Appendix F: Energy and Natural Resources Report

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

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For the

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DEPARTMENT OF ECOLOGY
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Acronyms and Abbreviations List

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

Executive Summary

The type and quantity of energy and natural resources used in construction, operation, and decommissioning of a utility-scale wind energy facility can affect overall availability of energy sources for other uses. This resource report reviews energy and mineral resources in the study area; assesses demands for electricity, transportation fuel, and construction aggregate by the different facility types; and evaluates impacts to energy and mineral resources due to the assessed demands, by facility type.

The key resources that are applicable to utility-scale onshore wind energy facilities 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.
- Transportation fuels including gasoline and diesel fuel.
- Construction aggregate (the collective term for sand, gravel, and crushed stone).

The analysis of onshore wind energy facilities found the following:

- Through compliance with laws and permits and with implementation of actions that could avoid and reduce impacts, the construction, operation, and decommissioning of facilities 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 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 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 actions 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 actions to avoid and reduce impacts

1 Introduction

This resource report describes energy and natural resources within the study area and assesses probable impacts associated with types of facilities (alternatives), including 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 evaluated in this resource report 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 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 wind energy facilities.

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 facility 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.

Regulation, statute, guideline	Description
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 areas for the energy and natural resources element includes the overall onshore wind geographic study area (Figure 1).

