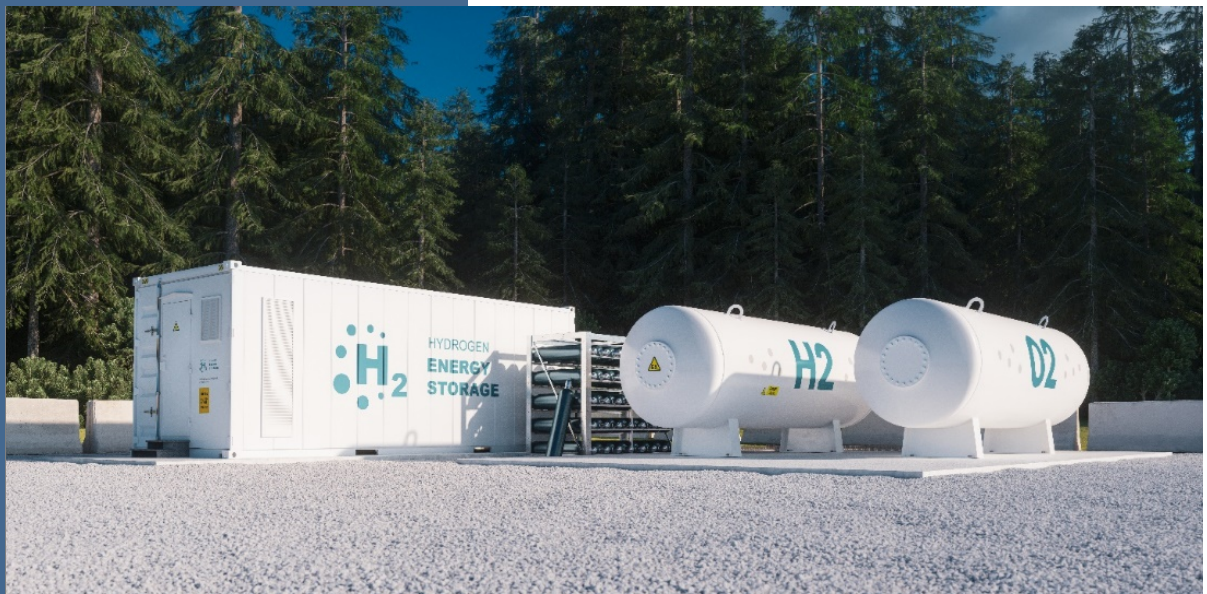

Appendix H: Energy and Natural Resources Technical Appendix

For Programmatic Environmental Impact Statement on Green Hydrogen Energy Facilities in Washington State

By

HDR

For the

Shorelands and Environmental Assistance Program

Washington State Department of Ecology

Olympia, Washington

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DEPARTMENT OF
ECOLOGY
State of Washington

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Acronyms and Abbreviations List

BESS	battery energy storage system
Commerce	Washington State Department of Commerce
DNR	Washington State Department of Natural Resources
Ecology	Washington State Department of Ecology
GW	gigawatt(s)
kg	kilogram
kWh	kilowatt-hours
MT	metric ton(s)
PEIS	Programmatic Environmental Impact Statement
RCW	Revised Code of Washington
RNG	renewable natural gas
scf	standard cubic feet
SMR	steam-methane reforming

Summary

This technical append reviews energy and mineral resources in the study area; assesses demands for electricity, fuel for transportation and equipment, and construction aggregate by the different facility types; and evaluates impacts to energy and mineral resources due to the assessed demands of facilities.

The key resources that are applicable to green hydrogen facilities and evaluated in the Programmatic Environmental Impact Statement (PEIS) include the following:

- Electricity that is generated from renewable and non-renewable sources
- Renewable natural gas (RNG)
- Biomass
- Fuels including gasoline and diesel fuel
- Construction aggregate (the collective term for sand, gravel, and crushed stone)

The demand for electricity, RNG, biomass, fuels, and construction aggregate would vary depending on the location, type, and size of the facility. In general, the larger the facility, the greater the potential for impacts because of the increased need for electricity, biomass, and/or RNG, as well as fuels and construction aggregate.

A green hydrogen facility developer would need to ensure that there is sufficient electricity for a project available by establishing an agreement with a utility for access to the electrical grid or with a producer of electricity. The amount of electricity available will vary based on the project location. If electricity is not available, a project would not be feasible.

The PEIS assumes that a developer has contracted for sufficient electricity. With this assumption, through compliance with laws and permits, and with implementation of measures to avoid and reduce impacts, the construction, operation, and decommissioning of green hydrogen facilities would likely result in **less than significant impacts** on electricity supply.

The PEIS assumes that a developer would contract for RNG through local natural gas providers to determine if RNG is available in their area. With this assumption, through compliance with laws and permits, and with implementation of measures to avoid and reduce impacts, the operation of steam-methane reforming (SMR) and pyrolysis green hydrogen production facilities would have **less than significant impacts** on the availability of RNG fuels. Electrolysis and bio-gasification facilities would have **no impact** on the availability of RNG fuels.

The PEIS assumes that a developer would contract for biomass through a local provider to determine if biomass is available in their area. With this assumption, through compliance with laws and permits, and with implementation of measures to avoid and reduce impacts, the operation of bio-gasification facilities would have **less than significant impacts** on the availability of biomass fuels. Electrolysis, SMR, and pyrolysis facilities would have **no impact** on the availability of biomass fuels.

The analysis evaluated the availability of resources needed for the various types of facilities. It found that through compliance with laws and permits, and with implementation of measures to avoid and reduce impacts, the construction, operation, and decommissioning of green hydrogen facilities would likely result in **less than significant impacts** on fuels and construction aggregate.

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

1 Introduction

This technical appendix describes energy and natural resources within the study area and assesses probable impacts associated with types of green hydrogen facilities, and a No Action Alternative, which are described in Chapter 2 of the State Environmental Policy Act Programmatic Environmental Impact Statement (PEIS).

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 the secondary energy resource, as follows:

- Primary energy means energy as a found, natural resource (e.g., coal, wood, and sunlight).
- Secondary energy means an energy commodity that is derived by processing a primary energy source (e.g., electricity and gasoline). Some of the secondary energy available to the study area was produced outside the study area and imported as electricity or liquid fuels.

The non-energy natural resources considered in this technical appendix are mineral resources. Of mineral resources in the study area, only construction aggregate (crushed rock, gravel, and sand) is relevant to construction, operation, or decommissioning of green hydrogen facilities.

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 appendices:

- **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 Appendix*.
- **Transportation**: Information on the movement of trucks, trains, or vessels to transport equipment is analyzed in the *Transportation Technical Appendix*.
- **Public services and utilities:** Information on public services and utility providers is analyzed in the *Public Services and Utilities Technical Appendix.*

1.2 Regulatory context

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

Table 1. Applicable laws, plans, and policies

Regulation	Description
State	
Chapter 19.405 Revised Code of Washington (RCW), 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 RCW, State Energy Office	Requires development of a State Energy Strategy at least once per 8 years. 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 Sections 2.2 and 2.3.

2.1 Study area

The study area for energy and natural resources includes the PEIS geographic scope of study for green hydrogen facilities (Figure 1) and surrounding areas that are relevant to this analysis.

