Appendix P: Public Services and Utilities Technical Appendix

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

By

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For the

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Acronyms and Abbreviations List

BESS	battery energy storage system
BMP	best management practice
DNR	Washington State Department of Natural Resources
DOH	Washington State Department of Health
Ecology	Washington State Department of Ecology
EMS	emergency medical services
EMT	Emergency Medical Technician
EPA	U.S. Environmental Protection Agency
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
FERC	Federal Energy Regulatory Commission
GIS	geographic information system
HAZMAT	hazardous materials
IBC	International Building Code
IFC	International Fire Code
kg	kilogram(s)
kV	kilovolt(s)
medevac	medical evacuation
NFPA	National Fire Protection Association
NPDES	National Pollutant Discharge Elimination System
OSHA	Occupational Safety and Health Administration
PEIS	Programmatic Environmental Impact Statement
PG&E	Pacific Gas and Electric Company
PPE	personal protective equipment
PUD	public utility district
RCW	Revised Code of Washington
RNG	renewable natural gas
scf	standard cubic feet
SEPA	State Environmental Policy Act
SMR	steam-methane reforming
TMDL	total maximum daily load
USC	U.S. Code
USFS	U.S. Forest Service
UTC	Washington Utilities and Transportation Commission
UW	University of Washington
WAC	Washington Administrative Code
WSP	Washington State Patrol

Summary

This technical appendix describes the public services and utilities conditions in the study area. It also describes the regulatory context and potential impacts and actions that could avoid or reduce impacts.

This technical appendix analyzes the following key features:

- Public services:
  - Fire and emergency response services
  - Wildfire response
  - Law enforcement
  - Health care facilities
  - Public school enrollment
- Utilities:
  - Solid waste disposal including landfill and recycling capacity
  - Wastewater and stormwater infrastructure
  - Water supply
  - Electricity service and infrastructure
  - Communications
  - Natural gas

This impact assessment considers whether the construction, operation, and decommissioning phases of the types of green hydrogen energy facilities evaluated would result in a significantly increased demand for public services such that the capacities of existing service providers would be exceeded. The assessment also considers whether facilities would result utility capacity exceedances or utility service interruptions.

A green hydrogen facility developer would need to ensure that there are sufficient utilities for a project available by establishing agreements with utility providers. A green hydrogen facility developer would also need to ensure that there is sufficient water available for a project, both physically and legally. The PEIS assumes that a project developer has contracted for sufficient electricity and renewable natural gas and obtained a water right as needed. Impacts to energy resources are discussed in the Energy and Natural Resources Technical Appendix, and impacts to water resources are discussed in the Water Resources Technical Appendix.

Green hydrogen facilities would have hydrogen and other flammable materials present on site that pose a risk of fire and explosion. These risks are discussed in the Environmental Health and Safety Technical Appendix. The severity of risks would need to be assessed for each facility based on the project location, production method, and quantities of flammable materials produced or stored on site. Risk can be reduced through proper design and operation. Having a fire response plan, flame and leak detection systems, and fire response equipment in place would reduce risks. Utilizing setbacks and establishing site perimeters that are nonflammable would also reduce risks.

Findings for public services and utilities impacts described in this technical appendix are summarized below:

- Through compliance with laws and permits and with implementation of actions that could avoid and reduce impacts, most construction, operation and decommissioning activities would likely result in **less than significant impacts** on public services and utilities.
- A facility would result in **potentially significant adverse impacts** on emergency response if activities required a large emergency response in remote locations with limited response capabilities, if a fire or explosion during operations spreads rapidly or impacts large areas, or if there are other unique aspects of a facility site.
- **Potentially significant and unavoidable adverse impacts** may occur if activities require a large emergency response in remote locations with limited response capabilities, if a fire or explosion during operations spreads rapidly or impacts large areas, or if there are other unique aspects of a facility site or operations that affect emergency response. Determining if mitigation options would reduce or eliminate impacts below significance would be dependent on the specific project and site.

1 Introduction

This technical appendix describes public services and utilities within the study area and assesses probable impacts associated with the types of green hydrogen facilities evaluated, and a No Action Alternative. Chapter 2 of the State Environmental Policy Act (SEPA) Programmatic Environmental Impact Statement (PEIS) provides a description of the types of facilities evaluated.

This section provides an overview of the aspects of public services and utilities evaluated and lists relevant regulations that contribute to the evaluation of potential impacts.

1.1 Resource description

Key features of public services described in this technical appendix consist of considerations for emergency response including that of law enforcement, fire departments (including wildfire response capabilities), and the availability of emergency medical services (EMS), healthcare facilities, and public schools in the study area as potentially affected by green hydrogen facilities.

Key features of utilities described in this technical appendix include solid waste, wastewater, and stormwater management; water supply; electricity; communications; and natural gas.

In the study area, the following resources could have impacts that overlap with impacts to public services and utilities, or the impact analysis for these resources may be informed by the analysis of public services and utilities. Impacts on these resources are reported in their respective technical appendices:

- **Energy and natural resources:** Energy consumption by a new green hydrogen facility is analyzed in the *Energy and Natural Resources Technical Appendix*.
- **Environmental health and safety:** Information on risks associated with environmental health and safety like fire, explosion, and exposure to hazardous materials from the *Environmental Health and Safety Technical Appendix* is referenced in this technical appendix when discussing risks that could lead to fire and emergency response.
- **Water resources:** Information on water rights and water quality from the *Water Resources Technical Appendix* is referenced in this technical appendix when discussing stormwater, wastewater, and water supply.

1.2 Regulatory context

Potentially applicable federal, state, and local regulations are listed in Table 1, which will contribute to the evaluation of potential public services and utilities impacts.

Table 1. Applicable laws, plans, and policies

Regulation, statute, guideline	Description
Federal	
42 U.S. Code (USC) 6901 et seq., Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act (42 USC 6901 et seq.) and the Hazardous Solid Waste Amendments of 1984	Applicable to solid and hazardous waste generated during construction, operation, and decommissioning.
29 Code of Federal Regulations (CFR) 1910, Occupational Safety and Health Administration	Establishes the Occupational Safety and Health Administration (OSHA), which regulates worker safety and hazards in the United States. Multiple sections would be relevant to green hydrogen facilities, including but not limited to 29 CFR 1910.103, Hydrogen; 29 CFR 1910.119, Process safety management of highly hazardous chemicals; and 29 CFR 1910, Subpart I Personal Protective Equipment (PPE).
47 USC 303(q), Antenna Tower Lighting and Marking Requirements; 47 CFR 17.21- 17.58, Federal Aviation Administration (FAA) Advisory Circulars	Standards and specifications set forth in FAA advisory documents govern antenna tower lighting and marking requirements, which are mandatory under the Federal Communications Commission (FCC) rules. The FCC requirements for filing with the FAA for proposed structures vary based on a number of factors including height, proximity to an airport, location, and frequencies emitted from the structure, etc. Depending on such factors, communication structures associated with the green hydrogen facilities may be subject to the FAA standards.
State	
Chapter 246-272A Washington Administrative Code (WAC), On-Site Sewage Systems	Applicable for green hydrogen facilities that will not tie into local sewer systems. The chapter provides guidance and requirements to limit on-site sewer discharges.
Chapter 70A.200 Revised Code of Washington (RCW), Waste Reduction, Recycling, and Model Litter Control Act	Applicable for waste generated during construction, operation, and decommissioning.
Chapter 70A.214 RCW, Waste Reduction	Applicable to waste generated during construction, operation, and decommissioning. Establishes programs and incentives for waste reduction, recycling, and proper handling and disposal of hazardous waste.
Chapter 70A.218 RCW, Hazardous Waste Fees	Applicable to hazardous waste generated during construction, operation, and decommissioning.
Chapter 70A.300 RCW, Hazardous Waste Management	Applicable to hazardous waste generated during construction, operation, and decommissioning.
Washington State Department of Ecology Stormwater Management Manual for Western Washington (SWMMWW) and Stormwater Management Manual for Eastern Washington (SWMMEW)	Establishes stormwater management standards for construction and permanent stormwater systems. Applicable for stormwater control and treatment during construction, operation, and decommissioning.