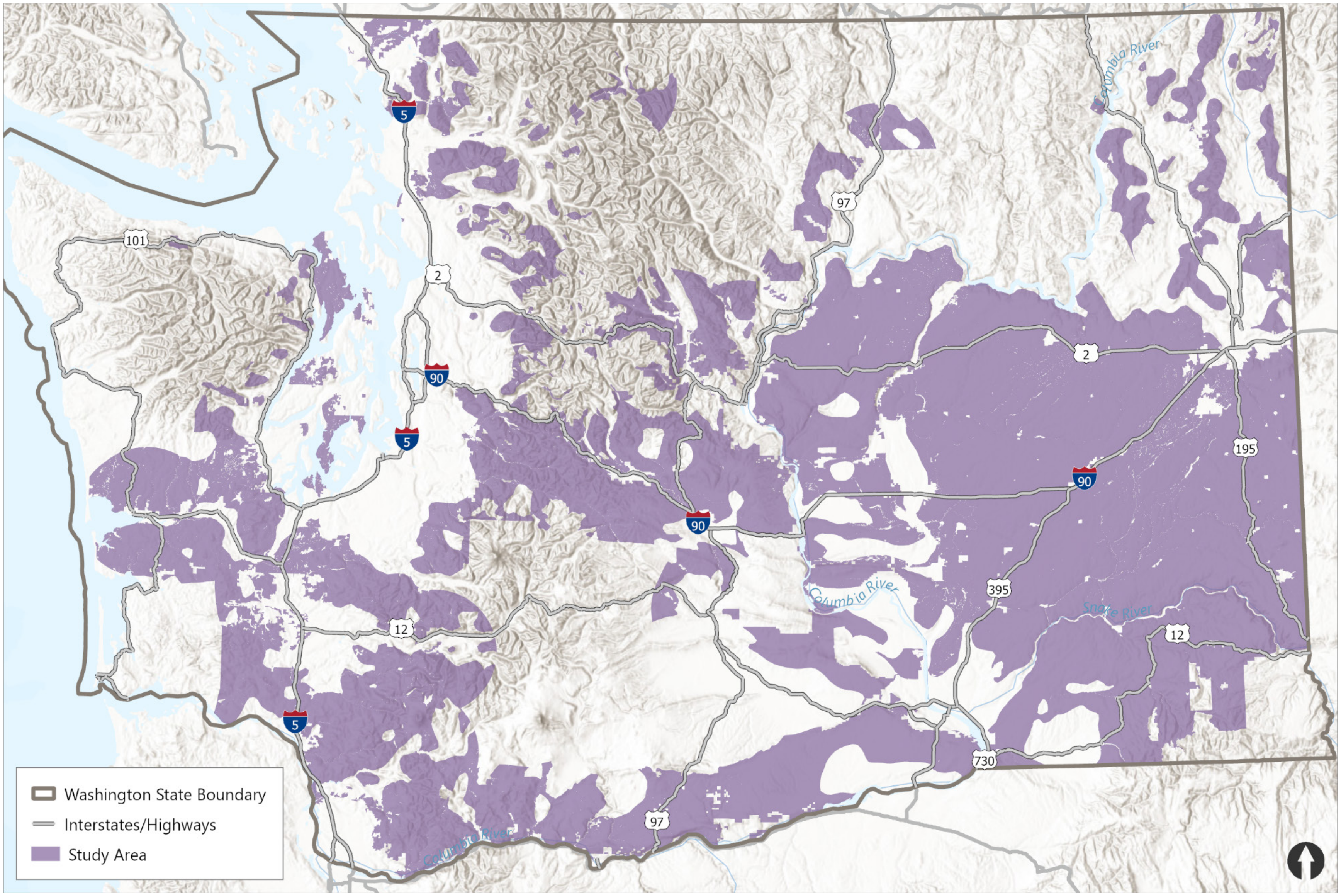

Figure 1. Onshore Wind Energy Facilities PEIS – geographic scope of study

2.2 Technical approach

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 facilities, worker commuting, transportation of materials and equipment, and on-site equipment.
2. Calculate needs for these resources relative to the facility 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

Impacts on energy and natural resources would occur if a facility resulted in any of 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 transportation fuels sufficient to affect statewide annual production
- Demand for construction aggregate sufficient to induce one or more new surface mines

This resource report covers only impacts of energy *consumption* by a new onshore wind energy facility. Impacts on public service or utility providers are analyzed in the *Public Services and Utilities Resource Report* (ESA 2024a). Emissions that may be associated with use of energy and natural resources are analyzed in the *Air Quality and Greenhouse Gases Resource Report* (ESA 2024b).

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 actions that could avoid, minimize, or reduce the identified impacts, and potential unavoidable significant adverse impacts. This resource report analyzes resources and demands on primary energy, secondary energy, and construction aggregate during construction, operation, and decommissioning of the facilities considered.

3.2 Affected environment

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 plays
- 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 transportation fuels (gasoline and diesel fuel) are described in more detail below.

All remaining natural resources that are relevant to onshore wind energy facilities are evaluated in other PEIS 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 study area for the PEIS is broader than where facilities are being built now because new technologies could allow development of 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.