The study area for the evaluation of energy and natural resources associated with construction and operation of facilities would be determined by the presence (or absence) of energy and natural resources during project-specific reviews. Parameters could include energy demand and consumption, supply, capacity and updated technologies.

Figure 1, which shows the PEIS geographic scope of study, does not include federal lands, national parks, wilderness areas, wildlife refuges, state parks, or Tribal reservation lands, but information related to these areas is provided as context for the affected environment.

2.2 Technical approach

The PEIS analyzes a timeframe of up to 25 years of potential facility construction and up to 50 years of potential facility operations (totaling up to 75 years into the future). Analysis of energy and natural resources 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 data gathering efforts were conducted as part of this process, and no additional 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 green hydrogen facilities.

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

- Determine energy and natural resource demands for types of facilities. This includes attention to materials used to construct facilities, worker commuting, transportation of materials and equipment, and on-site equipment.
- Estimate needs for these resources relative to similar types of facilities.
- Use published information about sources and quantities of the energy and natural resources available in Washington State.

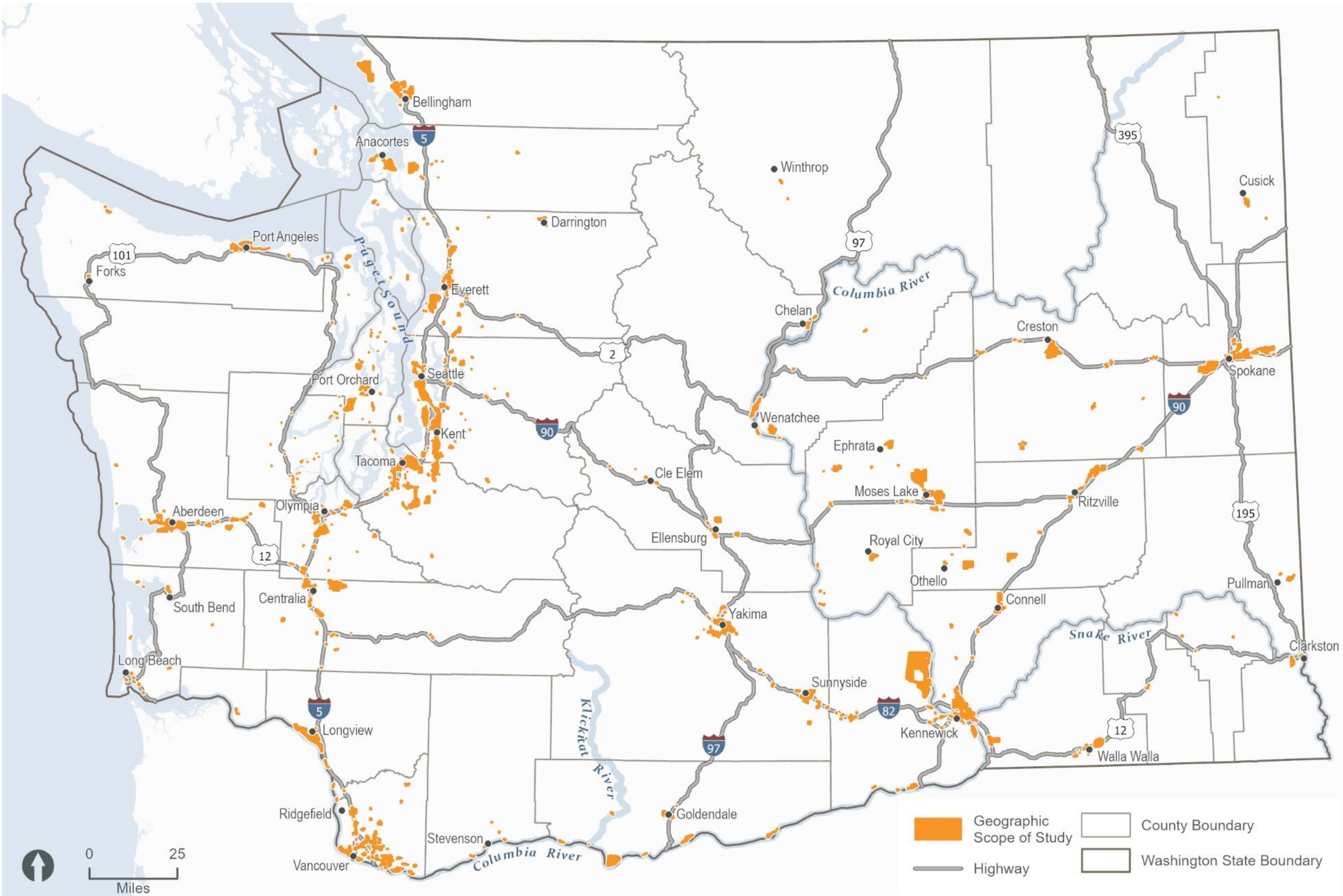

Figure 1. Green Hydrogen Energy Facilities PEIS geographic scope of study

2.3 Impact assessment approach

Impact analysis within this technical appendix focuses on construction, operation, and decommissioning. Temporary and permanent impacts from the facilities on energy and natural resources, relative to baseline and predicted future conditions, were evaluated.

For the purposes of this assessment, potentially significant impacts on energy and natural resources would occur if a facility resulted in the following:

- Demand for electricity or renewable natural gas sufficient to induce construction of new production capacity (whether inside or outside of the study area)
- Demand for biomass sufficient to induce an increase of supply capacity
- Permanent increased demand for fuels that could affect statewide annual production
- Demand for construction aggregate sufficient to induce one or more new surface mines

This technical appendix covers only impacts of energy consumption by a new green hydrogen facility. Impacts on public service or utility providers are analyzed in the *Public Services and Utilities Technical Appendix*. Emissions that may be associated with use of energy and natural resources are analyzed in the *Air Quality and Greenhouse Gases Technical Appendix.*

3 Technical Analysis and Results

3.1 Overview

This section describes the affected environment, anticipated permit requirements, and potential adverse impacts on energy and natural resources that might occur for a green hydrogen 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 technical appendix analyzes resources and demands on secondary energy and construction aggregate during construction, operation, and decommissioning of the facilities considered. The PEIS considers two categories of green hydrogen based on how the hydrogen is produced (see Table 2):

- "Renewable hydrogen" is hydrogen produced using renewable resources both as the source for hydrogen and the source for the energy input into the production process. This definition was first enacted in 2019 in providing authority to public utility districts to produce and distribute hydrogen (Revised Code of Washington [RCW] 54.04.190[1]) and to provide a sales tax exemption on equipment used to produce hydrogen (RCW 82.08.816[2]).
- "Green electrolytic hydrogen" is hydrogen produced through electrolysis. It does not include hydrogen manufactured using steam-methane reforming (SMR) or any other conversion technology that produces hydrogen from a fossil fuel feedstock. In this definition, water is the feedstock for the hydrogen, while the electricity is not a feedstock but is the input energy or process energy used in electrolysis of the water. Hydrogen produced through electrolysis will meet this definition regardless of whether the electricity is produced from on-site renewable sources, from fossil-fired generation, from unspecified grid sources, or any combination of these resources. The Clean Energy Transformation Act requires all electricity used in Washington to be greenhouse gas neutral by 2030 and 100% clean by 2045. Under the 2030 greenhouse gas-neutral standard, a utility may use fossil-fired electricity for up to 20% of its supply under an alternative compliance mechanism.