Regulation, statute, guideline	Description
Chapter 51-50, State Building Code adoption and amendment of the 2021 edition of the International Building Code (IBC)	Establishes the Washington State Building Code's adoption of the IBC, which sets standards for commercial construction. This chapter also adopts National Fire Protection Association (NFPA) 70, National Electric Code, which sets national standards for electric, and communications components installed in buildings, structures, and in open-air settings. The IBC has adopted parts of and full standards of NFPA sections including NFPA 241, Standard for Safeguarding Construction, Alteration, and Demolition Operations, which sets construction and demolition fire safety standards.
Chapter 51-56 WAC, adoption and amendment of the 2021 edition of the Wildland-Urban Interface Code	The International Wildland-Urban Interface Code sets additional requirements code officials can require for structures and subdivisions located within the wildland-urban interface areas. These include a site plan, vegetation management plan, vicinity plan, fire apparatus access roads, and water supply.
Chapter 51-52 WAC, State Building Code adoption and amendment of the 2021 edition of the International Mechanical Code	Establishes the Washington State Building Code's adoption of the International Mechanical Code which sets standards for mechanical infrastructure in buildings and structures. This chapter also adopts several NFPA standards including NFPA 72 National Fire Alarm and Signaling Code.
Chapter 51-54A WAC, State Building Code Adoption and Amendment of the 2021 Edition of the International Fire Code	Establishes Washington State's adoption of the International Fire Code (IFC) and also adopts some IFC standards including NFPA 855 Standards for Installation of Energy Storage Systems relevant to battery energy storage system installation. Washington State provides amendments to each iteration of the IIFC. The current Washington State amendments to the 2021 IFC have been effective since March 15, 2024. The IFC sets standards for fire preparedness and safety.
Title 118 WAC, Military Department (Emergency Management)	Establishes standards for emergency response and management including emergency response plans, 9-1-1, operations, and funding sources.
WAC 332-24-301, Industrial Restrictions	Applicable to construction and operations as it relates to wildfire risk.
RCW 80.28.440, Wildfire mitigation plan—Review/revision	Requires wildfire mitigation plan for investor-owned utilities.
WAC 173-303-573, Standards for universal waste management	Applicable for lithium-ion battery disposal.
RCW 36.70A.070, Washington State Growth Management Act	Requires cities and counties to include a utilities element in their comprehensive plans.
Local	
Comprehensive plan goals and objectives, and local codes and requirements pertaining to public services and utilities	A local planning effort by cities and counties that provides a vision for the community and identifies steps needed to meet that vision. Many counties and cities in Washington defer to state regulations.

2 Methodology

2.1 Study area

The study area for public services and utilities includes the PEIS geographic scope of study for green hydrogen facilities (Figure 1) and the surrounding areas that have potential for off-site impacts.

The study area for the evaluation of public services and utilities associated with the construction and operation of green hydrogen facilities would be determined by identification of the service territories of all relevant public services and utilities that provide service to areas during project-specific reviews. 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.

2.2 Technical approach

Impacts associated with construction, operation and maintenance, and decommissioning were qualitatively analyzed. To evaluate the potential impacts on public services and utilities, existing providers in the study area were identified using a desktop analysis of information obtained through public websites, and mapped sources. Available datasets were accessed to inform high-level considerations.

This non-project-specific evaluation considered typical siting and design parameters, regulatory requirements, and plans and procedures intended to reduce effects. For analytical purposes, it is assumed that the green hydrogen facilities would comply with existing regulations and that the requirements would be enforced by the applicable local, state, and/or federal jurisdictions. Standard measures and best management practices (BMPs) may be considered for integration as actions to avoid and reduce impacts. Geographic/regional variation would likely influence whether facility impacts on public services and utilities rise to the level where mitigation would be required.

The analysis also considered climate change and its influence with respect to wildfire risk as related to fire emergency response. The identified potential actions to avoid and reduce impacts are specific to impacts identified for public services and utilities, except where crossovers with other resource areas exist. In these cases, mitigation potential actions are cross-referenced from other PEIS technical memoranda or resource reports. Additional details regarding public health and safety, including wildfire risk as it informs this analysis, are provided in the *Environmental Health and Safety Technical Appendix*.

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).

2.3 Impact assessment approach

The potential impacts on public services and utilities include those from construction, operation and maintenance, and decommissioning of the green hydrogen facilities analyzed in the PEIS. This impact assessment considered whether the green hydrogen facilities would result in:

- Increased demand for public services (e.g., fire and law enforcement, emergency medical response, schools) that exceeds capacities of existing service providers
- Relocation or prolonged service interruptions of existing utilities
- Construction of new or modified utilities
- Potential for hazards associated with green hydrogen facilities to impact emergency response capabilities

A green hydrogen facility developer would need to ensure that there are sufficient utilities available for a project by establishing agreements with utility providers. A green hydrogen facility developer would also need to ensure that there is sufficient water available for a project, both physically and legally. The PEIS assumes that a project developer has contracted for sufficient electricity and renewable natural gas (RNG) and obtained a water right as needed.

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

- The facility would result in a significantly increased demand for public services, exceeding existing capacities of public service providers (e.g., fire and emergency response, law enforcement, wildfire response, health care facilities, public schools, solid waste).
- The facility would result in a significantly increased demand for public services such that unplanned new or physically altered governmental facilities would be needed to serve the facility.
- The facility would cause significant service interruptions by exceeding existing or anticipated utility or service system capacity, resulting in the modification, construction, or relocation of utilities or services.

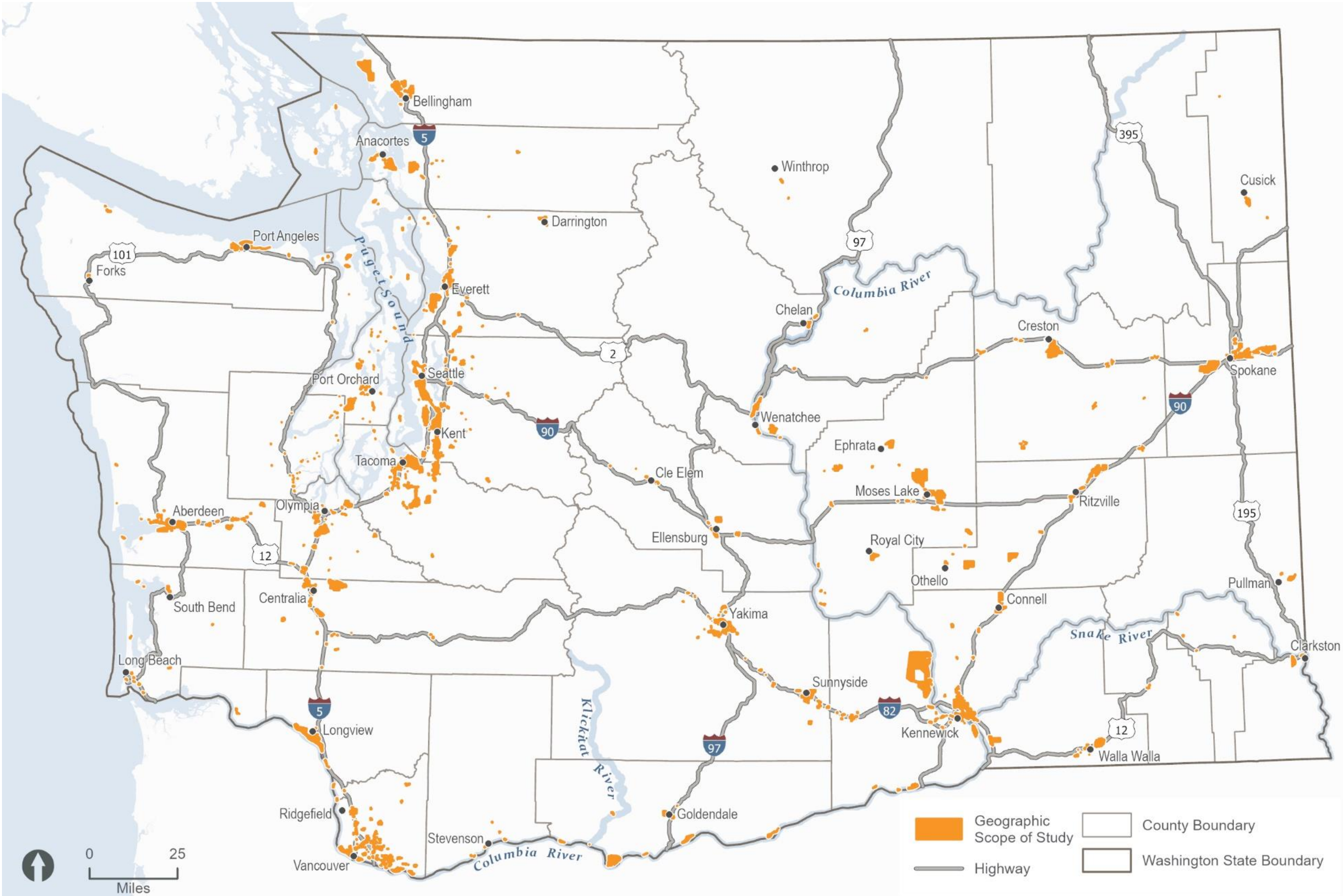

Figure 1. Green Hydrogen Energy Facilities PEIS geographic scope of study

3 Technical Analysis and Results

3.1 Overview

This section describes the public services and utilities conditions in the study area and provides an analysis of potential impacts that could occur for green hydrogen facilities analyzed in the PEIS. This section also evaluates actions that could avoid, minimize, or reduce the identified impacts and potentially unavoidable significant adverse impacts.