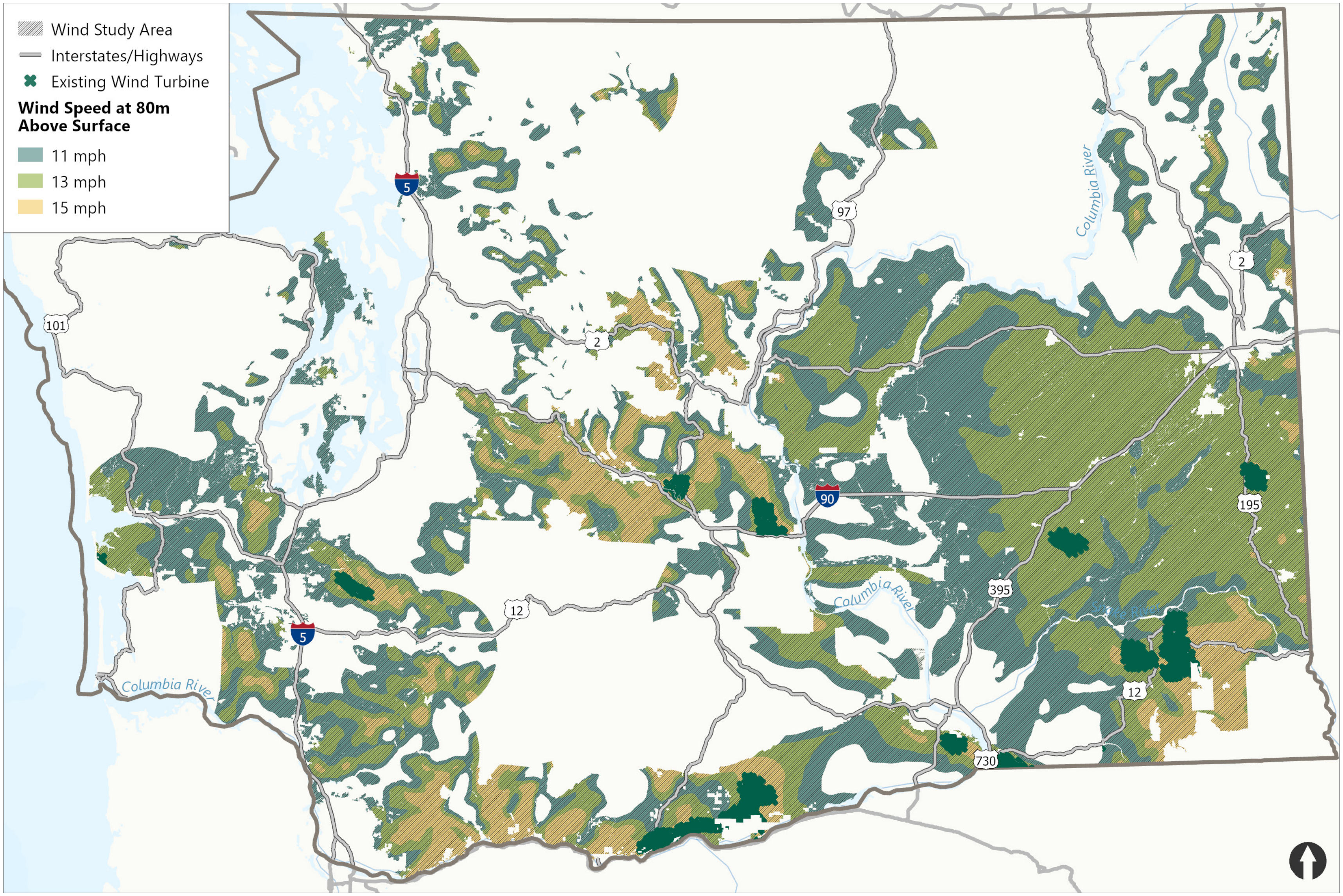

Figure 2. Wind resource and existing wind facilities

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**

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**

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 Transportation fuel

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

As with electricity, Washington is a net exporter of transportation 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.[3]

The Clean Fuel Standard (Chapter 70A.535 Revised Code of Washington [RCW]) requires suppliers to gradually reduce the carbon intensity of transportation 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] 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).