Table 2. Green hydrogen production pathways

Production technology	Inputs
Electrolysis	Water, electricity
Steam-methane reforming	Renewable natural gas [a]
Pyrolysis	Renewable natural gas, biomass [a]
Bio-gasification	Biomass [a]

Note:

a. See RCW 19.285.030[3] for definition of biomass and RCW 80.50.020[4] for definition of renewable natural gas.

[1] https://app.leg.wa.gov/rcw/default.aspx?cite=54.04.190
[2] https://app.leg.wa.gov/rcw/default.aspx?cite=82.08.816
[3] https://app.leg.wa.gov/rcw/default.aspx?cite=19.285.030
[4] https://app.leg.wa.gov/rcw/default.aspx?cite=80.50.020

Based on the regulatory definitions, green hydrogen production facilities could use electricity generated by different types of energy sources. The primary source of energy for an electrolysis facility would need to be evaluated in the project-level environmental review.

3.2 Affected environment

The different methods of green hydrogen production use different energy resources. The electrolysis method of green hydrogen production uses electricity, but all types of green hydrogen facilities would be expected to use electricity during operations to power stationary equipment for production and storage. Two methods of green hydrogen production, SMR and pyrolysis, use RNG. Biomass is used in pyrolysis and bio-gasification methods of green hydrogen production. For all facilities, fuels (gasoline and diesel fuel) would be used by workers for vehicles and equipment during site characterization, construction, operation, and decommissioning. All facilities would also use aggregate for construction.

The primary energy[5] and secondary energy evaluated in this report include:

- Electricity
- RNG[6]
- Fuels (gasoline and diesel fuel)
- Biomass

The affected environment represents existing conditions at the time this study was prepared.

3.2.1 Electricity

Information on the use and supply of electricity in Washington is described below. The PEIS does not evaluate the source or sources of electricity used by green hydrogen facilities. A green hydrogen facility developer would need to ensure that there is sufficient electricity for a project available by establishing an agreement with a utility for access to the electrical grid or with a producer of electricity. The amount of electricity available will vary based on the project location. If electricity is not available, a project would not be able to operate.

In 2023, Washington State consumed 88,702 million kilowatt-hours (kWh) of electricity (Table 3).

Table 3. Electricity consumption in Washington, 2023

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

[5] Ocean waves and tides are also primary energy sources in Washington but do not occur within the study area.
[6] Aviation gasoline, kerosene (jet fuel), and marine diesel are also possible in the study area.

Washington is a net exporter of electricity, meaning that more electricity is generated in the state than is consumed. In 2023, Washington generated 98,725 million kWh of electricity (Table 4). The State Energy Strategy provides estimates of future electricity needs for the state.

Table 4. 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	98,725

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

In 2023, hydroelectric power accounted for 60% of Washington’s total electricity generation and typically contributes between one-fourth and one-third of all hydroelectric generation in the United States. Natural gas, nonhydroelectric renewable sources, nuclear energy, and coal provide nearly all the remainder of the state’s electricity generation. Renewable sources other than hydroelectric power accounted for approximately 10% of electricity generation in the state in 2023 (EIA 2024b).

In 2024, the Washington State Department of Commerce (Commerce) published a legislative report that provided analysis about likely supply and demand expectations for green electrolytic hydrogen and renewable hydrogen in Washington state through 2050 (Commerce 2024). This report anticipates that demand for green electrolytic hydrogen and renewable fuels will be high, and as a result, Washington may expect to install 0.8 gigawatt (GW) of electrolysis capacity and produce 200,000 metric tons (MT) per year of hydrogen by 2030, and additionally to require 4.5 GW of electrolysis capacity in order to produce approximately 700,000 MT per year of hydrogen by 2035.

Hydrogen and renewable fuels production must be developed in coordination with expanded renewable electricity capacity. Washington cannot meet the levels of hydrogen and renewable fuel production envisioned in this appendix without new transmission and generation capacity.

3.2.2 Renewable natural gas (RNG)

RNG is a gas consisting largely of methane and other hydrocarbons derived from the decomposition of organic material in landfills, wastewater treatment facilities, and anaerobic digesters (RCW 80.50.020). RNG is also known as biogas. Landfill gas has been the greatest source for RNG in the United States, producing 72% of RNG in 2021; however, new facilities are beginning to use mostly agricultural and animal wastes (IEA 2023). The decomposition of plant and animal material at solid waste landfills, water treatment plants, livestock farms, and other facilities produces a biogas primarily composed of methane, carbon dioxide, nitrogen, and oxygen. This biogas is then conditioned to pipeline quality and injected into the natural gas pipeline grid as RNG for use in place of fossil natural gas. Hundreds of locations exist in Washington in proximity to the natural gas grid that have the potential to produce RNG. Facilities would need to be developed to collect and condition the biogas to pipeline-quality standards as well as construct new pipelines and inject the RNG into the pipeline grid (Commerce 2018).

There are several RNG facilities in Washington. These facilities include the Cedar Hills Landfill in King County, the Roosevelt Landfill in Klickitat County, and the South Treatment Plant in King County. As of 2018, these three facilities were capable of producing enough RNG to replace approximately 1.3% of fossil natural gas consumption in Washington State, or about 4,002,400 million British thermal units per year. However, the RNG from these facilities is mainly sold out of state and is subject to long-term supply contracts to provide RNG for transportation consumption outside of Washington (Commerce 2018). RNG production in the United States has been historically driven by the transportation sector, and the United States is currently the largest user of RNG for transportation in the world, with 48% of the nation’s RNG production used in transportation (IEA 2023).

Other RNG projects in Washington include the Central Wastewater Treatment Plant in Tacoma, the Augean RNG Project Facility in Yakima County, and the proposed Sunnyside RNG Project in Sunnyside.

3.2.3 Biomass

Biomass is renewable organic material that comes from plants and animals and that can be burned for heat or converted to liquid and gaseous fuels through various processes. RCW 80.50.20 requires that biomass used for green hydrogen production come from solid organic fuels including wood, forest, or field residues, or from dedicated energy crops that do not include wood pieces treated with chemical preservatives. Estimates indicate that biomass was used as a primary energy source to generate about 351 million kWh of electricity in 2023 in Washington (Table 4).

Wood fuels are the main source of biomass in Washington. In early 2024, about 86% of the state's biomass generating capacity for electricity was from wood-fueled electrical power facilities. Crop residues from Washington's agricultural areas in the east could be a source of biomass (EIA 2024a).

3.2.4 Fuels for transportation and equipment

In 2019, Washington consumed 2.8 million gallons of gasoline and 950 million gallons of diesel fuel. As with electricity, Washington is a net exporter of 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 2024b), producing approximately 4.2 billion gallons of gasoline and 2.5 billion gallons of diesel each year.[7] The Clean Fuel Standard (Chapter 70A.535 RCW[8]) requires suppliers to gradually reduce the carbon intensity of fuels to 20% below 2017 levels by 2034.

3.2.5 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 basis by the U.S. Geological Survey, and surface mine permitting is handled by the Washington State Department of Natural Resources (DNR). Active permitted aggregate surface mining resource sites are shown in Figure 2.

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 2022; DNR 2023).

