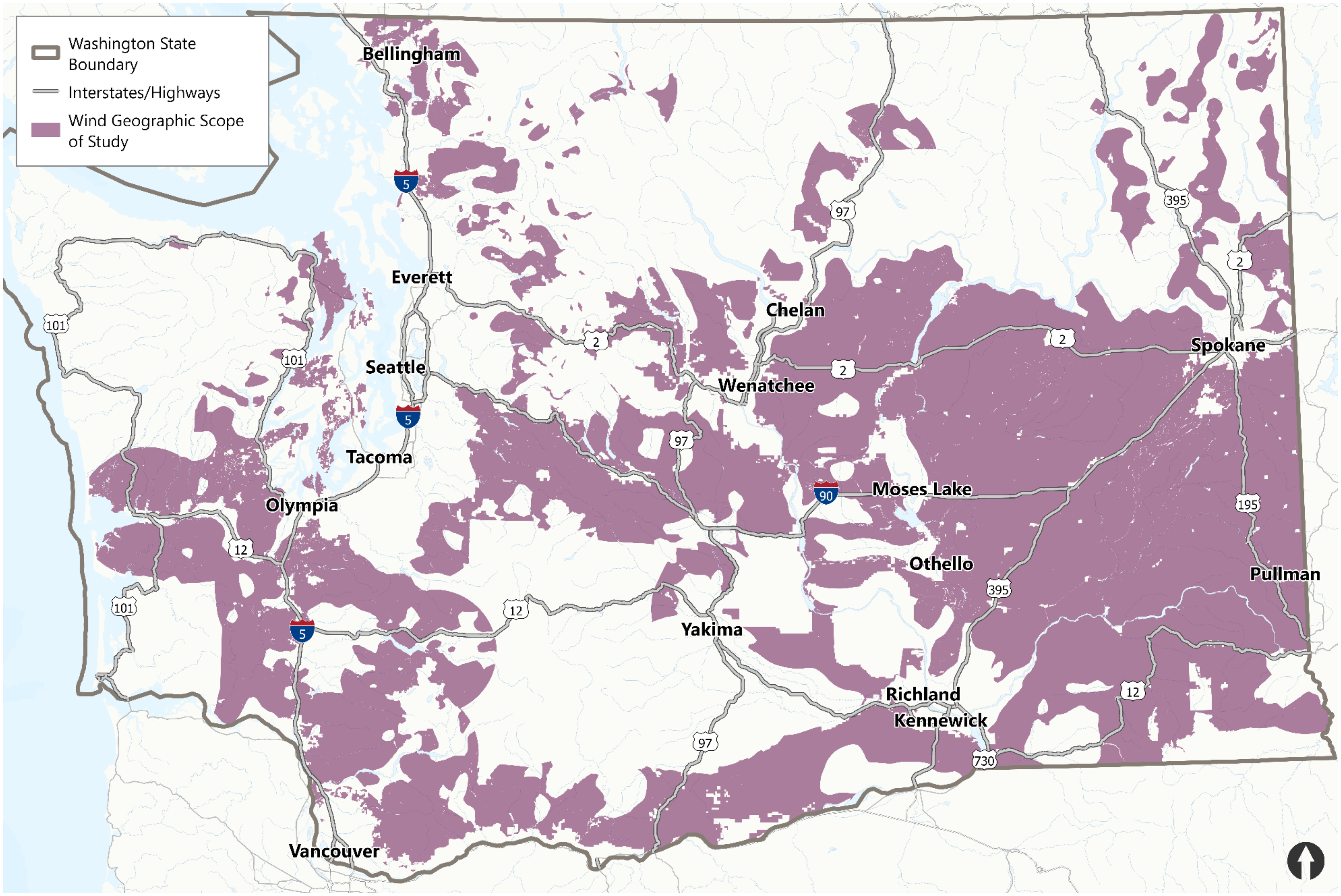

Figure 1. Onshore Wind Energy Facilities PEIS – geographic scope of study

2.2 Technical approach

Analysis of energy and natural resources within the study area was conducted using publicly available data sources and based upon review of mapping data from federal, state, and local sources; agency guidance and reports; and scientific literature. No new research, field studies, or modeling were performed as part of the analysis. Impacts on energy and natural resources were considered relative to the requirements to construct, operate, and decommission onshore wind energy projects.

The energy and natural resources evaluation was completed based on the following steps:

1. Determine energy and natural resource demands for previously analyzed utility-scale onshore wind energy facilities. This includes attention to materials used to construct projects, worker commuting, transportation of materials and equipment, and on-site equipment.
2. Calculate needs for these resources relative to the project size, specifically per megawatt (MW) of installed capacity.
3. Compare the calculated needs with published information about sources and quantities of the energy and natural resources available in the study area. Where available energy and natural resources could not be quantified specifically for the study area, they were quantified for Washington state as a whole.

2.3 Impact assessment approach

The PEIS analyzes a timeframe of up to 20 years of potential project construction and up to 30 years of potential facility operations (totaling up to 50 years into the future). Impact analysis within this technical resource report focuses on construction, operations, and decommissioning phases. Temporary and permanent impacts from the projects on energy and natural resources, relative to baseline and predicted future conditions, were evaluated.

For the purposes of this assessment, a potentially significant impact would occur if a project resulted in the following:

- Reduction of wind resource sufficient to affect an adjacent site for wind energy facility development
- Demand for electricity sufficient to induce construction of new production capacity (whether inside or outside of the study area)
- Permanently increased demand for fuels sufficient to affect statewide annual production
- Demand for construction aggregate sufficient to induce one or more new surface mines

This technical resource report covers only impacts of energy consumption by a new onshore wind energy project. Impacts on public service or utility providers are analyzed in the *Public Services and Utilities Technical Resource Report*. Emissions that may be associated with use of energy and natural resources are analyzed in the *Air Quality and Greenhouse Gases Technical Resource Report*.