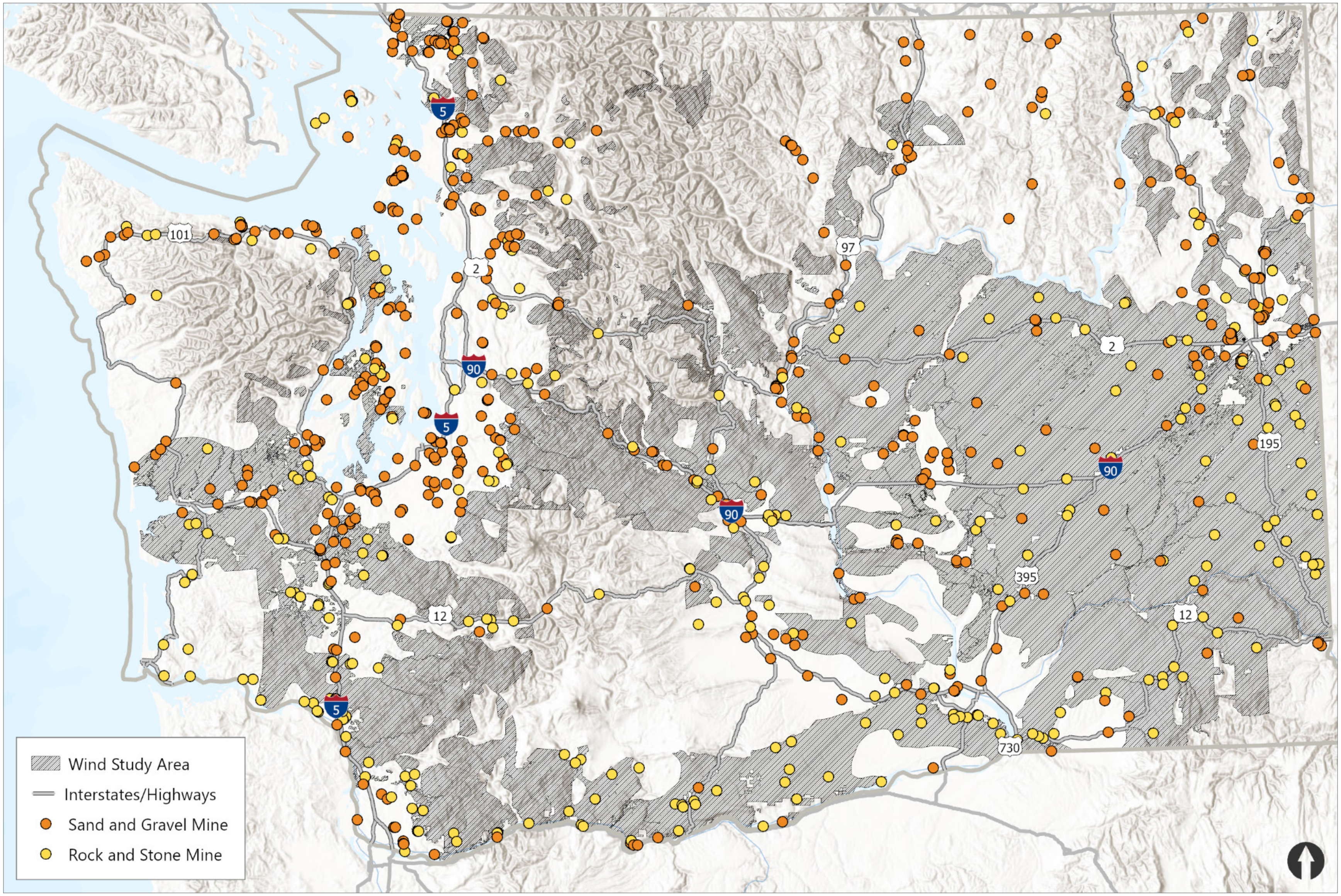

Figure 3. Aggregate resource locations

Data source: DNR 2023

3.3 Potentially required permits

If the facility developer would be drawing electricity from the local utility during the construction phase, then the following electrical permit would be required (L&I 2024):[4]

- Washington State Department of Labor and Industries (L&I) electrical permit, via Electronic Permit and Inspection System[5]

Transportation fuels consumed for onshore wind energy facilities would be purchased on the open market, which requires no permits.

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

- DNR's Surface Mining Reclamation Permit for extraction of materials such as sand, gravel, or rock from state- or privately owned lands
- Washington State Department of Ecology's (Ecology's) Sand and Gravel Permit for extraction of materials that have a discharge of process wastewater, stormwater, or mine dewatering water

3.4 Small to medium utility-scale facilities of 10 MW to 250 MW (Alternative 1)

The total area of an onshore wind energy facility capable of generating between 10 and 250 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, transportation fuels, and construction aggregate would vary depending on the size and nature of each wind facility. The extent and magnitude of impacts would also vary depending on the geographical region of a specific facility 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).

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[4] This resource report covers only impacts of energy *consumption* by an energy project. Additional permits are likely required for the energy project's generation intertie.

[5] Some cities, and Tacoma Power, displace the L&I electrical permits with their own electrical permits. However, because the study area excludes urban areas, the relevant permitting agency will always be L&I.

3.4.1 Impacts from construction

Small to medium facilities would consume electricity and transportation fuel during the site characterization and construction phase 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 and construction 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 transportation fuel demand (see next subsection). In the case of electricity provided by a utility, the facility developer would collaborate with the local utility to extend distribution infrastructure to the facility. Electricity demands for construction of small to medium facilities are typical of construction projects generally, and they are often dominated by construction trailers.

3.4.1.2 Transportation fuels

Small to medium facilities would consume transportation fuels during site characterization and construction for three broad purposes: on-road fuels (diesel and gasoline) for worker commuting, on-road fuels for haul-truck trips, and off-road fuels (diesel and dyed diesel) for site equipment.

The *Transportation Resource Report* estimates 100 to 400 workers per energy facility site, with construction lasting 6 to 24 months (ESA 2024c). 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 891,000 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 61,700 gallons of transportation fuels on site.

The *Transportation Resource Report* estimates 49 to 1,169 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), 2,370 gallons and 56,600 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 1.01 million gallons of transportation fuels, representing between 0.0019% and 0.032% of Washington's gross annual production.