3.2 Affected environment

The affected environment represents the existing conditions at the time this study was prepared. The study area includes variable public service and utility providers. For the purposes of the analysis, the temporal scope of affected environment considerations consists of 25 years within which facilities may be constructed and up to 50 years of operation for each facility. The conditions described in this section include a high-level consideration of climate change over this timeframe and its potential to alter conditions for public services and utilities.

3.2.1 Public services

The green hydrogen facility study area is served by a variety of public service providers, which are funded in part through public resources such as business and sales tax revenue. Depending on the local conditions, public services may be provided by federal, state, county, or local governments, as well as volunteer groups including volunteer fire departments. Public services addressed in this section include emergency response including that of law enforcement, fire departments (including wildfire response capabilities), and the availability of EMS, healthcare facilities, and public schools.

3.2.1.1 Emergency response

Emergency response in the study area includes law enforcement, fire departments, and EMS. Coordination and emergency alert communication are conveyed to the public through subscriber-based text alerts via cell phone and email; radio and other media are used to communicate with the public about hazard conditions and natural disasters. Emergency management services are provided at the county level and consist of various divisions that carry out dispatch services to all law enforcement, fire, and emergency management and response services (including 9-1-1 response) through centers within their respective divisions. Depending on the location of a green hydrogen facility, emergency services provided may be from a local, county, or state entity.

Law enforcement

Law enforcement in Washington is provided by various county, municipal, and state entities. Unincorporated areas of the state are served by local county sheriff's offices. All state routes and interstate highways are patrolled by the Washington State Patrol (WSP). WSP services include but are not limited to traffic enforcement on state and interstate highways, incident response, drug enforcement, forensic analysis, investigative services, a bomb squad, a special weapons and tactics team, and fire and hazardous materials (HAZMAT) training through the WSP Fire Protection Bureau (WSP 2023a, 2023b). Washington State Department of Ecology (Ecology) also provides has a HAZMAT Spill response team.

Fire and wildfire prevention and response

Fire prevention and response for facilities in the study area would be under the control of city, and county fire departments with support from volunteer units and other response teams, depending on the jurisdiction. City and county jurisdictions coordinate proactive controls such as promoting defensible space vegetation removal, prescribed burning, or invoking burn bans, as conditions warrant, to prevent the uncontrolled spread of wildfires. Although each jurisdiction maintains the primary responsibility for providing services within its boundaries, mutual aid response agreements exist among different fire jurisdictions and regions, through which they assist each other in the event one jurisdiction or region is unable to contain a structure fire or another emergency situation using its own resources and personnel (WSF 2023).

Wildfire

The study area is within the jurisdiction for local emergency response. Some portions are close to forest lands under U.S. Forest Service (USFS) or Bureau of Land Management jurisdiction for emergency response. At the state level, the Washington State Department of Natural Resources (DNR) provides fire protection on properties it manages, including more than 13 million acres of private and state-owned forest lands. DNR works with other state, federal, and local agencies to respond to wildfires and offers local fire districts and volunteer units with support on fire protection and safety equipment requirements. DNR implements industrial fire precaution levels to limit certain activities as conditions warrant in lands under their jurisdiction.

DNR manages an aviation response and helitack program available for dispatch throughout Washington State (see Figure 2). Crews are staged in multiple locations statewide during the fire season and respond to threats to human life, property, and natural resources. Helitack crews are teams of firefighters who are transported by helicopter to wildfires. Available for dispatch throughout all of Washington State, these small teams provide initial attack capacity to fires occurring in areas not easily reached by ground.

Figure 2. Bell UH-1H(M) Huey helicopter used in DNR's helitack program

Source: DNR 2024

Washington State DNR Wildfire Aviation is a highly trained air–ground firefighting team available for initial attack rapid response to wildland fires (see Figure 3). Wildfire Aviation is comprised of 10 UH-1H(M) Huey helicopters modified for water and suppressant delivery in remote locations with the capability to deliver helitack crews into otherwise unreachable terrain.

The primary aviation bases are in Olympia and Yakima. Historically, DNR helitack program crews have been staged in Omak, Deer Park, Dallesport, Pomeroy, Wenatchee, Colville, and Olympia (DNR 2024). DNR implements industrial fire precaution levels to limit certain activities as conditions warrant in a given region, as defined in WAC 332-24-301.

Figure 3. Scooper plane dumping water on a wildfire

Source: DNR 2024

Climate change considerations for wildfire risk

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). This analysis includes a consideration of climate change effects on wildfire risk over this extended timeframe. Climate change is expected to impact multiple variables related to fire risk, including air temperature, precipitation, humidity, wind, solar radiation, and other interactive issues such as forest health, invasive species (notably including mountain pine beetle infestations), and prolonged drought, all of which influence fire risk and associated fire emergency response.

As discussed in the *Environmental Health and Safety Technical Appendix*, the University of Washington (UW) has conducted climate resilience mapping to model wildfire risk across the state through time. The map shows the projected change in high fire danger days[1] compared to historical (1971–2000) averages. An increase in high fire danger days indicates a greater potential for wildfire danger to damage infrastructure, interrupt businesses, and affect public health and well-being (UW 2024). Although the severity of fire risk is variable across the geography of the state, with a higher number of high fire danger days in the eastern part of the state, it is notable that all counties show a moderate increase in the projected number of fire days between the years 2010 and 2039 and a significant increase in the projected number of high fire days between the years 2040 and 2069, roughly coinciding with the extended timeframe of the green hydrogen facilities.

[1] A high fire day is defined by UW in the context of climate resilience mapping as a day in which in which 100-hour fuel moisture (i.e., the amount of water in fuel/vegetation available for combustion) is less than the historical 20th percentile.

The combination of longer fire seasons, population growth, declining forest health, and other threats have made wildfire considerations a top priority in Washington. The Washington State Wildland Fire Protection 10-Year Strategic Plan recognizes the need for proactive management of the landscape, the importance of maintaining a highly capable emergency response workforce, and the need to prepare for expected increases in wildland fires in future years (DNR 2019).

Emergency medical services and healthcare facilities

Fire departments and regional fire districts, public hospitals, and private ambulance provide EMS throughout the state. The Washington State Department of Health (DOH) coordinates EMS and trauma care in various regions throughout the state. Emergency Medical Technician (EMT) dispatch is handled through emergency management and response services as described above.

At a local level, there are multiple health care facilities and hospitals throughout the state providing public health preparedness and response services. Local emergency planning efforts by hospitals, public health providers, and other community entities are integrated with county comprehensive planning.

Major health care facilities in Washinton include trauma centers and hospitals. Trauma centers provide immediate definitive care for severe injuries. They have designated based on the level of care a health care facility is able to provide for traumatic injury. Level I trauma centers can provide the most comprehensive care for traumatic injury and Level IV and V trauma centers are able to provide basic services such as stabilizing a patient and arrange for transport to another facility (Southern and Celik 2023). Hospitals treat various injuries and emergency or urgent conditions. Medical evacuation (medevac) services are contracted through the public and private health facilities, and on state and federal lands with the support of agencies (such as DNR, USFS, and the U.S. Coast Guard).

3.2.1.2 Public schools

A variety of public school districts serve portions of the study area. These districts range in size from small rural school districts to larger districts with numerous schools.

In Washington State, the number of school-age students increased an average of 11,300 per year between 2013 and 2023. Enrollment peaked at 1.1 million K-12 students in 2019, then leveled off during and following the Covid-19 pandemic. Enrollment increases are expected to be moderate, as the growth in the school-age population is projected to ease after 2023 (OFM 2024).

3.2.2 Utilities

Utilities described in this section include solid waste, wastewater, and stormwater management; water supply; electricity; communications; and natural gas. Depending on the area, utilities may be provided by county, city, or private suppliers. In general, utility infrastructure often correlates to the size of the population it serves. As a result, population levels, coupled with any topographic or other constraints on where utilities can be provided, often dictate how well a community is served by utility systems. Because green hydrogen facilities are anticipated to be located on industrial land, most of the study area is located in utility service areas for the utilities described.