[7] Assuming a capacity factor (uptime) of 90% and assuming 19.5 gallons of gasoline and 11.5 gallons of diesel produced from each barrel of input crude (see EIA 2024b).
[8] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.535

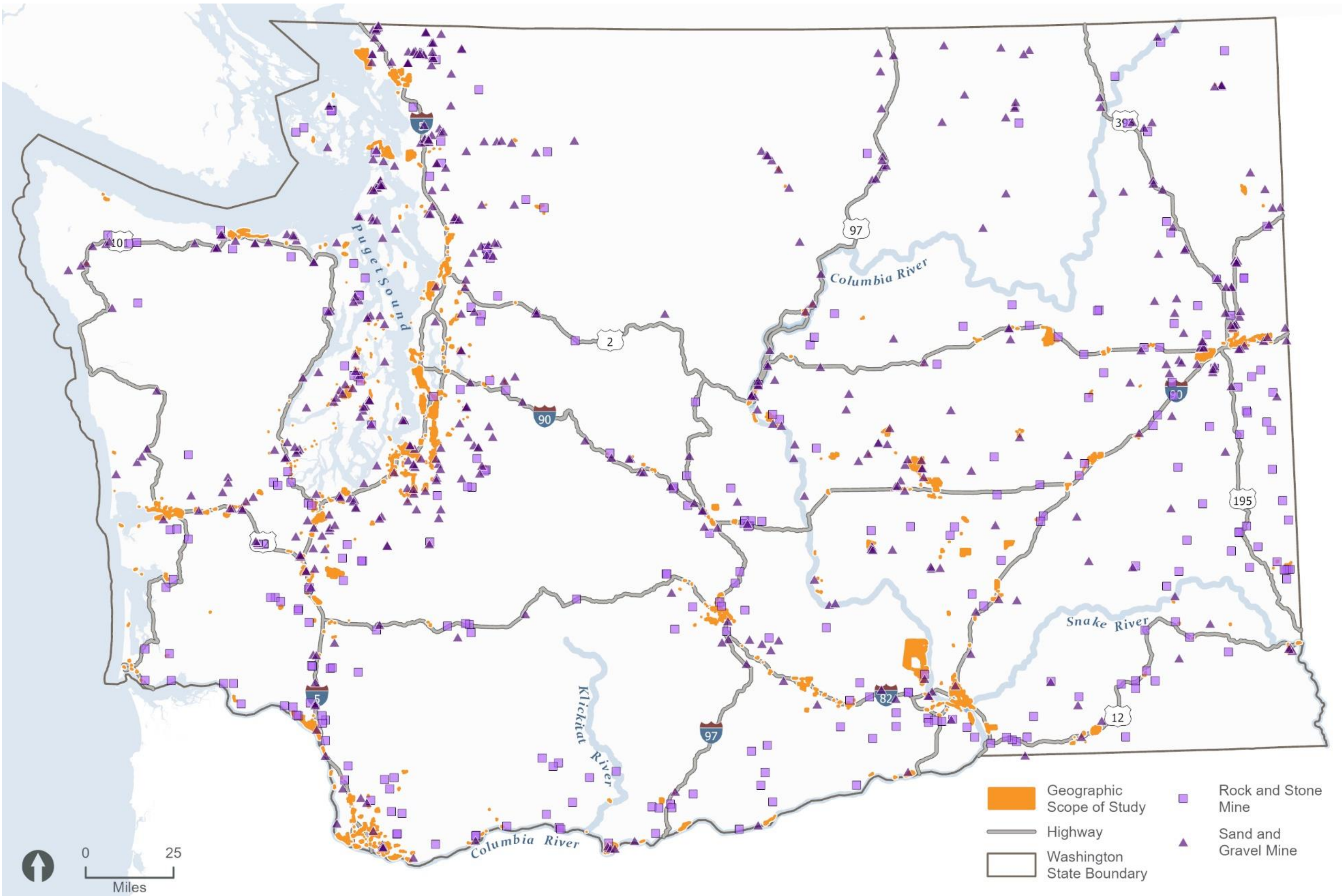

Figure 2. Aggregate resource locations

3.3 Potentially required permits and approvals

If the facility developer would be drawing electricity from the local utility, then the following permit would potentially be required:

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

Fuels, RNG, and biomass consumed for green hydrogen facilities would be purchased on the open market, which requires no permits.

Facility development is not expected to include the development of borrow bits or quarries for construction aggregate. Construction aggregate would be purchased on the open market, which requires no permits.

3.4 Green hydrogen production facility

This section describes potential impacts of green hydrogen production facilities on energy and natural resources. The demand for electricity, RNG, biomass, fuels, and construction aggregate would vary depending on the geographical region of the facility, the type of facility, and the size of the facility. In general, the larger the facility, the greater the potential for impacts because of the increased need for electricity, biomass, and/or RNG, as well as fuels and construction aggregate.

For the purposes of the PEIS, the estimated footprint of a green hydrogen production facility, based on existing facilities in other areas, ranges from 1 acre to 10 acres, depending on the production method, type of storage facilities, and the layout of external pipes and tanks, a parking area, and security fencing. The estimated height of structures is up to 100 feet.

A green hydrogen production facility would typically include a connection to the electricity grid to power all, or a portion of, the facility's equipment needs and buildings. Facilities typically connect to the main transmission line through distribution lines that can be up to 100 feet high and between 1 and 8 miles in length, which would be determined by the project developer based on the distance between a selected site and existing electricity grid infrastructure. This technical appendix includes evaluation of impacts associated with distribution line connections to main transmission lines.

Off-site access roads may be needed to connect a facility to the existing state routes. Most of the study area is less than 10 miles from a state route (63% within 1 mile and 99% within 10 miles). It is estimated that a 1-mile off-site access road would require approximately 4,693 cubic yards of aggregate and a 10-mile off-site access road would require approximately 46,933 cubic yards of aggregate. If needed, the project developer would determine the length of off-site access road, based on the distance between a selected site, existing road infrastructure, and coordination with state and local departments of transportation.

3.4.1 Impacts from construction and decommissioning

Green hydrogen production facilities would consume electricity and fuels during site characterization, construction, and decommissioning to run equipment, generators, and vehicles. Construction would use aggregate for concrete foundations for buildings and structures and for construction access. Gravel may be used for parking areas, equipment staging, and laydown areas.

3.4.1.1 Electricity

During construction and decommissioning activities, electricity would be needed to power tools and machinery (drills, saws, machinery), lighting (for work during overcast days, workspace safety and security), communication and safety systems (walkie-talkies, cameras, alarms), and site offices (temporary offices that need power for lights and office equipment).

The demand for electricity could 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 Section 3.4.1.4). In the case of electricity provided by a utility, the facility developer would work with the local utility to extend distribution infrastructure to the facility. During site characterization, the developer would consider power needs and requirements and seek to obtain the power needed. Electricity demands for construction and decommissioning of facilities are typical of construction projects generally, and they are often dominated by construction trailers.

Through compliance with laws and permits, and with implementation of measures to avoid and reduce impacts, the construction, and decommissioning of green hydrogen production facilities would likely result in **less than significant impacts** on electricity.

3.4.1.2 Renewable natural gas

During construction and decommissioning activities, RNG would not be needed. There would be no effect to supply chains or management and distribution of resources.