3.4.1.3 Construction aggregate

Construction of facilities 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 small to medium utility-scale facility would require between 14,000 cubic yards and 332,000 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 0.73% of the total available resource produced annually. The total of 45.3 million metric tons of aggregate comes from 842 active permitted surface mines in the state. Aggregate may need to be obtained from multiple mines, depending on the facility location.

To keep costs down, facility proponents would typically source aggregate as close as possible to the proposed facility site, with a 25-mile haul typically doubling the cost of aggregate products (DNR 2024).

Impacts on aggregate resources in the vicinity of a facility 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 simultaneous or consecutive projects occurring in the same region.

Through compliance with laws and permits and with implementation of actions that could avoid and reduce impacts, the construction of facilities would likely result in **less than significant impacts** on energy and natural resources, including electricity, transportation 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 facility 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 facility, the distance to any proposed, neighboring facility, and the geometry of any proposed, neighboring facility. 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 facility-level energy loss at adjacent lands (El-Asha et al. 2017). Such effects should be considered in siting and design of facilities at the project level to account for adjacent wind facilities.

Through compliance with laws and permits and with implementation of actions that could avoid and reduce impacts, the operation of facilities would likely result in **less than significant impacts** on wind resources.

3.4.2.2 Electricity

Once operating, a wind facility consumes a small amount of electricity in addition to generating it. Electricity would be used to power operations and maintenance buildings, sensors, lights, and similar. This energy consumption is much less than the energy generated by the facility and may be drawn from the facility's own generation ("parasitic load") or may be drawn from the local electric utility, depending on facility specifications. Facilities able to draw parasitic electricity may still draw from the local electric utility when wind speed is low. A small to medium utility-scale wind facility would require between 50 and 1,200 megawatt-hours (MWh) of electricity per year. This represents roughly 0.2% of the facility's production.

3.4.2.3 Transportation fuels

Small to medium facilities would consume gasoline and diesel fuels for maintenance vehicles during the life of the facility. 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). Even for the medium utility-scale facilities, this consumption would be very small in the context of transportation 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 8,000 cubic yards per year depending on facility size and access points (Skorseth and Selim 2000).

Through compliance with laws and permits and with implementation of actions that could avoid and reduce impacts, the operation of small to medium facilities would likely result in **less**

than significant impacts on energy and natural resources, including electricity, transportation fuels, and construction aggregate.

3.4.3 Impacts from decommissioning

Small to medium facilities would consume energy and natural resources during the decommissioning phase, similar in nature to those anticipated during construction activities.

3.4.3.1 Electricity

Decommissioning a facility at the end of its useful life would remove generating capacity from the region, which would have to be replaced by an equal amount of generation to meet energy demand. Rather than decommissioning, once turbines have reached the end of their useful life, it is common to replace aged equipment with modern, more efficient ones, 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.

3.4.3.2 Transportation fuels

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

3.4.3.3 Construction aggregate

Because new foundations and infrastructure would not be created, decommissioning or repowering is not expected to require additional on congregation aggregate.

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

3.4.4 Actions to avoid and reduce impacts

Site-specific mitigation actions would be developed during project-specific reviews and permitting for each facility proposed in the future. The following types of actions would avoid and reduce potential impacts.

3.4.4.1 Siting and design considerations

To reduce impacts on energy and natural resources, applicants may consider the following options:

- Site and design facilities to minimize wind wake on any adjacent wind development.
- Limit construction of new roads and design new roads based on federal, state, and local requirements and based on local climate conditions, soil moisture, and erosion potential. Consider the use of existing roads, parking and staging areas, and utility corridors to the maximum extent feasible and if safe and structurally sound. Design any new access roads to the appropriate standard no higher than necessary for the intended function.
- Minimize electricity demand by using facility power for operational needs whenever possible, using high-efficiency fixtures and appliances in operations buildings, and using high-efficiency security lighting.