3.2.2.1 Solid waste

Solid waste generated throughout the study area is collected and managed by the various cities, counties, and private waste management entities. There are nearly 1,000 solid waste handling facilities of various types throughout Washington. There are 14 municipal solid waste landfills operating in the state: 11 are publicly owned and 3 are privately owned. These landfills received 5.5 million tons of waste in 2019 and have an estimated capacity of 280 million tons, or about 40 years of capacity at current disposal rates. There is also one “Waste-to-Energy” facility in Spokane, which is the only incinerator in the state that burns municipal solid waste (Ecology 2021a). Ecology tracks and measures waste generation in Washington through review of submitted annual reports and recycling surveys from the regulated solid waste handling facilities in the state. Quantified waste generation activities include landfill disposal, incineration of mixed municipal solid waste, recycling, composting, anaerobic digestion, land application, and burning source-separated materials for energy. Other than municipal and commercial solid waste, by category, the largest quantities of solid waste generated in the state include construction and demolition debris, industrial waste, and cured concrete. In rural areas, where no collection systems are available, nonhazardous waste is removed by regulated providers and trucked to regional landfills.

Solid waste diversion incorporates a sustainable materials management approach intended to serve human needs by increasing productive reuse from the point of extraction to materials disposal (Ecology 2021b). Metals and other materials capable of reuse may be collected and sold for reuse, recycled, or otherwise managed separately consistent with state requirements.

A substantial portion of the materials that make up green hydrogen facilities are recyclable, such as steel and aluminum. Green hydrogen facilities could produce hazardous waste that would be disposed of during operation and decommissioning. Waste fluids that could not be treated and discharged to a sanitary sewer and soil exposed to hazardous materials would have to be transported to the appropriate disposal location. Green hydrogen facilities that are collocated with battery energy storage systems (BESSs) would have to dispose of batteries after they reach their 5- to 10-year lifespan. Lithium-ion batteries are considered a hazardous waste that cannot be hauled away with a standard solid waste pickup. Health and safety concerns with waste produced during construction, operation, and decommissioning are described in more detail in the *Environmental Health and Safety Technical Appendix*.

3.2.2.2 Wastewater and stormwater

Wastewater and stormwater utilities are provided through various sources in the study area. Wastewater and stormwater infrastructure in more populated areas is generally provided by local cities and counties, or public utility districts (PUDs)/water districts. Less-populated areas may not have wastewater or stormwater infrastructure available. In these areas, sanitary wastewater would be managed with a permitted on-site septic system or trucked off site to an appropriate disposal location. Stormwater would infiltrate on site if feasible or would require a treatment and conveyance system to outflow to a local water body or conveyance system.

The analysis assumes that if septic or sanitary systems are employed as part of a facility, such systems would be required to conform to local permit design and installation requirements to protect public health and surface and ground water resources. Existing subsurface utilities (including wells and water lines) would also require identification prior to ground-disturbing construction and avoidance during operation and maintenance.

3.2.2.3 Water supply

Water supply in the study area is provided through various sources, including public or private water utilities, groundwater wells, and surface water diversions. The DOH and Ecology share responsibilities under the state's Municipal Water Law under coordinated planning, engineering, and public health and safety agreements related to water resources and supply systems. Connecting to a public water system requires a service connection application to a public utility district, municipal, or county system. Allocation and development of water supplies may be subject to restrictions depending on the location. Appropriation of groundwater and well construction, with limited exceptions, requires local permits. Such activities near surface waters may need to demonstrate that the allocation will allow for the maintenance of instream flow requirements adequate to support fisheries habitats. Water resources are discussed in additional detail in the *Water Resources Technical Appendix*.

Water needs would vary depending on the green hydrogen production process. Some methods, such as methane pyrolysis, require no water for production, whereas others, like steam-methane reforming (SMR), require 6–8 gallons of water per kilogram (kg) of hydrogen produced. Water used for electrolysis needs to be de-mineralized for the production process, which would require additional treatment not provided by public or private water utilities.

3.2.2.4 Electricity

Electrical utilities are provided in the State of Washington through PUDs and three main corporations including Avista Utilities, Pacific Power and Light, and Puget Sound Energy. PUDs are not-for-profit community-owned entities governed by locally elected commissioners who live in the communities they serve (WPUDA 2024). Oversight for electrical transmission and distribution networks is done by the Washington Utilities and Transportation Commission (UTC) and the Federal Energy Regulatory Commission (FERC).

Washington State is the nation's largest producer of hydroelectric power, with 60% of the state's power being generated by hydroelectric dams in 2023. Including biofuels and thermal energy, approximately 90% of Washington's power generation comes from renewable sources (EIA 2024).

The industrial land identified for the green hydrogen PEIS is located within 25 miles of minimum 55-kilovolt (kV) transmission lines to meet the energy requirements of green hydrogen facilities.

All facility types would require electricity during construction, operation, and decommissioning. 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. Some facilities may include co-located BESSs to balance loads from renewable resources with the demand of the production system. On-site energy storage also provides resilience to the facility in case of a power outage or power quality deviation.

3.2.2.5 Communications

Internet, broadband, and cell phone services are available throughout the study area. Public emergency alert systems report natural hazards (such as flooding or wildfire) through local radio stations, cell phones, and email notifications. The various cities and counties in the study area provide emergency alert and notification systems, allowing subscribers to access alerts in real time. Although these areas are very limited in the study area, unpopulated or sparsely populated areas where cell service and internet systems are unavailable, would utilize radio signals to broadcast alerts and communicate information pertaining to fire, police, severe weather, and other public hazards. There are standalone communications sites throughout the study area. These sites include cell towers, radio towers, and microwave towers, which serve to relay communications signals. Communications lines enabling internet or cellular signals can be mounted in a shared configuration with electrical lines on dual use poles or buried underground as cables or in conduits.

3.2.2.6 Renewable natural gas

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. RNG is available from all major gas companies in Washington except for Pacific Gas and Electric Company (PG&E) Gas Transmission Northwest (UTC 2022; PG&E 2023; Avista 2024; Cascade Natural Gas 2024; Northwest Natural Gas 2024; Puget Sound Energy 2024; Williams 2024). PG&E Gas Transmission Northwest is actively exploring RNG opportunities (PG&E 2023). In addition, 28 PUDs provide RNG. As discussed in the *Energy and Natural Resources Technical Appendix*, the market demand for RNG in Washington is expected to grow, and RNG infrastructure and supply are expected to increase accordingly.

Similar to electricity, utilities maintain renewable natural gas systems in various geographies throughout the state with regulatory oversight from the UTC and FERC. Green hydrogen facilities using SMR or methane pyrolysis as a production method would require RNG as a feedstock. For all green hydrogen facilities, locations of existing subsurface gas lines would need to be identified prior to construction to reduce potential ground-disturbance conflicts.

3.3 Potentially required permits

The following permits related to public services and utilities could be required for construction, operation, or decommissioning of typical green hydrogen facilities and activities:

- **CWA Section 402 National Pollutant Discharge Elimination System (NPDES) Construction Stormwater Permit (Ecology/U.S. Environmental Protection Agency [EPA]):** Required for construction that disturbs more than 1 acre of land and would have the potential to discharge stormwater to state surface waters, or construction disturbance of any size that would have the potential to be a significant contributor of pollutants or may be expected to cause a violation of any water quality standard (including groundwater standards).
- **NPDES Industrial Stormwater General Permit (administered by Ecology):** Required for industrial facilities. Ecology administers this federal permit as well, with an application process similar to that of the Construction Stormwater General Permit, though BMPs and treatment methods stated in this application are for operation rather than construction.
- **State Wastewater Discharge Permit – Industrial to Publicly Owned Works (permit authority varies):** Required by industrial facilities that discharge wastewater to privately or publicly owned wastewater treatment plants unless they have obtained a pretreatment discharge permit issued by a delegated municipality.
- **Water Right Permit – New (Ecology):** Required to use any amount of surface water for any purpose. A permit for a water right would be required to withdraw groundwater from a well for any uses not covered by a groundwater permit exemption (e.g., typically domestic and industrial uses less than 5,000 gallons per day each, although some areas are more restrictive).
- **Water Right Change or Transfer Authorization (Ecology):** Required to change certain elements of a water right.
- **Federal Communications Commission (FCC) and Federal Aviation Administration (FAA):** FAA advisory documents govern antenna tower lighting and marking requirements, which are mandatory under the FCC rules. The FCC requirements for filing with the FAA for proposed structures vary based on a number of factors, including height, proximity to an airport, location, and frequencies emitted from the structure. Depending on such factors, towers’ or communication structures’ associated electrical infrastructure may be subject to the FAA standards.
- **Local utility connection permits/approvals:** Depending on the location of a green hydrogen facility, the applicant would have to apply through a utility provider (local, county, PUD, water district) to connect to utility infrastructure. Design standards would be required to be met to make sure connection points do not fail. The applicant may have to determine and provide anticipated needs to make sure the utility provider can meet demand.
- **Local land use permits/approvals:** Municipals and counties each have their own land use process to make sure a proposed land use aligns with their zoning code and comprehensive plan. Oftentimes, zoning/land use code includes code requirements to

make sure a development is consistent with local utility provider requirements. This can include design requirements such as providing adequate space for trash and recycling trucks to maneuver in and out of a site or designing electricity connection points to be underground in municipalities where powerlines have been buried.