3 Technical Analysis and Results

3.1 Overview

This section describes the potential adverse impacts on energy and natural resources that might occur for a utility-scale onshore wind facility analyzed in the PEIS. This section also evaluates measures to avoid, minimize, or reduce the identified impacts, and potential unavoidable significant adverse impacts. This technical resource report analyzes resources and demands on primary energy, secondary energy, and construction aggregate during construction, operation, and decommissioning.

3.2 Affected environment

The affected environment represents existing conditions at the time this study was prepared. Primary energy existing inside the study area consists of the following:

- Wind
- Sunlight
- Biomass
- Geothermal heat[1]
- Snowpack, glaciers, and other freshwater
- Petroleum and gas deposits
- Coal deposits
- Uranium deposits

Onshore wind energy facilities may affect the wind primary energy resource through wind wake effects, so this resource is shown in more detail below. Onshore wind energy facilities do not affect any other primary energy resources, so these are not described further in this section.

Secondary energy available in the study area consists of the following:

- Electricity
- Gasoline
- Diesel fuel
- Fuel oil
- Natural gas
- Liquefied petroleum gas (i.e., propane)[2]

[1] Geothermal heat refers to naturally occurring heat from below the earth's surface, not geothermal heat pumps or "geo-exchange," in which engineered systems move heat between above and below the ground surface.
[2] Aviation gasoline, kerosene (jet fuel), and marine diesel are also possible in the study area.

Onshore wind energy facilities do not demand secondary energy intended for stationary heating (fuel oil, natural gas, and LPG), so these are not described further in this section. Electricity and fuels for transportation and equipment are described in more detail below.

All remaining natural resources that are relevant to onshore wind energy facilities are evaluated in other PEIS technical resource reports, with the exception of construction aggregate, which is described in more detail below.

3.2.1 Wind

Washington's current wind facilities are shown in Figure 2, along with characterization of the state's wind resource based on average annual wind speeds at 80 meters above the ground surface. The geographic scope of study for the PEIS is broader than where facilities are being built now because new technologies could allow development of onshore wind energy facilities in areas not previously considered. Facilities depicted in Figure 2 are those in the U.S. Energy Information Administration dataset as of publication of this report; wind turbine locations will continue to change as new facilities are sited and developed. Future facility developers should review the current Interactive Data Viewer (EIA 2024a) and other data sources when considering facility siting and design for wind availability.