3.4.4.2 Permits, plans, and BMPs

This section lists actions associated with potential permits, plans, or best management practices (BMPs). BMPs are activities, maintenance procedures, managerial practices, or structural features that prevent or reduce adverse impacts. These may be required in permits or plans by a regulatory agency and include the following:

- If the facility has an aggregate storage capacity of oil greater than 1,320 gallons or where a discharge could reach a navigable water body, either directly or indirectly, a Spill Prevention, Control, and Countermeasure Plan is required to prevent spills during construction and operation and to identify measures to expedite the response to a release if one were to occur. The plan would be prepared in consultation with Ecology and pursuant to the requirements of *Code of Federal Regulations* Part 112, Sections 311 and 402 of the Clean Water Act, Section 402 (a)(1) of the Federal Water Pollution Control Act, and RCW 90.48.080.
- Minimize transportation fuels use by encouraging carpooling or electric vehicle use for work crews, providing multiple site access locations and routes, shifting work hours to facilitate off-peak commuting times to minimize congestion, or implement a ride-sharing or shuttle program. These actions would mitigate impacts related to the daily commutes of construction workers.
- Use alternative fuel, electric, or latest-model-year vehicles as facility service vehicles.
- Implement operational measures such as limiting engine idling time and shutting down equipment when not in use.
- Limit the idling time of diesel equipment to no more than 5 minutes unless idling must be maintained for proper operation (e.g., drilling, hoisting, and trenching).
- Reuse suitable excavated materials to replace in disturbed areas once construction has been completed.
- Recycle all components of a facility that have the potential to be used as raw materials in commercial or industrial applications.
- Identify and secure commitments from aggregate suppliers with maximum possible notice.

- Schedule facility construction to avoid simultaneous large demands on the aggregate resource by other local projects.

3.4.5 Unavoidable significant adverse impacts

Through compliance with laws and permits and with implementation of actions to avoid and mitigate significant impacts, small to medium utility-scale onshore wind energy facilities would have **no significant and unavoidable adverse impacts** on energy and natural resources from construction, operation, or decommissioning.

3.5 Large utility-scale facilities of 251 MW to 1,500 MW (Alternative 2)

Onshore wind energy facilities capable of generating between 251 and 1,500 MW of energy would have varied demand for electricity, transportation fuels, and construction aggregate depending on the size and nature of each wind facility. The ranges of estimates given below are based on powering a 251-MW wind facility utilizing 1.5-MW nameplate capacity turbines and powering a 1,500-MW wind facility utilizing 6-MW turbines. This recognizes a facility developer's likely choice to leverage efficiency of scale in the largest facilities.

3.5.1 Impacts from construction

Large facilities would consume energy and natural resources during the site characterization and construction phase to run construction equipment, generators, and vehicles. Construction would use aggregate for concrete turbine, gen-tie line, and building foundations and for constructing access roads. Gravel would likely be used for parking areas and equipment storage areas.

3.5.1.1 Electricity

Though electricity demands for large facilities would be proportionally higher than those for small to medium facilities, the electric loads are identical, limited to low demands for some stationary construction equipment and construction trailers/housing. During site characterization and construction of large facilities, the demand for electricity is not expected to require new or substantially modified production or energy transmission.

3.5.1.2 Transportation fuels

Construction worker travel times would likely be similar to those noted for small to medium facilities, but to the extent the size and schedule for the facilities would require more workers or a longer construction period. The increase is probably less than proportional because there will be some efficiencies of scale, in particular due to the higher likelihood of very large turbine sizes for large facilities.

On-site construction equipment activities would be similar to those for small to medium facilities but scaled proportionately, requiring between 62,500 and 93,000 gallons of fuel. The demand for freight transport would increase proportionately to the greater number of turbines and/or larger turbines. The *Transportation Resource Report* estimates 1,180 to 7,000 truckloads required to deliver wind turbine components for large facilities, meaning 57,100 to 339,000 gallons of fuel demand for wind turbine transportation.

Construction of a large onshore wind energy facility would require a total of 388,000 to 1.32 million gallons of transportation fuels, equivalent to 0.01% to 0.04% of statewide annual production. This demand would be temporary over the 6- to 18-month construction period.

3.5.1.3 Construction aggregate

A large onshore wind energy facility would require between 336,000 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 demands would range from 0.74% to 1.1% of the total available resource produced annually. This would be for the construction period of 6 to 18 months. The total of 45.3 million metric tons of aggregate comes from 842 active permitted surface mines in the state. Aggregate may need to be obtained from multiple mines, depending on the facility location.