- **Local fire marshal permit/approval:** The local fire department that serves a green hydrogen facility would need to review and approve design features that pertain to fire safety (e.g., fire extinguisher placement, fire alarm system, sprinkler system, fire doors).

3.4 Green hydrogen production facility

This section describes potential impacts of green hydrogen production facilities. 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 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 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 study area is less than 10 miles from a state route (63% within 1 mile and 99% within 10 miles). If needed, the project developer would determine the length of off-site access road needed, 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

Probable adverse impacts associated with site characterization and construction of green hydrogen facilities could consist of those related to emergency response capacity exceedances, conflicts with existing utilities, and potential prolonged service interruptions that may occur over portions of the facility construction period. Construction would require a temporary workforce of approximately 10 to 100 workers depending on the size of the facility. Some workers could be local, and others could temporarily relocate to work on a green hydrogen facility. These temporary workforces may impact demand for public services in the area.

Decommissioning of green hydrogen facilities could generate impacts to most public services and utilities similar to those identified for construction. Additional considerations for solid waste during decommissioning are discussed below.

3.4.1.1 Emergency response

Law enforcement
Construction would entail the use of equipment and presence of materials, which may increase the potential for theft, vandalism, trespass, fire, safety issues, and accidents requiring law enforcement or other emergency response services. Facilities would have provisions for site security, including a combination of fencing, lighting, and/or security cameras and other electronic security monitoring systems as needed. Materials and equipment staging areas would be fenced and security cameras installed and monitored to protect the site during construction. Other proactive security measures to reduce the demand on local law enforcement include security lighting, private security patrols, security cameras, alarm systems, and no trespassing signage. The presence of workers during site characterization and construction may also deter incidents that would require a law enforcement response.

Fire and wildfire prevention and response
Activities during site characterization and construction could include welding, removal of vegetation, and use of vehicles and equipment and associated fuels, all of which introduce ignition risks during construction. The potential for increased emergency response demand at construction of any facility varies by facility type and location. In general, facilities proposed in more-populated areas would have faster response times and more fire-fighting resources available than facilities proposed in less-populated areas. The study area includes industrially zoned areas or areas zoned to support industrial uses, which are usually already suited for land-intensive activities.

If a fire occurs during construction and is not contained, it could spread outside of the construction perimeter and lead to a wildfire. Green hydrogen production facilities proposed in less-developed areas may also be at greater risk of wildfire impacts, especially when conditions are dry. Wildfire risks are discussed further in the *Environmental Health and Safety Technical Appendix*. Areas adjacent to industrial land, particularly in rural areas, may be less developed and have limited response capabilities, and the emergency response demand in the event of a construction-related wildfire could limit emergency response resources needed to address other firefighting in the vicinity.

Emergency medical services and health care facilities
Construction of green hydrogen production facilities would increase the potential for accidents and incidents requiring emergency medical response services or health care facility services. Emergency response services would need to transport construction workers who sustain injuries while on the job site via vehicles. More severe injuries or remote locations may require medevac. Winter conditions could further exacerbate medical response access considerations if, for example, snow, ice, or other weather conditions prevent a medevac landing or cause access roads closures. Summer conditions may increase the need for emergency services due to increased heat causing heat stroke or heat exhaustion. Compliance with Occupational Safety and Health Administration (OSHA) worker safety training and requirements and appropriate site construction management would reduce risks of accidents and incidents.

The study area is within EMS service response areas and within 38 miles of a trauma center equipped with basic emergency department facilities (a Level V trauma center). Parts of the study area that are more remote, such as the San Juan Islands, might require a medevac for emergency services. Consultation or early coordination with emergency response providers to ensure access and other proactive safety planning would reduce such risks.

Emergency response impact summary
Through compliance with laws and permits, and with implementation of actions that could avoid and reduce impacts, most construction and decommissioning activities would likely result in **less than significant impacts** on emergency response.

A facility would result in **potentially significant adverse impacts** on emergency response if activities required a large emergency response in remote locations with limited response capabilities or if there are other unique aspects of a facility site.

3.4.1.2 Public schools

The impact on local schools would be minor and temporary because few out-of-area construction workers would be likely to permanently relocate their families to the community where a green hydrogen facility is being developed. Facilities developed in more urban areas could also draw from the local construction workforce. Therefore, impacts on school enrollment during construction and decommissioning would be **less than significant**.

3.4.1.3 Solid waste

During construction, the primary solid waste generated would consist of solid construction debris such as scrap metal, cable, wire, wood pallets, cardboard, packaging for construction materials, and a negligible amount of waste associated with the construction workforce. A portion of this waste (e.g., scrap metal, cardboard) could be recycled; the remainder would be accumulated into receptacles and transported to a licensed transfer station or landfill.

Special consideration of the type of technology employed and disposal of associated components of a green hydrogen facility would be required due to the use of oils and other hazardous materials during facility operation. The precise quantities and content of solid waste would vary depending on the facility size, and the actions associated with decommissioning would depend on construction materials used and specific site restoration actions needed based on the local environment. It is anticipated that decommissioning would involve removal of all aboveground components of the facilities and would generate more solid waste than construction or operation. Some equipment such as steel tanks may have remaining useful life beyond what can be achieved by the hydrogen production equipment, and there may be opportunity to reuse or recycle other materials. Therefore, the quantity of solid waste generated in facility decommissioning is not anticipated to exceed the capacity of available solid waste management service providers.

Therefore, solid waste impacts during construction and decommissioning would be **less than significant**.

3.4.1.4 Wastewater and stormwater

Sanitation for construction workers could be managed through contracted portable systems, which would be regularly maintained during construction. Construction wastewater could also be managed through a portable system or discharged to an available sanitary sewer system with the proper permits and BMPs in place. Sanitary sewer would be needed for operation, so the contractor and developer would need to coordinate with the local municipality, water district, or PUD providing sewer; apply for any required permits; and adhere to design standards for sewer connections.

Construction stormwater would be managed using construction stormwater BMPs compliant with the Ecology Stormwater Management Manual for Western Washington or the Stormwater Management Manual for Eastern Washington, depending on the location of the facility. Coverage under the NPDES Construction Stormwater General Permit would be required. Compliance with this permit would likely require pretreatment before discharge of stormwater to surface waters or a stormwater or sewer system that discharges to surface waters. Proper construction stormwater BMPs would be required to maintain compliance with the permit. As described above for sewer connections, the contractor and developer would need to coordinate with the local municipality, water district, or PUD providing stormwater conveyance and treatment, apply for any required permits, and adhere to design standards.

The developer and contractor would need to coordinate with local stormwater and wastewater utility providers and pothole if necessary to determine the locations of any existing stormwater and sewer lines within the construction footprint to avoid damage and utility conflicts.

Through compliance with laws and permits, and with implementation of actions that could avoid and reduce impacts, construction and decommissioning activities would likely result in **less than significant impacts** on wastewater and stormwater utilities.

3.4.1.5 Water supply

Water demand during construction would include supplies needed for construction activities: concrete production, dust control, equipment cleaning, potable and wastewater for construction crews, and revegetation and landscaping. Depending on the proposed location of the facility, this could be sourced from groundwater, surface water, a water utility provider connection on-site, or trucked to the site. Potable water would be needed for drinking and could be supplied by a commercial supplier of bottled water or from a water utility provider. For water provided from a utility provider, the developer and contractor would need to apply for permits with the municipality, water district, or PUD providing the water to coordinate specific water availability and water needs. Connection points would need to be designed to meet applicable design standards. Green hydrogen production facilities proposed in more arid climates would likely require more water for dust control than facilities proposed in wet climates, and water usage would vary depending on the season.