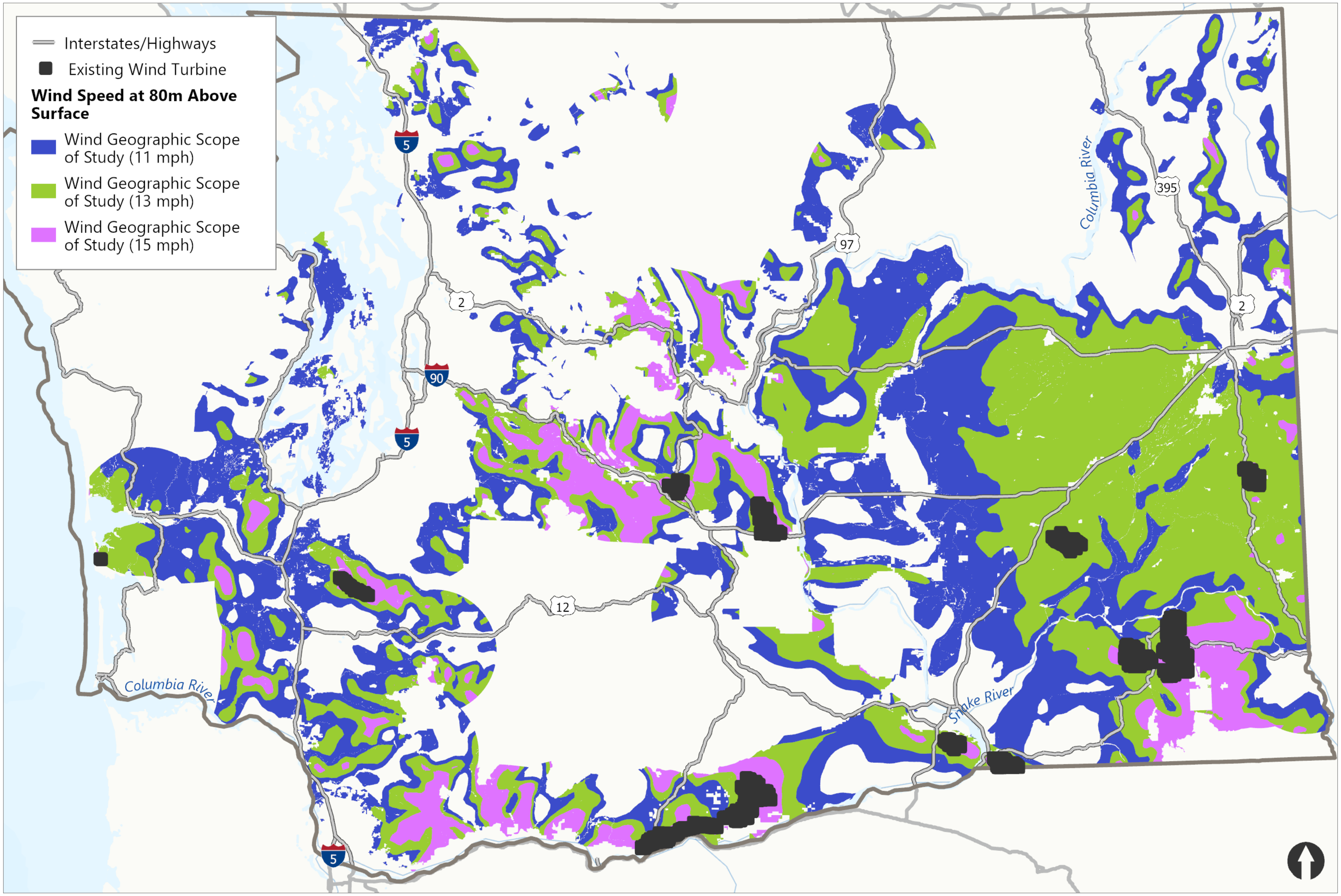

Figure 2. Wind resource and existing onshore wind facilities

Data sources: EIA 2024a; Draxl et al. 2015

3.2.2 Electricity

In 2023, Washington State consumed 88,702 million kilowatt-hours (kWh) of electricity (Table 2).

Table 2. Electricity consumption in Washington, 2023

Sector	Energy consumed (million kWh)
Residential	38,787
Commercial	29,164
Industrial	20,648
Transportation	103
TOTAL	**88,702**

Source: EIA 2024d

Washington is a net exporter of electricity, meaning that more electricity is generated in the state than consumed. In 2023, Washington generated 98,726 million kWh of electricity (Table 3). The State Energy Strategy provides estimates of future electricity needs for the state.

Table 3. Electricity generation in Washington, 2023

Primary energy source	Energy generated (million kWh)
Wind	7,601
Sunlight	363
Biomass	351
Freshwater	60,840
Petroleum	15
Natural gas	16,914
Coal	4,138
Uranium	8,435
Other	69
TOTAL	**98,726**

Source: EIA 2024e

The primary energy sources used to generate electricity in Washington do not necessarily originate in Washington. In particular, all natural gas and all uranium used to generate electricity in Washington was imported into the state. Petroleum products were also derived from crude oil extracted elsewhere.

3.2.3 Fuels for transportation and equipment

In 2019, Washington consumed 2.8 billion gallons of gasoline and gasoline equivalents, and 950 million gallons of diesel fuel and diesel equivalents[3] (EIA 2024b).

As with electricity, Washington is a net exporter of fuels for transportation and equipment (gasoline and its equivalents plus diesel and its equivalents, hereinafter “fuels”). Washington has the fifth-largest crude oil refining capacity in the United States, processing domestic and foreign crude oils. The state’s five refineries can process approximately 648,000 barrels of crude oil per day (EIA 2024c), producing approximately 4.2 billion gallons of gasoline and 2.5 billion gallons of diesel each year.[4] The Clean Fuel Standard (Chapter 70A.535 Revised Code of Washington [RCW]) requires suppliers to gradually reduce the carbon intensity of fuels to 20% below 2017 levels by 2034.

3.2.4 Construction aggregate

Construction aggregate is the collective term for sand, gravel, and crushed stone. Regulatory agencies typically segregate this resource into the following two components: 1) sand and gravel; and 2) crushed stone. Production of each is surveyed at the state-level on a quarterly time period by the U.S. Geological Survey, and surface mine permitting is handled by the Washington State Department of Natural Resources (DNR). Additionally, resource availability in the study area can be assessed from DNR aggregate resource maps. Active permitted aggregate surface mining resource sites are shown in Figure 3.

Though it is a non-renewable resource, construction aggregate is readily available in Washington. In 2023 Washington produced 30.9 million metric tons of sand and gravel from 544 active permitted surface mines, and 14.4 million metric tons of crushed stone from 298 active permitted surface mines (USGS 2024; DNR 2023).

[3] The U.S. Energy Information Administration reports sales of ethanol together with sales of gasoline, and reports sales of biodiesel and renewable diesel together with sales of conventional diesel.
[4] Assuming capacity factor (“uptime”) 90% and assuming 19.5 gallons of gasoline and 11.5 gallons of diesel produced from each barrel of input crude (see EIA 2024c).