Through compliance with laws and permits and with implementation of actions that could avoid and reduce impacts, the construction of large facilities would likely result in **less than significant impacts** on energy and natural resources, including electricity, transportation fuels, and construction aggregate.

3.5.2 Impacts from operation

3.5.2.1 Wind

Impacts would be similar to those for small to medium facilities.

3.5.2.2 Electricity

A large facility would draw somewhat more electricity during operation and maintenance, but likely benefiting from the efficiencies of scale associated with very large turbine sizes used in some facilities to require between 1,200 and 1,800 MWh per year. This represents roughly 0.2% of the facility’s production.

3.5.2.3 Transportation fuels

Operation and maintenance of large facilities would require approximately 102 gallons per turbine per year (combined between gasoline and diesel).

3.5.2.4 Construction aggregate

If it is assumed that new surface gravel is required once every 5 years, at a depth of 4 inches, average annual demand will range between 8,160 and 12,140 cubic yards per year depending on facility size and access points.

Through compliance with laws and permits and with implementation of actions that could avoid and reduce impacts, the operation of large facilities would likely result in **less than significant impacts** on energy and natural resources, including electricity, transportation fuels, and construction aggregate.

3.5.3 Impacts from decommissioning

Large facilities would consume energy and natural resources during the decommissioning phase, similar in nature to those anticipated during construction activities.

3.5.3.1 Electricity

Decommissioning or repowering impacts on local or regional demand for electricity would be similar to construction.

3.5.3.2 Transportation fuels

Decommissioning or repowering large facilities would demand 388,000 to 1.32 million gallons of transportation fuels, the same as construction

3.5.3.3 Construction aggregate

Because new foundations and infrastructure would not be created, decommissioning or repowering is not expected to require additional construction aggregate.

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

3.5.4 Actions to avoid and reduce impacts

Actions to avoid and reduce impacts are the same as those identified for small to medium facilities (Section 3.4.4).

3.5.5 Unavoidable significant adverse impacts

Through compliance with laws and permits and with implementation of actions to avoid and mitigate significant impacts, large utility-scale onshore wind energy facilities would have **no significant and unavoidable adverse impacts** on energy and natural resources from construction, operation, or decommissioning.

3.6 Wind energy facility and co-located battery energy storage system (Alternative 3)

The resource needs of co-located battery energy storage systems (BESSs) and wind facilities are best understood in relation to conventional 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 facility footprint. BESSs can be added inside the boundary of the conventional wind facility they support.

3.6.1 Impacts from construction

Relative to a conventional wind installation, wind augmented with a BESS would require some additional resources during construction for the BESS portion of the facility.

3.6.1.1 Electricity

Compared to facilities analyzed in Sections 3.4 and 3.5, construction of a utility-scale onshore wind energy facility and a co-located BESS would be similar, with a minor addition of additional electricity demand for constructing the BESS storage container or structure. Electricity use may be more intensive for short periods during testing of the installed BESS equipment, prior to regular operations. Similar to facilities without a BESS, the demand for energy during construction is not expected to require new or substantially modified production or energy transmission.

3.6.1.2 Transportation fuels

Adding BESS to conventional wind energy facilities would require some additional hours for construction and installation, increasing demand for transportation fuels to support worker commuting. Impacts would be similar to facilities described in Sections 3.4 and 3.5, 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 of the BESS would be minimal compared to what is already demanded for construction of the larger facility.

3.6.1.3 Construction aggregate

A BESS would typically be installed on a concrete slab and/or gravel area. A concrete slab is typically 6 to 8 inches thick, 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, and an acre of slab would be sufficient to support 40 to 200 MWh of BESS capacity. Facilities without a BESS were estimated to require 14,000 to 500,000 cubic yards, so the addition of a BESS to a facility would not be a dramatic change to aggregate demand. Therefore, construction impacts would be similar to facilities without a BESS.

Through compliance with laws and permits and with implementation of actions that could avoid and reduce impacts, the construction of onshore wind energy facilities with co-located BESSs would likely result in **less than significant impacts** on energy and natural resources, including electricity, transportation fuels, and construction aggregate.

3.6.2 Impacts from operation

A BESS would require additional resources during operations and maintenance.

3.6.2.1 Wind

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

3.6.2.2 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.