Coordination with water utility providers would also be necessary to avoid conflicts and damage to existing water lines. Additional discussion regarding impacts on water availability is provided in the *Water Resources Technical* Appendix. The PEIS assumes that a project developer would have water rights as needed. With proper water supply coordination with providers, impacts to water supply from construction and decommissioning would be **less than significant**.

3.4.1.6 Electricity

Depending on the proposed location of a green hydrogen production facility, power needs for construction could be required, which could cause temporary interruptions to electrical system service while disengagement or rerouting to connect to the electrical grid occurs. It is expected that the facility would connect to the local electric utility grid (electric grid) using overhead distribution lines in existing utility or road rights-of-way and would either replace or be co-located with existing transmission and distribution lines. More than 81% of potential sites within the study area are within 1 mile of existing 55-kV (or greater) transmission lines. The remaining sites are up to 8 miles from existing transmission lines. This is the range used for impact analysis.

The contractor and developer would have to coordinate, apply for permits, and meet the design specifications of the local power provider for connections. Service providers require that line outages be scheduled during off-peak times, which would be coordinated to limit service disruptions. Notifications to residents and businesses for planned service interruptions would also likely be required. Occasional and temporary service interruptions could occur during construction. It is recommended that measures be implemented to reduce conflict with existing electrical systems. Additionally, the contractor and developer would need to account for existing electrical utility infrastructure, both above and below ground, to avoid utility conflicts and damage to existing infrastructure during construction. With appropriate siting and design and proper coordination, construction and decommissioning impacts to electricity would be **less than significant**.

3.4.1.7 Communications

Depending on the location and the contractor, communications connections may be necessary for mobile construction offices. The contractor and developer would need to coordinate with local communications providers to avoid damage to existing communications infrastructure and to avoid utility conflicts. Communications infrastructure could be above or below ground and provided by multiple companies. Walkie-talkies would likely be used by construction crews, which would use frequencies that do not interfere with emergency frequencies used by law enforcement, fire departments, and EMS. The size of structures constructed on green hydrogen production facilities would be designed to not interfere with radio, radar, broadband, or cellular service. With appropriate siting and design and proper coordination, construction and decommissioning impacts on communications would be **less than significant**.

3.4.1.8 Natural gas

Natural gas would not be used during construction of a green hydrogen production facility. Existing natural gas lines may exist within or adjacent to a proposed green hydrogen production facility construction footprint. The developer and contractor would need to coordinate with local natural gas providers as necessary to avoid utility line conflicts and causing damage to an existing gas line during construction.

Green hydrogen production facilities that would use SMR or methane pyrolysis as a production method would need natural gas connections. The developer and contractor would need to coordinate with the local natural gas provider, apply for the necessary permits, and design natural gas pipeline connections following the specifications of the local natural gas provider. This is typical for any developer wanting to connect into existing natural gas infrastructure. Like electricity, coordination with service providers would be needed to minimize temporary service interruptions. With appropriate siting and design and proper coordination, construction and decommissioning impacts to natural gas would be **less than significant**.

3.4.2 Impacts from operation

3.4.2.1 Emergency response

Law enforcement

As with construction, green hydrogen production facility operations could increase the demand for law enforcement services due to potential theft, accidents, vandalism, or trespassing. However, various security measures (e.g., fencing portions of the site to protect systems and equipment; employing site security personnel; providing motion-triggered lighting and facility monitoring systems) would typically be in place as part of normal operations to protect the facilities.

Fire and wildfire prevention and response

Fire risks associated with facility operations are described in the *Environmental Health and Safety Technical Appendix*. Fire risks during facility operation include those caused by green hydrogen facility operational activities and fires started outside of facilities that have altered behavior (i.e., spread, movement, or ability to be suppressed) due to the presence of a green hydrogen facility. This analysis assumes that green hydrogen facilities would be regularly maintained and monitored to reduce these risks, and proper fire control measures and procedures would limit the need for emergency response services. However, accidents and fires could still occur.

Due to the flammable substances that would be present at a green hydrogen production facility, fires that start outside of the facility could be exacerbated by the green hydrogen production facility. In the planning process, the developer should review the surrounding areas for potential fire risks such as other industrial uses that involve fire or flammable substances. There is also a risk of arson. Proper security measures would reduce this risk.

Proper fire control measures and procedures would limit the need for emergency response services. Prior to opening a green hydrogen production facility for operations, coordination with local fire departments would be required.

Hydrogen burns with nearly invisible flames (OSHA 2024). If a fire department is not aware of potential leak causing a hydrogen fire, they may not be able to properly assess and fight the fire. Fire code and International Building Code (IBC) requirements, proper procedures and trainings, proper detection systems, and coordination with local fire departments would provide knowledge of the facility so that local fire responders are better prepared to fight a fire.

If a fire or explosion were to occur during operations, facilities in more-populated areas would have faster response times and more response resources available than facilities proposed in less-populated areas. Additionally, industrial land would be expected to have similar types of industrial operations occurring with similar types of industrial emergency response considerations.

If a fire during operation is not contained, it could spread outside of the operation perimeter and spread, potentially leading to a wildfire. Facilities proposed in less-developed areas may also be at greater risk of wildfire impacts, especially when conditions are dry. In remote locations with limited response capabilities, the emergency response demand in the event of an operation-related wildfire could limit emergency response resources needed to address other fires in the vicinity.

Facilities located in areas with greater risk of wildfire could reduce risks through BMPs, including having non-flammable ground cover (e.g., gravel or pavement) surrounding the facility and flammable materials, irrigating any perimeter landscaping, and monitoring local wildfire conditions using publicly available data such as the Fire Information for Resource Management System US/Canada wildfire geographic information system (GIS) map (NASA and USFS 2024).

Emergency medical services and health care facilities

During operation, EMS and health care facilities could be required for employees (up to three) during routing operations and maintenance. EMS could be needed to address accidents that involve a fire, electrical shock, or a medical emergency. The challenges of an emergency medical response could be exacerbated by winter conditions, distance of the facility site from medical services, and access to the site.

Additionally, as described in the *Environmental Health and Safety Technical Appendix*, operation of green hydrogen facilities includes risk of fires, explosions, and other accidents that could result in chemical burns from sodium or potassium hydroxide, hypothermia or frostbite from liquid hydrogen exposure, steam burns, asphyxiation from gas leaks, falls, or similar incidents. Given the size of the workforce, medical emergencies are unlikely to exceed response capabilities within the study area. In 221 documented incidents involving hydrogen[2] between

[2] Data was collected from the following types of facilities and vehicles that use, store, and/or produce hydrogen: battery charging facility, chemical plant, hydrogen delivery vehicle/tube trailer (either at a facility, on a city street, at a fueling station, or at a government facility), passenger vehicle, commercial facility, fueling station, furnace room, government facility (including government storage and use facilities, research and development facilities, and warehouses), hazardous waste facility, hydrogen production facility, hydrogen storage or use facility, laboratory, municipal refuse incineration facility, nuclear processing or waste facility, paper mill, passenger ship, power plant, processing facility for slop water, research and development facility, refinery, school auditorium, and spacecraft (H2 Tools 2024).

1969 and 2019, 19 caused minor injury, 12 caused injuries serious enough to cause the victims to miss work, 13 caused loss of life or injury, and 14 caused the facility to close permanently (H2 Tools 2024). As of 2022, there are 33 operational green hydrogen facilities in North America (Terra 2024). No injuries or deaths were documented at hydrogen production facilities. While the cited dataset sets are not all-inclusive, it does indicate that injury during normal operation of hydrogen production facilities is rare.

As described above for emergency response, land that is industrially zoned or zoned to support industrial uses and other industrial uses in the study area would have similar considerations for emergency medical services. Providing proper training, providing proper personal protective equipment (PPE), following IBC and International Fire Code (IFC) standards, having first aid readily available, and having trained emergency response personnel on staff would all reduce impacts on EMS, especially for facilities in more remote areas.

Emergency response impact summary

Through compliance with laws and permits and with implementation of actions that could avoid and reduce impacts, most operations activities would likely result in **less than significant impacts** on emergency response.

A facility would result in **potentially significant adverse impacts** to emergency response if activities required a large emergency response in remote locations with limited response capabilities, a fire or explosion during operations spreads rapidly or impacts large areas, or if there are other unique aspects of a facility site.

3.4.2.2 Public schools

Green hydrogen production facilities would employ up to three full-time employees. Some employees could already live in the region, and some could move full-time to work at the facility. Population increases due to employment opportunities would be negligible and would not lead to over-enrollment or construction of new schools. Impacts to public schools would be **less than significant**.