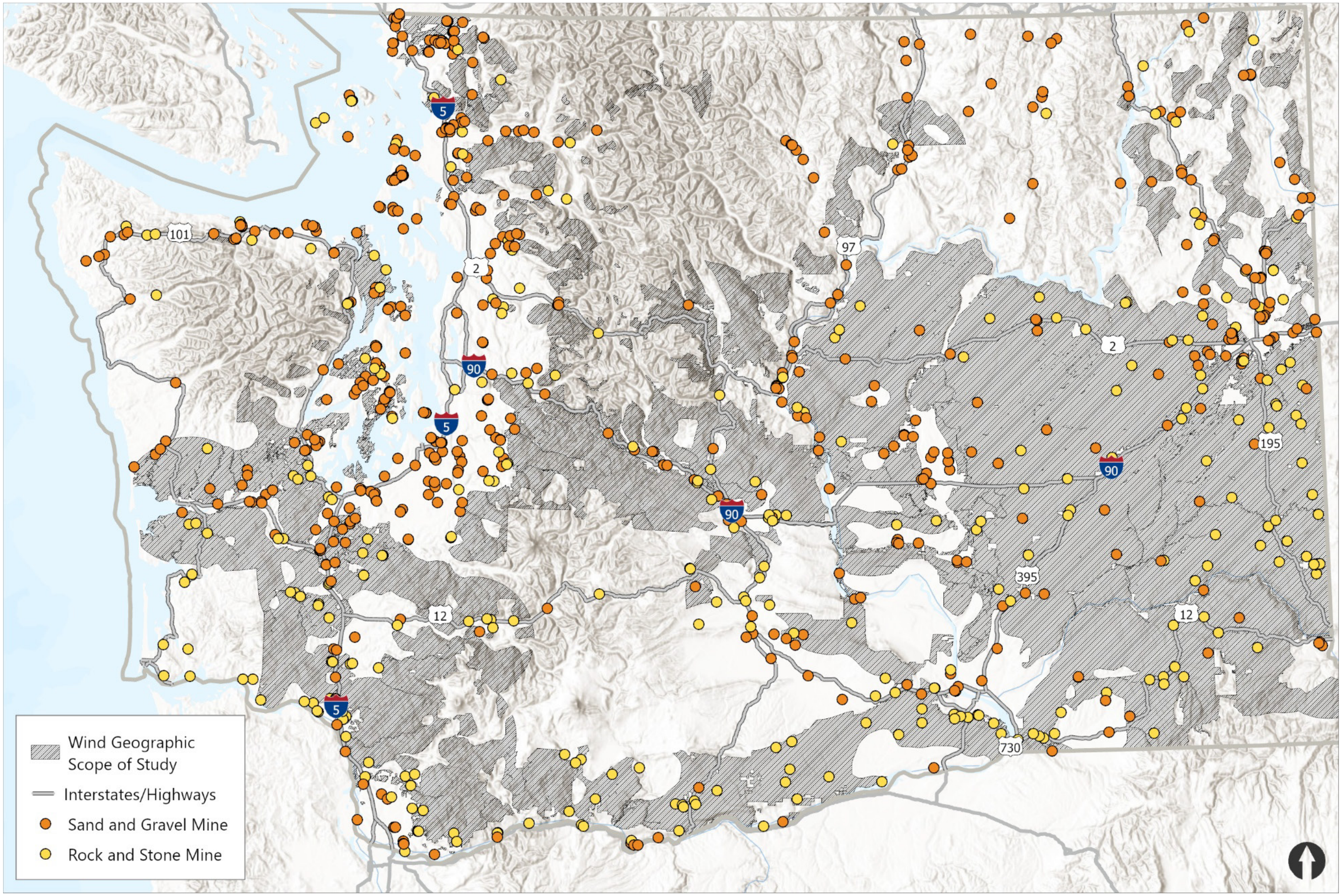

Figure 3. Aggregate resource locations

Data source: DNR 2023

3.3 Potentially required permits and approvals

If the project developer would be drawing electricity from the local utility during the construction phase, then the following permit would be required:

- **Electrical Permits (Washington State Department of Labor and Industries):** These permits ensure all electrical installations meet federal and state safety standards.

Fuels consumed would be purchased on the open market, which requires no permits.

If a project includes extraction of sand, gravel, or rock for construction aggregate, then the following permits would potentially be required. Onshore wind energy facilities are not expected to include these activities on site.

- **Sand and Gravel General Permit (Washington State Department of Ecology):** Required for extraction of sand and gravel aggregate materials that have a discharge of process wastewater, stormwater, or mine dewatering water.
- **Surface Mining Reclamation Permit (DNR):** Required for extraction of materials such as sand, gravel, or rock from state- or privately owned lands. Required for each surface mine that results in more than 3 acres of disturbed ground, or has a high-wall or disturbance area that meets certain criteria.

3.4 Utility-scale onshore wind facilities

The total area of an onshore wind energy facility capable of generating between 10 and 1,500 MW of energy would include the perimeter surrounding all the turbines; however, the spacing between turbines could be large and the areas actually in use would be much smaller. For example, some recent facilities capable of generating around 150 MW are on sites ranging from 5,000 acres to 40,000 acres; however, the amount of land area in use by the turbines in those facilities ranges from 100 to 200 acres.

The demand for electricity, fuels, and construction aggregate would vary depending on the size and nature of each onshore wind project. The extent and magnitude of impacts would also vary depending on the geographical region of a specific project and the lengths of roads and electric transmission lines that may be required. Estimates below are based on uniform use of 1.5-MW nameplate capacity turbines, with most impacts scaling more or less on a per-turbine basis (e.g., a 10-MW facility requires seven 1.5-MW turbines; a 250-MW facility requires one hundred and sixty-seven 1.5-MW turbines).

3.4.1 Impacts from construction and decommissioning

Utility-scale facilities would consume electricity and fuel during the site characterization, construction, and decommissioning phases to run construction equipment, generators, and vehicles. Construction would use aggregate for concrete for foundations for turbines, generation-tie transmission lines (gen-tie lines), and buildings and aggregate for constructing access roads. Gravel would likely be used for parking areas and equipment storage areas.

3.4.1.1 Electricity

During site characterization, construction, and decommissioning activities, electricity would be needed to power construction tools and equipment and to power construction lighting. This demand can be met either with portable generators or with electricity provided by a utility. In the case of portable generators, the energy source used to generate electricity is diesel fuel, and the generators would add to the fuel demand (see next subsection). In the case of electricity provided by a utility, the developer would work with the local utility to extend distribution infrastructure to the project. Electricity demands for construction of utility-scale projects are typical of construction projects generally, and they are often dominated by construction trailers.

Decommissioning a project at the end of its useful life would remove generating capacity from the region. Rather than decommissioning, once turbines have reached the end of their useful life, it is common to replace aged equipment with modern, more efficient equipment, a process known as repowering.

Impacts on electricity demand would be similar to construction. Electricity would be needed to run equipment necessary for decommissioning or repowering. This demand could be met through the use of portable generators or electricity brought in from the local utility.