3.4.1.3 Biomass

During site characterization, construction, and decommissioning activities, biomass would not be needed. There would be no effect to supply chains or management and distribution of resources.

3.4.1.4 Fuel for transportation and equipment

Green hydrogen production facilities would consume fuels during construction and decommissioning for equipment use, vendor trips, on-site trucks and haul trucks (diesel) and worker (gasoline) trips (see Table 5). Estimated ranges of trips are generated from the air quality model used in the *Air Quality and Greenhouse Gases Technical Appendix* and summarized below.

Major interstate freeways and state routes that intersect the study area are expected to serve as first- and last-mile connections between the green hydrogen facilities and workers, equipment, and other elements necessary for the facility. The study area assumes that a green hydrogen production facility would be within 50 miles or less of freight highway routes.

Table 5. Fuel consumption based on worker and equipment (vendor, on-site truck, hauling) trips during construction

Trip type	One-way trips – 1-acre site	One-way trips – 10-acre site	Fuel consumption (gal) – 1-acre site	Fuel consumption (gal) – 10-acre site
Worker (gasoline)	3,888	99,943	2,166	55,682
Vendor (diesel)	1,179	37,573	1,269	39,545
Onsite truck (diesel)	261	1,542	420	2,847
Hauling (diesel)	378	1,873	1,219	6,042
Total	5,706 trips (3,888 per worker/1,818 equipment)	140,931 trips (99,943 per worker/40,988 equipment)	5,074 2,166 gasoline per worker/ 2,908 diesel)	104,166 (55,682 gasoline per worker/ 48,434 diesel)

Source: CAPCOA 2022.

Note: gal = gallons.

Worker commuting

The number of people employed for construction would vary but is expected to be approximately 10 individuals for construction of a facility on a 1-acre site and 100 individuals for construction of a facility on a 10-acre site. One full-time construction worker commuting to a 1-acre site would use approximately 2,166 gallons of gasoline during construction and 55,682 gallons of gasoline commuting to a 10-acre site. Therefore, it is estimated that the upper limit of gasoline consumed for 10 construction workers commuting to a 1-acre construction site would be 21,660 gallons of gasoline. The upper limit estimate of gasoline consumed for 100 construction workers commuting to a 10-acre construction site would be 556,820 gallons of gasoline.

Haul truck trips

Building materials and site equipment would be shipped to the site via various modes of transport, but the demand on fuel resources in the study area would be almost entirely from the final leg driven by trucks. The number of anticipated one-way haul truck trips needed for construction of a facility on a 1-acre site and a 10-acre site is estimated at approximately 378 to 1,873 trips, respectively. This equates to approximately 1,219 to 6,042 gallons of diesel fuel for truck haul trips during construction.

On-site equipment

Once on-site, site equipment (cranes, generator sets, welding equipment) would stay on site and not generate daily trips. Diesel fuel would be needed to operate and move within the site boundaries. Site preparation and construction would use equipment such as graders, rubbertired dozers, tractors, loaders, backhoes, excavators, cranes, forklifts, tractors, loaders, backhoes, generator sets, and welders.

Fuel usage was estimated using off-road equipment assumptions from CalEEMod and average fuel consumption rates derived from studies that similarly used CalEEMod. These studies are the 2021 Santa Monica Final Housing Element Environmental Impact Report (City of Santa Monica 2021) and the Environmental Impact Report for the Beach Cities Health District Healthy Living Campus Master Plan (Beach Cities Health District 2021). Detailed fuel assumptions and calculations are included in Attachment D of the *Air Quality and Greenhouses Gases Technical Appendix*. On-site construction equipment is expected to demand between 19,840 and 87,843 gallons of diesel fuel for construction equipment used during construction.

Total fuel consumption
The combined diesel and gasoline fuel consumed by worker commuting, vendors, on-site trucks and hauling during construction would be 5,074 gallons for a 1-acre site and 104,166 gallons for a 10-acre site. Diesel or gasoline would be purchased from suppliers in Washington. Relative to the total annual diesel production in Washington (2.5 billion gallons of diesel each year), 2,908 to 48,434 gallons of diesel represents 0.0001% to 0.002% of the total available diesel fuel resource produced in the state. Relative to the total annual gasoline production in Washington (4.2 billion gallons of gasoline), 2,166 to 55,682 gallons of gasoline represents 0.00005% to 0.001% of the total available fuel resource produced in the state. Decommissioning activities are expected to require similar fuels as required during construction. The construction and decommissioning of green hydrogen production facilities would likely result in **less than significant impacts** on fuels.

3.4.1.5 Construction aggregate

Construction of a green hydrogen production facility would use aggregate for concrete building and equipment foundations or hard-pack gravel equipment pads. Concrete and gravel may also be used for parking areas, equipment storage areas, and perimeter hardening. No demand for aggregate is expected for decommissioning.

Demand for aggregate for a facility on 1 acre would be between 942 and 1,256 cubic yards. For a facility on 10 acres, demand for aggregate would be between 11,945 and 14,582 cubic yards of aggregate.[9] Assuming that 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, these aggregate demands would range from 0.03% to 0.04% of the total available resource produced annually. Approximately 4,693 cubic yards to 46,933 cubic yards of aggregate could be needed to construct off-site access roads.

Aggregate for construction of the facility may need to be obtained from multiple mines, depending on the facility location. To keep costs down, facility developers would typically

[9]Concrete estimated to be composed of between 60% and 80% aggregate.

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 other projects constructed around the same timeframe.

Through compliance with laws and permits, and with implementation of measures to avoid and reduce impacts, the construction and decommissioning of green hydrogen production facilities would likely result in **less than significant impacts** on construction aggregate.

3.4.2 Impacts from operation

Operation includes maintenance activities that would likely require fuel for maintenance vehicles and tools. Electricity would be needed for lighting, heating, and other purposes at buildings. Electricity would also be required to produce hydrogen using any of the production types. RNG and/or biomass would be required to produce hydrogen using SMR, pyrolysis, or bio-gasification methods. Gravel would be needed for upkeep of access roads and other rocked surfaces.

3.4.2.1 Electricity

A green hydrogen facility would consume electricity during operations. Electricity would be used to power buildings, sensors, lights, cameras, gates, and other basic site functions. For a green hydrogen production facility, the majority of the electrical energy used would be for the production process. Components such as heating or cooling equipment may change the electricity needs of a given facility.

Kilowatt hour requirements for each production facility type were based on electricity required to produce 1 kilogram (kg) of hydrogen at a 1-acre site and a 10-acre site. The anticipated maximum electricity requirements for each green hydrogen production method are shown in Table 6. The provided estimated ranges for electricity consumption are assumptions based on published specifications (data sheets) for commercial electrolysis units on the market today (Hydrogenics Corporation 2020; Siemens Energy 2020; Plug 2022, 2024a, 2024b). During project-level environmental review, estimates would be refined based on project-specific information for the type of facility proposed.