3.6.2.3 Transportation fuels

Adding BESSs to a conventional wind facility would require additional hours for maintenance, which would result in a minor increased demand for transportation fuels beyond what is already demanded for operation of the facility as a whole.

3.6.2.4 Construction aggregate

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

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

3.6.3 Impacts from decommissioning

3.6.3.1 Electricity and transportation fuels

Impacts from decommissioning or repowering resemble those from construction for electricity and transportation fuels.

3.6.3.2 Construction aggregate

Because new foundations and infrastructure would not be created, decommissioning or repowering is not expected to require additional congregation aggregate.

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

3.6.4 Actions to avoid and reduce impacts

Actions to avoid and reduce impacts are the same as those identified for small to medium facilities (Section 3.4.4).

3.6.5 Unavoidable significant adverse impacts

Through compliance with laws and permits and with implementation of actions to avoid and mitigate significant impacts, large utility-scale onshore wind energy facilities with co-located BESSs would have **no significant and unavoidable adverse impacts** on energy and natural resources from construction, operation, or decommissioning.

3.7 Wind energy facility combined with agricultural land use (Alternative 4)

Most wind facilities share their land with agricultural users (Hall et al. 2022; Retik 2021). 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).

3.7.1 Impacts from construction

3.7.1.1 Electricity

Retained, new, or modified agricultural uses would not add electric demands during wind facility construction and demands on local electricity during construction would be the same as those considered for facilities in Sections 3.4 and 3.5. Similar to facilities without agricultural land use, the demand for energy during construction is not expected to require new or substantially modified production or energy transmission.

3.7.1.2 Transportation fuels

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

3.7.1.3 Construction aggregate

Retained, new, or modified agricultural uses may demand less construction aggregate than facilities without agricultural land use if facility design focuses on maximizing arable land and minimizing access roads. Construction aggregate is typically adverse to cropland, so facilities would likely minimize loose aggregate on site, and the gross demand for construction aggregate might be reduced in comparison to facilities without agricultural uses. However, any such reduction would be small compared to the volumes required for turbine foundations.

Through compliance with laws and permits and with implementation of actions that could avoid and reduce impacts, the construction 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, transportation fuels, and construction aggregate.

3.7.2 Impacts from operation

For a facility 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 at such facilities 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 facility construction, there would not be additional energy or resource use beyond the continuation current conditions and the impacts considered for facilities 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 agrivoltaic features of these facilities could require more maintenance-related truck trips, which would vary by facility.

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.

3.7.2.1 Wind

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

3.7.2.2 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 of irrigation can be supplied by facility output.

3.7.2.3 Transportation fuels

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 a wind energy facility could add 2.5 to 3.5 times the transportation fuel demand compared to the fuel required for turbine maintenance in facilities without agricultural uses.

3.7.2.4 Construction aggregate

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

Through compliance with laws and permits and with implementation of actions that could avoid and reduce impacts, the operation 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, transportation fuels, and construction aggregate.

3.7.3 Impacts from decommissioning

3.7.3.1 Electricity and transportation fuels

Impacts from decommissioning or repowering resemble those from construction for electricity and transportation fuels.

3.7.3.2 Construction aggregate

Because new foundations and infrastructure would not be created, decommissioning or repowering is not expected to require additional construction aggregate.

Through compliance with laws and permits and with implementation of actions that could avoid and reduce impacts, the 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, transportation fuels, and construction aggregate.

3.7.4 Actions to avoid and reduce impacts

Actions to avoid and reduce impacts are the same as those identified for small to medium facilities (Section 3.4.4), with the following addition::

- Where possible, supply new electric demand for irrigation equipment utilizing wind turbine energy output.

3.7.5 Unavoidable significant adverse impacts

Through compliance with laws and permits and with implementation of actions to avoid and mitigate significant impacts, large utility-scale onshore wind energy facilities with co-located agricultural use would have **no significant and unavoidable adverse impacts** on energy and natural resources from construction, operation, or decommissioning.

3.8 No Action Alternative

Under the No Action Alternative, city, county, and state agencies would continue to conduct environmental review and permitting for utility-scale wind energy development under existing state and local laws on a facility-by-facility basis.

The potential for energy and natural resource use for future utility-scale wind energy developments under the No Action Alternative would be similar as those noted for Alternatives 1 through 4, depending on facility size and design, and would have **less than significant impacts**.

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