3.4.1.2 Fuels for transportation and equipment

Utility-scale projects would consume fuels during site characterization, construction, and decommissioning for three broad purposes: on-road fuels (diesel, gasoline, and their equivalents) for worker commuting, on-road fuels for haul-truck trips, and off-road fuels (diesel and dyed diesel) for site equipment.

The *Transportation Resources Technical Report* estimates 100 to 2,000 workers per project site, with construction lasting 6 to 24 months. Assuming an average 50-mile travel distance to the (remote) work site and an average light vehicle economy of 23.7 miles per gallon (mi/gal; Davis and Boundy 2022), between 55,700 gallons and 4.46 million gallons of fuel demand for worker commuting during construction, without carpooling, is expected.

On-site equipment needed for site preparation, turbine foundation construction, and turbine erection (e.g., heavy earthmoving equipment, cranes) would remain at a facility site for the duration of construction activities. Based on construction activity estimated for other onshore wind energy facilities proposed in Washington state (EFSEC 2007, 2011, 2023), this equipment is expected to consume 2,600 to 93,000 gallons of fuels on site.

The *Transportation Resources Technical Report* estimates 49 to 7,000 truckloads required to deliver wind turbine components to the site. Assuming an average 150-mile travel distance to the work site and an average combination truck fuel economy of 6.2 mi/gal (Davis and Boundy 2022), between 2,370 gallons and 339,000 gallons of fuel demand are expected for wind turbine transportation. If some portion of the wind turbine components are transported by marine or rail, then the fuel consumption per ton-mile will be lower than for truck transport, so the given range of fuel consumption estimates can be considered a maximum. In total, during the construction phase, a facility would consume between 60,700 and 1.32 million gallons of fuels, representing between 0.0019% and 0.04% of Washington's gross annual production. This demand would be temporary over the 6- to 18-month construction period.

Transportation and equipment for utility-scale facilities would consume gasoline and diesel fuels for decommissioning or repowering activities and would mirror the demand for these fuels for the construction phase. Onshore wind facilities are not demolished but are dismantled, with most materials transported to recycling facilities. This technical resource report assumes that the road transport from site to recycling facilities would be similar in distance to road transport from manufacturing facility to site (during construction).

3.4.1.3 Construction aggregate

Construction would use sand, gravel, and construction aggregate for construction activities. Gravel would likely be used for building roads, while sand and gravel are key components of the concrete used for turbine foundations, operations buildings, and crane pads.

Review of three Washington wind projects that utilize 1.5-MW-scale turbines provided estimates of needed construction aggregate (EFSEC 2005, 2007, 2011). They average, on a per-turbine basis, 2,000 cubic yards of aggregate. When using 1.5 MW turbines, a project would require between 14,000 cubic yards and 500,000 cubic yards of aggregate.

Assuming 1 cubic yard of aggregate weighs 1 metric ton, relative to the 45.3 million metric tons of sand, gravel, and crushed stone produced in Washington in 2023 (see Section 3.2.4), these aggregate requirements would range from 0.03% to 1.1% of the total available resource produced annually. Aggregate may need to be obtained from multiple mines, depending on the project location. To keep costs down, project developers would typically source aggregate as close as possible to the project site, with a 25-mile haul typically doubling the cost of aggregate products (DNR 2024).

Impacts on aggregate resources in the vicinity of a project site would primarily include a temporary reduction in available supply of those materials for other projects; however, the relative impact on those resources would be dependent on the number of local and regional suppliers as well as the number of other projects occurring in the same region.

3.4.1.4 Summary of impacts from construction and decommissioning

Through compliance with laws and permits and with the implementation of measures to avoid and reduce impacts, construction and decommissioning would likely result in **less than significant impacts** on energy and natural resources, including electricity, fuels, and construction aggregate.

3.4.2 Impacts from operation

Operation includes maintenance activities that would require fuel for maintenance vehicles and tools. Electricity would be needed for lighting, heating, and other domestic purposes at buildings. Gravel would be needed for upkeep of access roads.

3.4.2.1 Wind

A project may have an impact on the wind energy resource available to adjacent areas if an operating facility produces a wake of reduced-velocity wind downstream of its location (Archer et al. 2018). The ability of some neighboring lands to produce electricity may be reduced. The size of this loss would be highly dependent on the local climate; the geometry of the project; the distance to any proposed, neighboring project; and the geometry of any proposed, neighboring project. One study estimated energy loss of up to 4% due to wake effects among the turbines of a single, 25-turbine, onshore wind farm, which might be considered an indicator of potential project-level energy loss at adjacent lands (El-Asha et al. 2017). Such effects should be considered in siting and design at the project level to account for adjacent wind projects.

3.4.2.2 Electricity

A project would consume electricity during operations and maintenance. Electricity would be used to power operations and maintenance buildings, sensors, lights, and similar project components. This energy consumption is much less than the energy generated by the project and may be drawn from the project's own generation ("parasitic load") or may be drawn from the local electric utility, depending on project specifications. Projects able to draw parasitic electricity may still draw from the local electric utility when wind speed is low. A utility-scale onshore wind facility would require between 50 and 1,800 megawatt-hours (MWh) of electricity per year. This represents roughly 0.2% of the facility's production.

3.4.2.3 Fuels for transportation and equipment

Projects would consume gasoline and diesel fuels for maintenance vehicles during the life of the project. On-road diesel fuels and gasoline would be used to power vehicles for maintenance crews. The quantity of fuel consumed would be approximately 102 gallons per turbine per year (combined between gasoline and diesel). For most utility-scale facilities, this consumption would be very small in the context of fuel consumption throughout the study area.