3.4.2.3 Solid waste

General

Solid waste such as garbage, food waste, and recyclables from employees would be generated from employees during operation. The estimated solid waste generation for individual employees is 4.9 pounds per day per person (EPA 2023). The solid waste generated by employees would be collected in dumpsters on site. Solid waste such as cardboard, paper, packing materials, and metals would also be generated from operation of an industrial facility.

During operation, industrial land uses are estimated to generate approximate 52.06 solid waste tons per year per acre. A facility size of 1 acre would generate approximately 56.06 tons of solid waste per year, and a facility size of 10 acres would generate approximately 540.06 tons of solid waste per year.

Prior to operation, the developer would coordinate with the local trash and recycling providers to have waste removed on a regular basis. Trash and recycling enclosures, as well as access points to the facility site, would be designed to accommodate trash and recycling trucks.

Green hydrogen production solid waste
Solid waste specific to green hydrogen production facilities would include PPE. Proper receptacles would be required for soiled PPE, some of which could be exposed to hazardous chemicals. Soiled PPE would have to be transported to a proper disposal facility or require coordination for special pickup.

Solid byproduct disposal from green hydrogen operations would be required for pyrolysis and biomass production methods. Methane pyrolysis would create particulate carbon. Particulate carbon has uses in industries that use or create carbon composite materials, including carbon-based composite building construction. Since this byproduct has monetary value, it is unlikely that any operator using methane pyrolysis would directly dispose of this byproduct.

Solid byproducts from biomass would be dependent on the feedstock. State law requires biomass used for green hydrogen production to come from solid organic fuels including wood, forest, or field residues, or from dedicated energy crops that do not include wood pieces that have been treated with chemical preservatives. Based on these feedstocks, the potential waste from biomass includes moisture, ash (solid carbon), carbon dioxide, hydrogen, nitrogen, chlorine, sulfur, and oxygen. Feedstocks that contain sulfur would be discharged in a liquid form that requires disposal.

The amount of solid waste from green hydrogen facilities varies vastly, based on the exact feedstock used, process efficiency, and requirements for preprocessing of feedstock or post-processing of product streams. Coordination with local waste management services to characterize the hazardous waste, transport it, and treat it to be compliant for disposal would be required. A waste hauler that receives waste from industrial sources would be identified during facility planning.

A solid waste collection service that is under contract with a private hazardous waste management firm would be identified based on location. A local disposal company would assist with management to a disposal location through disposal contracts. Long-term capacity needs are required to be identified in county hazardous waste management plans. These plans base the anticipated capacity of landfills on current population and tonnage projections. If the amount of disposal material or the type of hazardous waste is not accepted, it may require disposal service through a private hazardous waste management firm. The developer and contractor would need to coordinate with local disposal facilities to properly dispose of large quantities or contaminated material and determine capacity limits.

During the life of the facility, equipment and materials would reach their lifespans and have to be replaced. Waste would include but is not limited to large pieces of metal, tanks with housed hazardous fluids, and site electronics. Most of these materials would not be suitable for normal trash and recycle pickup and would need to be transported to an appropriate disposal facility as identified by the local waste hauler.

Through compliance with laws and permits, and with implementation of actions that could avoid and reduce impacts, operation activities would likely result in **less than significant impacts** on solid waste.

3.4.2.4 Wastewater and stormwater

Sanitary wastewater would be managed using a local sanitary sewer system or an on-site septic system. On-site septic systems would conform to the state's siting and design requirements (WAC 70.118.010 et seq.) for the protection of water resources and public health. Septic systems or portable units, if utilized, would typically be maintained by a contracted, licensed service provider.

Facilities using electrolysis as wastewater would discharge to sanitary sewer or a stormwater system after wastewater was treated in an on-site wastewater treatment facility. Wastewater from the reverse osmosis process would be treated on site or routed to a wastewater treatment plant. Stormwater on site would be discharged to an existing stormwater conveyance and treatment system or would be infiltrated if feasible. In general, more-developed areas would not be feasible for infiltration due to potential existing soil contaminants, existing impervious surfaces, or space constraints. Facilities connecting to wastewater or stormwater conveyance systems would need to coordinate with utility providers for on-site connections. Green hydrogen facilities would be required to comply with NPDES standards and requirements. Wastewater would be treated on site to meet NPDES permit requirements or routed to a wastewater treatment plant. Facilities proposed in locations discharging to impaired surface waters with total maximum daily loads (TMDLs) could receive a Water Quality-based Effluent Limitation consistent with TMDL waste load allocations. If an NPDES permit is not required, developers would still be required to manage projects to prevent pollutants from reaching surface waters. Developers can reference the most recent version of Ecology's stormwater management manuals for BMPs. The *Water Resources Technical Appendix* contains additional information on operations wastewater and stormwater, including regulatory requirements related to water quality.

Depending on availability in a proposed green hydrogen production facility's location, stormwater and wastewater utility providers may need to expand sewer lines, conveyance systems, or treatment facilities. For providers to meet the needs of a facility, the developer may have to pay for proper infrastructure to be built out. The study area includes many areas already developed for industrial use that currently have infrastructure for industrial wastewater and stormwater treatment and conveyance. Some areas are within future urban growth areas for industrial use. As part of comprehensive planning, these areas have plans in place for increasing utility infrastructure as needed. Developers would need to confirm with local utility providers and may be required to pay for some or all infrastructure improvements to support a green hydrogen production facility.

Through compliance with laws and permits, and with implementation of actions that could avoid and reduce impacts, operation activities would have less than significant impacts on wastewater and stormwater.

3.4.2.5 Water supply

Potable water would be needed for operations staff. In addition, water would be required for three of the four production methods of green hydrogen. Water needs for each production method are shown in Table 2. The *Water Resources Technical Appendix* contains additional information on operations water needs and water availability.

Table 2. Production water needs for green hydrogen production facilities

Production method	Water requirements (gal/kg of hydrogen)[a]
Electrolysis	2–3 gallons
SMR	6–8 gallons
Pyrolysis	0
Bio-gasification	Variable based on feedstock composition

Notes:
gal = gallons.
a. Does not include potable water used by operations staff, for landscape irrigation, etc.

Depending on the facility location, water would be sourced from a municipal, water district, or PUD water supply; from groundwater using an on-site well; or through on-site surface water diversions. Electrolysis requires demineralized water, so on-site treatment, likely through reverse osmosis, would be required. Prior to operations, facilities would need to obtain water rights or confirmation of water supply from water provider. Developers would need to work with water providers to supply on-site water utility connections or deliver water to the site via trucks. Permits and water rights would be required for on-site groundwater wells or surface water diversions. As with stormwater and wastewater, any significant infrastructure improvements would be at the cost of the developer. The developer would need to coordinate with the local jurisdiction or water district and to assess proposed water needs and confirm what utility connections would be required. Through compliance with laws and permits, and with implementation of actions that could avoid and reduce impacts, impacts to water supply would be **less than significant**.

3.4.2.6 Electricity

Electricity would be needed for site lighting, site electronics, and production methods. Electricity needs are shown in Table 3. 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.

Table 3. Electricity needs for green hydrogen production facilities

Production method	Electricity requirements (kWh/kg of hydrogen)
Electrolysis	50 kWh
SMR	0.1–3 kWh
Pyrolysis	10 kWh
Bio-gasification	30 kWh

Note: kWh = kilowatt hours.

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. The study area includes areas in Washington within 25 miles of transmission lines of 55 kV and above. Facilities typically connect to the main transmission line through distribution lines, the length of which would be determined by the project applicant based on the distance between a selected site and existing electricity grid infrastructure. More than 81% of the study area is within 1 mile of existing 55-kV or greater transmission lines. The study area includes many areas already developed for industrial use with existing electrical infrastructure. 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 able to operate. Through proper siting and design and coordination with service providers, impacts to electricity would be **less than significant**.

3.4.2.7 Communications

Communications for internet, site communications, and monitoring systems (e.g., hydrogen leak detectors) would be needed for green hydrogen production facilities. Operations staff would also utilize walkie-talkies for site communication using frequencies that do not interfere with emergency frequencies used by law enforcement, fire departments, and EMS. The size of structures on green hydrogen production facilities would be designed to not interfere with radio, radar, broadband, or cellular service. Communication line availability for most of the study area is anticipated to be adequate to serve a green hydrogen production facility. Where industrial lands in the study area are in more rural areas, developers would need to coordinate with communications providers to confirm communication utility needs. Through proper siting and design and coordination with service providers, impacts to communications would be **less than significant**.