Table 6. Green hydrogen production - electricity requirements

Production method	Electricity required to produce 1 kg of hydrogen (kWh)	Daily hydrogen output (kg) (1-acre to 10-acre site)	Daily kWh requirements (1-acre to 10-acre site)	Annual kWh requirements (1-acre to 10-acre site) (kWh)	Production demands as a percentage of 2023 total statewide electricity production (kWh)	Production demands as a percentage of 2023 renewable statewide electricity production (kWh)
Electrolysis	50	900 to 9,000	4,500 to 450,000	16,425,000 to 164,250,000	0.016 to 0.166%	0.023 to 0.238%
SMR	3	10,000 to 100,000	30,000 to 300,000	10,950,000 to 109,500,000	0.011 to 0.111%	0.015 to 0.158%
Pyrolysis	10	1,000 to 10,000	10,000 to 100,000	3,650,000 to 36,500,000	0.003 to 0.037%	0.005 to 0.053%
Bio-gasification	4	10,000 to 100,000	40,000 to 400,000	14,600,000 to 146,000,000	0.001 to 0.148%	0.021 to 0.211%

Based on the regulatory definitions, green hydrogen production facilities could use electricity generated by different types of energy sources. This would decrease over time to meet the state's greenhouse gas limits. The primary source of energy for an electrolysis facility would need to be evaluated in the project-level environmental review.

Washington's renewable energy is anticipated to grow as energy consumption decarbonizes. The 2021 Washington State Energy Strategy (Commerce 2021) identifies a plan to prioritize 100% clean electricity to decarbonize energy in the state, including accelerated investment in renewable generating sources and facilitating community deployment of renewable generation sources. State greenhouse gas limits require net zero emissions by 2050. Across the United States, power generation from renewables is expected to increase from 21% in 2021 to 44% in 2050, consisting mainly of new wind and solar energy (EIA 2023).

As described above, a green hydrogen facility developer would need to ensure that there is sufficient electricity for a project available by establishing an agreement with a utility for access to the electrical grid or with a producer of electricity, such as from a new renewable energy facility. If electricity is not available, a project would not be feasible.

The PEIS assumes that a project developer has contracted for sufficient electricity for production operations. With this assumption, through compliance with laws and permits, and with implementation of measures to avoid and reduce impacts, the operation of green hydrogen production facilities would likely result in **less than significant impacts** on electricity.

3.4.2.2 Renewable natural gas

RNG may be used during operation of facilities relying on the SMR and pyrolysis methods of production. Table 7, prepared using information from PEIS Chapter 2 and Section 3.2.2 of this technical appendix, outlines anticipated maximum RNG requirements. For context, an average petroleum refinery in the United States in 2018 consumed 7,484,375,000 standard cubic feet (scf) of natural gas (EIA 2018).

Table 7. Green hydrogen production - RNG requirements

Production method	RNG required to produce 1 kg of hydrogen (scf)	Daily hydrogen output (kg) (upper bound production)	Daily RNG requirements (based on upper bound production) (scf)	Annual RNG requirements (based on upper bound production) (scf)	Annual statewide RNG production (2018) (scf)	Percentage of total statewide 2018 RNG required (based on upper bound production)
SMR	150	100,000	15,000,000	5,475,000,000	3,830,000,000	142.950%
Pyrolysis	200	10,000	2,000,000	730,000,000	3,830,000,000	19.060%

RNG requirements for upper-bound SMR and pyrolysis facilities exceed current statewide RNG supply. As discussed in Section 3.2.2, the market demand for RNG in Washington is expected to grow, and RNG infrastructure and supply are expected to increase accordingly. For example, one utility plans to grow the percentage of RNG in its mix from 0.5% of its annual gas volume to nearly 3.5% of annual gas sales in 2024. As described in Section 3.2.2, the largest landfills in the state and a major metropolitan wastewater treatment facility had already begun upgrading their biogas to RNG and injecting it into the natural gas pipeline grid. Several smaller facilities, including landfills, wastewater treatment plants, and anaerobic digesters at dairies, use biogas to generate renewable electricity.

A 2018 project to identify RNG growth opportunities in the state identified similar existing facilities that could have the potential to offset another 1.9% of the fossil gas market in the state in the next 5 to 10 years, if the adequate biogas and RNG projects are undertaken (Commerce 2018). Other RNG opportunities in the state could be developed by redirecting organic wastes such as fats, oils, and greases, or food residuals and other organics, from existing disposal markets to RNG production. Gasification of wood and other forest residuals and fibrous materials from urban areas has the capacity to more than double RNG production in the state; however, this would be subject to development of commercial-scale gasification technologies that are cost-effective (Commerce 2018).

The 2021 Washington State Energy Strategy (Commerce 2021) identified RNG as an option to decarbonize the energy sector in the state and recommends the increased incorporation of RNG infrastructure in Washington. More RNG laws and incentives have been passed in the state for alternative-fuel vehicle sales and fueling such as the Natural Gas Tax Exemptions, the Low Carbon Fuel Standard, and the Renewable Natural Gas and Renewable Hydrogen Fuel Sales Regulations. The RNG sector and infrastructure is expected to grow as the demand for RNG increases.

At current levels, RNG demand for energy during operations of large SMR and pyrolysis facilities could result in a reduction in access or create a substantial reduction in availability of RNG. Depending on the location, timing, size, and type of facility, the operation of a green hydrogen production facility could consume or exceed available supply of RNG fuels in Washington State. However, developers would not be able to propose or build facilities that utilize RNG where unavailable.

The PEIS assumes that a project developer would contract for RNG through local natural gas providers to determine if RNG is available in their area. With this assumption, through compliance with laws and permits, and with implementation of measures to avoid and reduce impacts, the operation of SMR and pyrolysis green hydrogen production facilities would have **less than significant impacts** on the availability of RNG fuels. Electrolysis and bio-gasification facilities would have **no impact** on the availability of RNG fuels.

3.4.2.3 Biomass

Biomass would be used for feedstock during operation of bio-gasification and pyrolysis facilities; of the two methods, bio-gasification would consume the larger volume of biomass during hydrogen production. Table 8 describes anticipated maximum biomass requirements of an upper-bound bio-gasification production facility. As discussed in Section 3.2.3, RCW 80.50.20 requires that biomass used for green hydrogen production come from solid organic fuels including wood, forest, or field residues, or from dedicated energy crops that do not include wood pieces treated with chemical preservatives.

Table 8. Green hydrogen production - biomass requirements

Production method	Biomass required to produce 1 kg of hydrogen (kg)	Daily hydrogen output (upper bound production)	Daily biomass requirements (based on upper bound production) (kg)	Annual biomass requirements (based on upper bound production) (kg)	2022 statewide consumption of biomass (kg)	Bio-gasification biomass requirements as a percentage of 2023 statewide consumption of biomass
Bio-gasification	13.5	100,000	1,350,000	492,750,000	8,839,000,000	3.610%

The 2021 Washington State Energy Strategy (Commerce 2021) identifies a specific focus on developing markets for low-grade woody biomass and the importance of continuing to consider biomass as a foundational resource in the state for energy production. Forest residuals and wildfire thinnings represent a significant, underutilized source of woody biomass in the United States (DOE 2024), but there is more information needed to make forest residuals and thinnings cost-effective. Agricultural residues are also major sources of potential biomass resources in the United States (DOE 2024).