3.4.2.4 Construction aggregate

During operation and maintenance, construction aggregate would be needed only to maintain maintenance roads leading to turbines and supporting facilities. If it is assumed that new surface gravel once per 5 years, and a layer depth of 4 inches, average annual demand will range between 350 and 12,140 cubic yards per year depending on project size and access points (Skorseth and Selim 2000).

3.4.2.5 Summary of impacts from operation

Through compliance with laws and permits and with the implementation of measures to avoid and reduce impacts, operations would likely result in **less than significant impacts** on energy and natural resources, including wind, electricity, fuels, and construction aggregate.

3.4.3 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.

3.4.3.1 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

    ***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.

3.4.3.2 Recommended measures for siting and design

- Minimize electricity demand by using project power for operational needs whenever possible, using high-efficiency fixtures and appliances in operations buildings, and using high-efficiency security lighting.
- Site and design facilities to minimize wind wake on any adjacent wind development**.**

3.4.3.3 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.

- Electrical Permits (Washington State Department of Labor and Industries)
- Sand and Gravel General Permit (Washington State Department of Ecology)
- Surface Mining Reclamation Permit (DNR)

3.4.3.4 Recommended measures for construction, operation, and decommissioning

- Minimize transportation and equipment fuels use by:
  - Encouraging carpooling or electric vehicle use by work crews or setting up ridesharing or shuttle programs
  - Using alternative fuel, electric, or latest-model-year vehicles as project service vehicles
  - Limiting engine idling time and shutting down equipment when not in use
- Minimize impacts to aggregate resources by reusing suitable excavated materials, identifying and securing commitments from commercial suppliers, and scheduling project construction to avoid simultaneous large demands on aggregate resources by other local projects.

3.4.3.5 Mitigation measures for potential significant impacts

- No potential significant impacts identified.

3.4.4 Unavoidable significant adverse impacts

Through compliance with laws and permits and with the implementation of measures to avoid, reduce, and mitigate impacts, construction, operation, or decommissioning would have **no significant and unavoidable adverse impacts** on energy and natural resources.

3.5 Onshore wind facilities with battery energy storage systems

The resource needs of co-located battery energy storage systems (BESSs) and onshore wind facilities are best understood in relation to conventional onshore wind facilities. While incorporating BESS requires additional construction inputs, adding BESS makes wind energy dispatchable to meet demand, even when the wind is not turning turbine blades.

BESS systems are typically containerized and require a very small fraction of the overall project footprint. BESSs can be added inside the boundary of the conventional wind project they support.

3.5.1 Impacts from construction and decommissioning

Onshore wind energy facilities with a BESS would require some additional resources during construction and decommissioning for the BESS portion of the project.

3.5.1.1 Electricity

Minor additional electricity demand for constructing the BESS storage container or structure would be needed. Electricity use may be more intensive for short periods during testing of the installed BESS equipment, prior to regular operations. Similar to projects without a BESS, the demand for energy during construction and decommissioning is not expected to require new or substantially modified production or energy transmission.

3.5.1.2 Fuels for transportation and equipment

Some additional hours for construction and installation would increase the demand for fuels to support worker commuting. Impacts would be similar to facilities described in Section 3.4, except that more truck trips would be required to transport the BESS and any additional gravel needed for the areas around the BESSs, and a few additional containers of support materials and equipment delivery may be required. The relative increase in fuel for construction and decommissioning of the BESS would be minimal compared to what is already demanded for the project.

3.5.1.3 Construction aggregate

A BESS would typically be installed on a concrete slab and/or gravel area. A concrete slab is typically 9 inches thick or less, compared to the 8- to 40-foot depth of each wind turbine foundation. The concrete required for these slabs would require aggregate, though far less than for the wind turbine foundations. The estimated aggregate required would be about 1,000 cubic yards per acre. One acre of slab supports up to 200 MWh of BESS capacity assuming 40-foot containerized units separated by 12-foot alleys, and 5 MWh maximum capacity per container (United Energy 2025). Projects without a BESS were estimated to require 14,000 to 500,000 cubic yards of aggregate, so the addition of a BESS to a project would not substantially change aggregate demand. Therefore, construction and decommissioning impacts would be similar to facilities without a BESS.

3.5.1.4 Summary of impacts from construction and decommissioning

Through compliance with laws and permits and with the implementation of measures to avoid and reduce impacts, construction and decommissioning activities of facilities with co-located BESSs would likely result in **less than significant impacts** on energy and natural resources, including electricity, fuels, and construction aggregate.

3.5.2 Impacts from operation

A BESS would require additional resources during operations and maintenance.

3.5.2.1 Wind

A BESS does not alter an onshore wind energy facility's impact to the wind resource. Impacts would be the same as facilities without a BESS.

3.5.2.2 Electricity

Electricity demands for facilities with a BESS would be similar to facilities without a co-located BESS. BESSs have a round-trip efficiency of approximately 90% (EIA 2021). That is, approximately 10% of the stored energy is lost as heat during operation of the system. This loss can be characterized as an energy requirement of the system, but because the lost energy is drawn entirely from the storage input, it is not drawn from the associated electric grid.

3.5.2.3 Fuels for transportation and equipment

Adding BESSs would require additional hours for maintenance, which would result in a minor increased demand for fuels beyond what is already required for operation of the project as a whole.

3.5.2.4 Construction aggregate

Similar to projects without a BESS, during operation and maintenance, construction aggregate would be needed only to maintain roads. Since the BESS would be co-located with the project, there would be no additional demands for aggregate resources during operations.