Competing markets for biomass create some unknowns in the near-term market supply and economics of biomass. While energy crops are considered the greatest potential resource in biomass, there is no established market for biomass. The 2024 U.S. Department of Agriculture *Building a Resilient Biomass Supply: A Plan to Enable the Bioeconomy in America* (USDA 2024) provides a policy and implementation plan to support the resilience of the domestic biomass supply chain in the United States, including energy crop and forestry and logging biomass resources. Markets are expected to increase for these biomass resources as demand for renewable energy increases.

Biomass requirements for bio-gasification for a single large bio-gasification facility may be equal to 3.6% of the 2022 total statewide consumption of biomass. Demand for biomass to operate large bio-gasification facilities could result in a local reduction in access or create a substantial reduction in availability of biomass feedstocks. Bio-gasification production facilities could alter the sector of the economy in which biomass is predominantly consumed.

Developers would not be able to build facilities where the market supply could not cost-effectively or feasibly provide for demand for biomass.

The PEIS assumes that a developer would contract for biomass through a local provider to determine if biomass is available in their area. With this assumption, through compliance with laws and permits, and with implementation of measures to avoid and reduce impacts, the operation of bio-gasification facilities would have **less than significant impacts** on the availability of biomass fuels. Electrolysis, SMR, and pyrolysis facilities would have **no impact** on the availability of biomass fuels.

3.4.2.4 Fuel for transportation and equipment

Green hydrogen production facilities would consume fuels for worker commuting and miscellaneous on-road fuels for haul-truck trips, and off-road fuels (diesel and dyed diesel) for site equipment. Fuel use would vary based on the end-users of green hydrogen, which would be determined during project-level reviews. Demand for fuels during operations would vary based on the way materials are brought into and transported from the facility. This could be by truck, rail, vessel, or pipeline.

Equipment at the facility on an annual basis would use no more than one-tenth of the total fuel required for facility construction, equaling a total of about 2,385 gallons of fuel for operational equipment. Full-time, on-site operations staff would be required. Smaller plants may be remotely operated, while larger plants might have one to three operations personnel on site 24 hours per day, 7 days per week. General maintenance for the facility would be completed by a facility's operations staff as needed**.**

One full-time staff commuting to a site is assumed to be 50 miles one-way (100 miles roundtrip) in a light vehicle with average fuel economy of 23.7 miles per gallon (Davis and Boundy 2022). This would use approximately 4.2 gallons per day of fuel, a total of 76,650 gallons during the entire operation period (18,250 days/50 years). The upper limit of total fuel used for three operation workers commuting to the site would be a fuel demand of 229,950 gallons.

The combined fuel consumed by worker commuting, delivery, and site equipment at green hydrogen production facilities during construction would be up to 232,335 gallons. Diesel or gasoline would be purchased from suppliers in Washington. Relative to the total annual fuel production in Washington, this represents approximately 0.02% of the total available fuel resource produced in the state.

Through compliance with laws and permits, and with implementation of measures to avoid and reduce impacts, the operation of green hydrogen production facilities would likely result in **less than significant impacts** on fuels.

3.4.2.5 Construction aggregate

During operations, gravel would be needed for upkeep of access roads and other rocked surfaces. It is assumed that up to 45% of a site could be permeable surface (gravel, dirt, or grass). For a 1-acre site, this would be 0.45 acre, and for a 10-acre site, this would be 4.5 acres. If it is assumed that new surface gravel is needed once every 5 years and gravel would be 4 inches deep, average annual demand would range from 500 to 16,000 cubic yards per year depending on facility size and access points (Skorseth and Selim 2000). It is not expected that aggregate needs during operations would cause aggregate resources in the vicinity of a facility site to result in a reduction in available supply of those materials for other projects.

Through compliance with laws and permits, and with implementation of measures to avoid and reduce impacts, the operation of green hydrogen production facilities would likely result in **less than significant impacts** on 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 and the PEIS impact analysis and significance findings assume that developers would comply with all relevant laws and regulations and obtain required approvals.

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

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

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

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

- **Choose a project site and a project layout to avoid and minimize disturbance:** Select the project location and design the facility to avoid potential impacts to resources. Examples include:
  - 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-locate 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:
    - 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 (WDFW), 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 actions 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

- Estimate electrical energy needs during construction, operation, and decommissioning and confirm adequate resource availability with providers.
- For SMR, pyrolysis, and bio-gasification facilities, identify and confirm resource availability with providers.
- 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.

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 & Industries 2024)

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 facility 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 facility 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.

3.5 Green hydrogen production facility with co-located battery energy storage system (BESS)

This section describes potential impacts of green hydrogen production facilities with up to two co-located battery energy storage systems (BESSs). BESSs would be used to balance loads or to provide up to 15% of power in case of an outage or power quality deviation. One BESS would provide 2.85 megawatts of electricity for 4 hours (a capacity of 11.4 megawatt hours or 11,400 kWh). Each container would be approximately 60 by 12 feet wide and 10 feet tall.

3.5.1 Impacts from construction, operation, and decommissioning

Potential construction, operation, and decommissioning impacts to energy and natural resources described for green hydrogen production facilities apply to green hydrogen production facilities with co-located BESSs. Relative to a green hydrogen production facility, the addition of co-located BESSs would require a small amount of additional resources during construction for the BESS portion of the facility.

3.5.1.1 Electricity

Compared to facilities analyzed in Section 3.4, construction of a green hydrogen production facility and a co-located BESS would be similar, with a minor addition of additional electricity demand for constructing BESS storage containers. Electricity use may be more intensive for short periods during testing of the installed BESS equipment prior to regular operations. Similar to green hydrogen production facilities, the demand for energy during construction, operation, and decommissioning is not expected to require new or substantially modified production or energy transmission. Impacts to electricity from decommissioning would be similar to impacts from construction.

Electricity demands during production for facilities with a BESS would be similar to demands for facilities without a co-located BESS; however, the BESS would provide some on-site electrical supply during times of maximum grid load or strain. 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.

Through compliance with laws and permits, and with implementation of measures to avoid and reduce impacts, the construction, operation, and decommissioning of a co-located BESS would likely result in **less than significant impacts** on electricity.

3.5.1.2 Renewable natural gas

The addition of up to two BESS units to a green hydrogen production facility would not alter the characterization of RNG impacts discussed in Section 3.4.2.2.

3.5.1.3 Biomass

The addition of up to two BESS units to a green hydrogen production facility would not alter the characterization of biomass impacts discussed in Section 3.4.2.3.

3.5.1.4 Fuel for transportation and equipment

Adding up to two BESSs would require additional hours for construction and installation. Impacts would be similar to those of 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 BESS, 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.

Adding BESSs to a green hydrogen production facility would require additional hours for maintenance during operations, which would result in a minor increase in demand for fuels beyond what is already required for operation of the facility as a whole. Decommissioning would also have approximately the same demand for fuels as construction.

Therefore, the construction, operation, and decommissioning of a facility with co-located BESSs would likely result in **less than significant impacts** on fuels.

3.5.1.5 Construction aggregate

A BESS container would typically be installed on a concrete slab 60 feet by 12 feet, requiring approximately 16.5 cubic yards of aggregate. The addition of up to two BESSs would not represent an overall change to the potential range of aggregate demand. Since the BESS would be co-located with other facility areas, there would be no additional demand for aggregate resources during operations and aggregate would not be needed during decommissioning.

Therefore, the construction, operation, and decommissioning of a facility with co-located BESSs would likely result in **less than significant impacts** on construction aggregate.