3.5.2.5 Summary of impacts from operation

Through compliance with laws and permits and with the implementation of measures to avoid and reduce impacts, operation activities of facilities with co-located BESSs would likely result in **less than significant impacts** on energy and natural resources, including electricity, fuels, and construction aggregate.

3.5.3 Measures to avoid, reduce, and mitigate impacts

Measures to avoid, reduce, and mitigate impacts are the same as those identified in Section 3.4.3.

3.5.4 Unavoidable significant adverse impacts

Through compliance with laws and permits and with the implementation of measures to avoid, reduce, and mitigate impacts, construction, operation, or decommissioning of facilities with co-located BESSs would have **no significant and unavoidable adverse impacts** on energy and natural resources.

3.6 Onshore wind facilities that include agricultural uses

Most wind facilities share their land with agricultural users (Hall et al. 2022). Nationwide, wind energy development on agricultural land correlates with a conversion to non-agricultural use in only 0.5% of cases (1 out of every 200 turbine installations; Maguire et al. 2024).

3.6.1 Impacts from construction and decommissioning

3.6.1.1 Electricity

Retained, new, or modified agricultural uses would not add electric demands during onshore wind facility construction or decommissioning and demands on local electricity during construction and decommissioning would be the same as those considered in Section 3.4. Demand is not expected to require new or substantially modified production or energy transmission.

3.6.1.2 Fuels for transportation and equipment

Retained, new, or modified agricultural uses would not add fuel demands during onshore wind facility construction or decommissioning. Demands on fuels during construction and decommissioning would be similar to those considered for projects without agricultural land use.

3.6.1.3 Construction aggregate

Retained, new, or modified agricultural uses may demand less construction aggregate than facilities without agricultural land use if project design focuses on maximizing arable land and minimizing access roads. Construction aggregate is typically adverse to cropland, so projects would likely minimize loose aggregate on site, and the gross demand for construction aggregate might be reduced in comparison to projects without agricultural uses. However, any such reduction would be small compared to the volumes required for turbine foundations. Because new foundations and infrastructure would not be created, decommissioning or repowering is not expected to require additional construction aggregate.

3.6.1.4 Summary of impacts from construction and decommissioning

Through compliance with laws and permits and with the implementation of measures to avoid and reduce impacts, the construction and decommissioning of onshore wind energy facilities with co-located agricultural use would likely result in **less than significant impacts** on energy and natural resources, including electricity, fuels, and construction aggregate.

3.6.2 Impacts from operation

For a project that includes agricultural land uses, any existing agricultural lands would be maintained, or new agricultural use could be co-located with the utility-scale onshore wind facility, including rangeland or farmland. Activities may include maintenance of existing or addition of new infrastructure, roads, fences, gates, and operation of farming machinery. If the agricultural uses exist prior to project construction, there would not be additional energy or resource use beyond the continuation current conditions and the impacts considered for projects without agricultural uses. New agricultural uses could generate some additional seasonal and temporary resource use from discing, harvesting, or other activities involving agricultural equipment. During operations, the agricultural use could require more maintenance-related truck trips, which would vary by project.

Cropland would demand some additional operational energy relative to rangeland. This analysis assumes that all irrigation (pump) energy would be provided as electricity, while all other field (mobile equipment) energy requirements would be provided as diesel fuel.

3.6.2.1 Wind

Agricultural land use will not alter an onshore wind energy facility's impact to the wind resource. Impacts would be the same as facilities without agricultural uses.

3.6.2.2 Electricity

Electric demand of irrigation in Washington state is approximately 1,000 kWh per acre-foot (Whittlesey and Gibbs 1978). Assuming 60 acres of lease boundary land surrounding each turbine and 6 inches of annual irrigation, the new electric demand associated with irrigation, if it is used at all, would be 30 MWh/turbine-year. If this is an existing use, there is not an additional use of electricity. Because turbines can generate over 4,000 MWh/year, any new potential electric demand can be supplied by project output.

3.6.2.3 Fuels for transportation and equipment

Farming of medium-maintenance crops like soy, corn, or wheat requires four to six gallons of diesel fuel per acre (Hanna and Sawyer 2012; Gjerek et al. 2021). Assuming 60 acres of lease boundary land surrounding each wind turbine, adding new crop farming to an onshore wind energy facility could add 2.5 to 3.5 times the fuel demand compared to the fuel required for turbine maintenance in projects without agricultural uses.

3.6.2.4 Construction aggregate

Agricultural land use would not induce additional demands for aggregate resources.

3.6.2.5 Summary of impacts from operation

Through compliance with laws and permits and with the implementation of measures to avoid and reduce impacts, the operation of facilities with co-located agricultural use would likely result in **less than significant impacts** on energy and natural resources, including electricity, fuels, and construction aggregate.

3.6.3 Measures to avoid, reduce, and mitigate impacts

Measures to avoid, reduce, and mitigate impacts are the same as those identified in Section 3.4.3.

3.6.4 Unavoidable significant adverse impacts

Through compliance with laws and permits and with the implementation of measures to avoid, reduce, and mitigate significant impacts, construction, operation, or decommissioning of facilities with co-located agricultural use would have **no significant and unavoidable adverse impacts** on energy and natural resources.

3.7 No Action Alternative

Under the No Action Alternative, agencies would continue to conduct environmental review and permitting for utility-scale onshore wind energy projects 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 project size and design, and would likely result in **less than significant impacts**.

4 References

Archer, C.L., A. Vasel-Be-Hagh, C. Yan, S. Wu, Y. Pan, J.F. Brodie, and A. Eoghan Maguire, 2018. "Review and evaluation of Wake Loss Models for Wind Energy Applications." *Applied Energy* 226:1187–1207.