3.5.2 Measures to avoid, reduce, and mitigate impacts

Measures to avoid, reduce, and mitigate impacts would be the same as those identified for green hydrogen production facilities (Section 3.4.3), with the addition of the below siting and design measure.

3.5.2.1 Siting and design considerations

- Co-locate BESSs with other facilities to minimize footprint of the facility.

3.6 Green hydrogen storage facility (gas or liquid form)

This section describes potential impacts of green hydrogen production facilities with hydrogen storage. A green hydrogen storage facility could store hydrogen in gas or liquid form. Gaseous hydrogen would be stored in stationary, aboveground, cylindrical storage systems, each of which employs different construction materials to achieve maximum working pressure ratings. Liquid hydrogen would be stored in double-walled, vacuum-insulated cryogenic storage tanks. The footprint of storage facilities would depend on the amount of hydrogen to be stored but would be less than 1 acre. This includes the storage tanks, separation space between tanks (if more than one), on-site access roads, and ancillary equipment.

A green hydrogen storage facility may be co-located with a green hydrogen production facility or a facility with BESSs or it may be located at a standalone facility, transport terminal, or end-use location such as an industrial facility or fueling facility.

3.6.1 Impacts from construction, operation, and decommissioning

Potential construction and decommissioning impacts to energy and natural resources described for green hydrogen production facilities in Section 3.4 would be similar for green hydrogen storage facilities. Relative to a green hydrogen production installation, a green hydrogen storage facility would require a small amount of additional resources, less than the estimates for a 1-acre green hydrogen production facility site.

3.6.1.1 Electricity

A green hydrogen storage facility would consume electricity during operations. Gas compression and liquefaction would require electricity to enable storage. Electricity would be needed to compress the hydrogen gas to liquid form. Upper bound kilowatt hour requirements for each storage type were based on electricity required to process and store 1 kg of hydrogen. Gas storage would require approximately 2–3 kWh/kg of hydrogen stored. Liquid storage would require 7–12 kWh/kg of hydrogen stored.

Kilowatt hour requirements for each storage method were based on the range of electricity required to process and store 1 kg of hydrogen for a small-scale (1,000 kg/day), mid-scale (10,000), and large-scale (10,000 kg/day) storage level. The range of electricity required reflects the variation that the pressure required, and the process used can have on electricity needs. Estimates for liquid storage include the energy needs of cooling equipment. The anticipated maximum electricity requirements for each green hydrogen storage method are shown in Table 9. The provided estimated ranges for electricity consumption are assumptions based on published specifications (data sheets) for commercial electrolysis units on the market today. During project-level environmental review, estimates would be refined based on project-specific information for the type of facility proposed.

Table 9. Green hydrogen storage - electricity requirements for processing and storage

Storage method	Electricity required to store 1 kg of hydrogen (kWh)	Daily hydrogen output (kg) level (small scale, medium scale and large scale storage)	Daily kWh requirements (small scale medium scale and large scale storage)	Annual kWh requirements (small scale, medium scale and large scale storage) (kWh)	Storage demands as a percentage of 2023 total statewide electricity production (kWh)	Storage demands as a percentage of 2023 renewable statewide electricity production (kWh)
Gas	2–3	1,000	2,000 to 3,000	730,000 to 1,095,000	0.00073 to 0.0011%	0.001 to 0.002%
		10,000	20,000 to 30,000	7,300,000 to 10,950,000	0.0073 to 0.011%	0.01 to 0.02%
		100,000	200,000 to 300,000	73,000,000 to 109,500,000	0.073 to 0.11%	0.1 to 0.2%
Liquid	7–12	1,000	7,000 to 12,000	2,555,000 to 4,380,000	0.0025 to 0.0044%	0.004 to 0.006%
		10,000	70,000 to 120,000	25,550,000 to 43,800,000	0.025 to 0.044%	0.04 to 0.06%
		100,000	700,000 to 1,200,000	255,500,000 to 438,000,000	0.25 to 0.44%	0.4 to 0.6%

Source: DOE 2009

Electricity demands for small-scale, medium-scale and large-scale processing and storage for both gas and liquid methods would range from 0.001% to 0.6% of the annual percentage of the total statewide electricity production. Impacts to electricity from decommissioning would be similar to impacts from construction.

As described above, a green hydrogen storage facility developer would need to ensure that there is sufficient electricity for a project available by establishing an agreement with a utility for access to the electrical grid or with a producer of electricity. If electricity is not available, a project would not be feasible.

The PEIS assumes that a developer has contracted for sufficient electricity for storage. With this assumption, through compliance with laws and permits, and with implementation of measures to avoid and reduce impacts, the construction, operation, and decommissioning of green hydrogen storage facilities would likely result in **less than significant impacts** on electricity.

3.6.1.2 Renewable natural gas

During site characterization, construction, operation, and decommissioning activities, RNG would not be needed. There would be no effect to supply chains or management and distribution of resources.

3.6.1.3 Biomass

During site characterization, construction, operation, and decommissioning activities, biomass would not be needed. There would be no effect to supply chains or management and distribution of resources.

3.6.1.4 Fuel for transportation and equipment

Storage facilities would require additional hours for construction and installation, increasing demand for fuels to support worker commuting. Impacts would be similar to those for facilities described in Sections 3.4 and 3.5, except that more truck trips would be required to transport the storage facility components and any additional gravel needed for the areas around the storage facilities. The relative increase in fuel for construction of the storage facilities would be minimal compared to what is already demanded for construction of the green hydrogen facility.

Adding storage facilities would require additional hours for maintenance, which would result in a minor increased demand for fuels beyond what is already demanded for operation of the facility as a whole. Decommissioning would also have approximately the same demand for fuels as construction.

Therefore, the construction, operation, and decommissioning of green hydrogen storage facilities would likely result in **less than significant impacts** on fuels.

3.6.1.5 Construction aggregate

Demand for construction aggregate could increase if the storage tanks are co-located at a green hydrogen production facility, depending on the size and type of facility. Liquid hydrogen can be stored in cylindrical tanks or spheres, which would require approximately 23 to 505 cubic yards of aggregate for support pads.

The resulting increase in construction aggregate demand would not be enough to materially increase overall consumption as analyzed for other facility types. Therefore, the construction, operation, and decommissioning of green hydrogen storage facilities would likely result in **less than significant impacts** on construction aggregate.

3.6.2 Measures to avoid, reduce, and mitigate impacts

The same measures to avoid, reduce, and mitigate impacts described previously (Section 3.4.3) also apply to this facility type.

3.7 No Action Alternative

Under the No Action Alternative, agencies would continue to conduct environmental review and permitting for green hydrogen energy facilities under existing laws on a project-by-project basis. The potential impacts would be similar to the impacts for the types of facilities described above for construction, operation, and decommissioning, depending on facility size and design, and would be **less than significant.**

3.8 Unavoidable significant adverse impacts

Demand for biomass for operations of green hydrogen bio-gasification facilities could result in a reduction in access or create a substantial reduction in availability of biomass resources. Demand for RNG for operations of green hydrogen SMR or pyrolysis facilities could result in a reduction in access or create a substantial reduction in availability of RNG resources. These impacts could be mitigated through development of new additional biomass or RNG facilities for use by green hydrogen facilities.

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

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