Davis, S.C., and R.G. Boundy, 2022. *Transportation Energy Data Book: Edition 40*. Oak Ridge National Laboratory. June 2022.

DNR (Washington Department of Natural Resources), 2023. Washington Geologic Information Portal. Accessed March 2024. Available at: https://geologyportal.dnr.wa.gov/2d-view#natural_hazards?-14334696,-13165515,5825030,6390053.

DNR, 2024. “Aggregate Resources.” Accessed February 20, 2024. Available at: https://www.dnr.wa.gov/aggregate-resources.

Draxl, C., B.M. Hodge, A. Clifton, and J. McCaa. 2015. "The Wind Integration National Dataset (WIND) Toolkit." *Applied Energy* 151: 355366.

EFSEC (State of Washington Energy Facility Site Evaluation Council), 2005. *Wild Horse Wind Power Project – Final Environmental Impact Statement*. May 2005. Available at: https://www.efsec.wa.gov/energy-facilities/wild-horse-wind-power-project/wild-horse-wind-power-project-sepa.

EFSEC, 2007. *Kittitas Valley Wind Power Project – Final Environmental Impact Statement*. February 2007. Available at: https://www.efsec.wa.gov/efsec-document/Kittitas%20Valley%20Wind%20Power%20Project/SEPA/Final%20EIS.

EFSEC, 2011. *Whistling Ridge Energy Project – Final Environmental Impact Statement*. August 2011. Available at: https://www.efsec.wa.gov/energy-facilities/whistling-ridge-energy-project/whistling-ridge-energy-project-sepa.

EFSEC, 2023. *Horse Heaven Wind Farm – Final Environmental Impact Statement*. October 2023. Available at: https://www.efsec.wa.gov/energy-facilities/horse-heaven-wind-project/horse-heaven-sepa.

EIA (U.S. Energy Information Administration), 2021. “Utility-Scale Batteries and Pumped Storage Return About 80% of the Electricity They Store.” *Power Plant Operations Report*. February 12, 2021. Available at: https://www.eia.gov/todayinenergy/detail.php?id=46756.

EIA, 2024a. Interactive Data Viewer. Accessed June 2024. Available at: https://eia.maps.arcgis.com/apps/webappviewer/index.html?id=5395ae9a72a04064932c1c11efc1db3e.

EIA, 2024b. Table CT7. *Transportation Sector Energy Consumption Estimates, 1960–2022, Washington*. Available at: https://www.eia.gov/state/seds/data.php?incfile=/state/seds/sep_use/tra/use_tra_WA.html&sid=WA.

EIA, 2024c. “Profile Analysis – Washington.” April 18, 2024. Available at: https://www.eia.gov/state/?sid=WA#tabs-3.

EIA, 2024d. “Electricity data browser – Retail sales of electricity.” May 3, 2024. Available at: https://www.eia.gov/electricity/data/browser/#/topic/5?agg=0,1&geo=000000000001&endsec=vg&linechart=ELEC.SALES.WA-ALL.A&columnchart=ELEC.SALES.WA-ALL.A&map=ELEC.SALES.WA-ALL.A&freq=A&ctype=linechart&ltype=pin&rtype=s&pin=&rse=0&maptype=0.

EIA, 2024e. “Electricity data browser - Net generation for electric power.” May 3, 2024. Available at: https://www.eia.gov/electricity/data/browser/#/topic/0?agg=2,0,1&fuel=ftt9&geo=000000000001&sec=008&linechart=ELEC.GEN.COW-WA-98.A&columnchart=ELEC.GEN.COW-WA-98.A&map=ELEC.GEN.COW-WA-98.A&freq=A&ctype=linechart&ltype=pin&rtype=s&pin=&rse=0&maptype=0.

El-Asha, S., L. Zhan, and G.V. Iungo, 2017. "Quantification of Power Losses Due to Wind Turbine Wake Interactions Through SCADA, Meteorological and Wind LiDAR Data." *Wind Energy* 20(11):1823–1839.

Gjerek, M., A. Morgan, N. Gore-Brown, and G. Womersley, 2021. *Diesel Use in NSW Agriculture and Opportunities to Support Net Zero Emissions*. Sydney: Australian Alliance for Energy Productivity for NSW Department of Primary Industries.

Hall, P.K., W. Morgan, and J. Richardson, 2022. “Land Use Conflicts Between Wind and Solar Renewable Energy and Agriculture Uses.” National Agricultural Law Center. April 2022.

Hanna, M., and J.E. Sawyer, 2012. *Energy Consumption for Row Crop Production*. Iowa State University. June 2012.

Maguire, K., S. Tanner, J. Winikoff, and R. Williams, 2024. *Utility-Scale Solar and Wind Development in Rural Areas: Land Cover Change (2009–20)*. Report No. ERR-330. U.S. Department of Agriculture, Economic Research Service. May 2024.

Skorseth, K., and A.A. Selim, 2000. *Gravel Roads: Maintenance and Design Manual*. November 2000.

United Energy, 2025. “Integrated Design 1MWh-5MWh Energy Storage Container.” Accessed March 2025. Available at: https://www.unitedpvsolar.com/integrated-design-1mwh-5mwh-energy-storage-container.

USGS (U.S. Geological Survey), 2024. *Mineral Industry Surveys: Crushed Stone and Sand and Gravel in the Fourth Quarter 2023*. February 2024. Available at: https://www.usgs.gov/centers/national-minerals-information-center/crushed-stone-statistics-and-information.

Whittlesey, N., and K.C. Gibbs, 1978. "Energy and Irrigation in Washington." *Western Journal of Agricultural Economics*. July 1978.