3.4.2.8 Renewable natural gas

RNG would be needed for green hydrogen production facilities using SMR or methane pyrolysis as a production method. SMR requires 150 standard cubic feet (scf) of renewable natural gas to produce 1 kg of hydrogen, and methane pyrolysis requires 200 scf of renewable natural gas to produce 1 kg of hydrogen. As described in the *Energy and Natural Resources Technical Appendix*, RNG requirements for upper-bound SMR and pyrolysis facilities exceed current statewide RNG supply. The market demand for RNG is Washington is expected to grow, and RNG infrastructure and supply are expected to increase accordingly.

Developers would need to work with natural gas providers to determine if RNG is available in their area and to interconnect the project with the natural gas infrastructure. Through proper siting and design and coordination with service providers, impacts to renewable natural gas would be **less than significant**.

3.4.3 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. Implementation of various plans designed to proactively address safety and hazards before they rise to emergency situations would alleviate impacts on public services and utilities.

An evaluation of potential project-specific impacts on public services and utilities should consider the siting and design parameters, regulatory requirements, plans and procedures intended to reduce impacts, and other mitigation measures identified in Sections 3.4.3.1 through 3.4.3.3.

3.4.3.1 Siting and design considerations

The following siting and design considerations could be taken into consideration to alleviate impacts to public services and utilities:

- Site green hydrogen production facilities in areas with lower wildfire risk. Use sources like DNR's wildland urban interface and UW's climate change prediction data to determine lower risk areas (Tonkel 2024; UW 2024).
- Coordinate with the local fire district, emergency management departments, and/or DNR (if facility siting is proposed on or near forests or wildlands) prior to and during construction and throughout the life cycle of the facility.
- Coordinate with the local fire district and DNR (as applicable) to ensure that adequate water supply is available for fighting fires. The facility developer may also be able to demonstrate that adequate water supply is available for firefighting via an on-site well or other water storage.
- Site green hydrogen production facilities in areas with adequate utility infrastructure, including electrical, communications, and RNG, to meet the demands of the facility. This varies between production methods (e.g., RNG is not needed for all green hydrogen production methods).
- Site green hydrogen production facilities in areas with adequate water availability for construction and green hydrogen production facility operation needs. Take into account the proposed production method, as water needs vary between production methods.
- Design facilities to reduce risks to neighboring land uses, including potential setbacks, to reduce the risk of ignitions in fire-prone environments. Determine appropriate setbacks in consultation with local or state land managers and consider the need to maintain access for maintenance and emergency response.

3.4.3.2 *Permits, plans, and best management practices*

The following permits, plans, and BMPs could be taken into consideration to alleviate impacts to public services and utilities:

- Install fire-protection equipment in accordance with the IFC, Washington Fire Code, and local regulations.
- Conduct appropriate site maintenance, including periodic mowing or vegetation control BMPs.
- A fire prevention and response plan, if required, would be site specific and outline procedures to reduce risks specific to the regions of proposed facility construction and operation. Actions include in the plan could include:
  - Provide easily accessible fire extinguishers and first-aid kits throughout the site, including in vehicles during construction, operation, and decommissioning.
  - Coordinate with the local fire district to ensure that adequate water supply is available for fighting fires. The facility owner/operator may also supply water for firefighting via an on-site well or other water storage.
  - Provide fire districts with keys to a master lock system that would enable emergency personnel to unlock gates that would otherwise limit access to the site.
- Develop required plans or additional plans to manage and minimize risks, such as an emergency repose plan, hazardous materials management plan, spill prevention and countermeasure control plan, decommissioning and site reclamation restoration plan, and construction and operational site security plan.
- Develop a traffic management plan to ensure that emergency ingress and egress are maintained during construction and operation. A traffic management plan should specify how lane closures would occur and how evacuation procedures would be followed in the event of an emergency.
- Implement measures recommended to reduce utility service interruptions and conflicts that include, but are not limited to, the following:
  - Mark and locate all underground utilities within the construction footprint prior to ground-disturbing construction activities.
  - Consult and coordinate with utility providers about siting and design planning, specifying the extent and timing of proposed construction activities.
  - Provide prior notification to residents and businesses where service interruptions may occur because of construction.
- Follow city, town, and county, and/or utility company design standards for utility connections.
- Conduct blasting using state-licensed explosive specialist contractors.
- Clear vegetation and any other flammable material from the evacuation zone if blasting is conducted and prepare water spray trucks and fire-suppression equipment for use, if needed.
- Develop and implement a site-specific fire prevention and response plan. This plan would include specific measures for coordinating and training response personnel, such as guidelines for first responders to safely shut down electrical systems in the event of fire, management requirements to reduce ignition risks throughout the sites, and site

management fire safety and awareness protocols including tracking fire conditions in the surrounding region, among others.
- Develop and implement a decommissioning and site reclamation restoration plan to include fire prevention measures.

3.4.3.3 Additional mitigation measures

- Provide funding for local emergency responders for training and equipment to address fire and explosion risks.

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 BESS containers. The 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 kilowatt hours). Each container would be approximately 60 by 12 feet wide and 10 feet tall.

The site characterization, construction, operation, and decommissioning of a facility co-located with BESSs is anticipated to include the same impacts on public services and utilities as those described for facilities without BESSs in Section 3.4.

Co-location of the BESSs introduces additional fire risk management, emergency response and solid waste considerations. For detailed discussion regarding public health and safety related to BESSs, refer to the *Environmental Health and Safety Technical Appendix*.

3.5.1 Impacts from construction, operation, and decommissioning

The site characterization, construction, operation, and decommissioning of a facility co-located with a BESS is anticipated to include the same impacts on public services and utilities as those described for green hydrogen production facilities in Section 3.4.

Co-location of BESSs introduces additional fire risk management, emergency response, and solid waste considerations. For detailed discussion regarding public health and safety related to BESSs, refer to the *Environmental Health and Safety Technical Appendix*.

3.5.1.1 Fire prevention and response

The types of BESSs evaluated in the PEIS rarely start fires if properly installed and maintained. BESSs come equipped with remote alarms for operations personnel and emergency response teams. Other protective measures include ventilation, overcurrent protection, battery controls to operate the batteries within designated parameters, temperature and humidity controls, smoke detection, and maintenance in accordance with manufacturers' guidelines.

BESS facilities could create hazards for firefighters and emergency responders with the possibility of explosions, flammable gases, toxic fumes, water-reactive materials, electrical shock, corrosives, and chemical burns. BESSs require specialized and reliable equipment to perform firefighting operations safely and effectively to the Washington Fire Code, NFPA, OSHA, and Underwriters Laboratories codes and standards, as discussed in the *Environmental Health and Safety Technical Appendix*, as well as the applicable county fire protection district codes and standards.

Specialized advanced planning and procedures for enhanced emergency response training would be required to ensure that the co-located BESSs do not generate hazards that could interfere with or exceed emergency response capabilities. For additional details regarding emergency response procedures for BESSs, see Attachment 1, First Responders Guide to Lithium-Ion Battery Energy Storage System Incidents. The recommended approach from the American Clean Power guidance for firefighting is to not use water but allow the battery to burn in a controlled manner. This would result in air emissions that could be hazardous to emergency responders and would require protective gear.

Impacts to public services and utilities would be similar to findings for green hydrogen production facilities described in Section 3.4, with additional emergency response considerations for BESSs.

3.5.1.2 Solid waste

Lithium-ion batteries have lifespans that are shorter than a typical green hydrogen production facility. Lithium-ion batteries typically last 5 to 10 years, and because their performance gradually degrades over time, a green hydrogen facility operator may choose to change them sooner than 5 years after installation. Lithium-ion batteries are considered universal waste.[3] Ecology provides guidance for managing universal waste, which includes the managing of batteries (Ecology 2024). The operator would need to coordinate with a universal waste transporter to transport old lithium-ion batteries to a treatment, storage, and disposal facility or a recycling facility (Ecology 2023).

Through compliance with laws and permits, and with implementation of actions that could avoid and reduce impacts, impacts to solid waste from green hydrogen production facilities co-located with BESSs would be **less than significant**.

3.5.2 Actions to avoid and reduce impacts

Available actions for facilities with BESSs would be the same as those proposed for green hydrogen production facilities. Additional actions to address BESS impacts are described below.

[3] Universal waste is a category of dangerous waste that allows businesses to handle several common types of dangerous waste under the Universal Waste Rule (WAC 173-303-573) (Ecology 2024).

3.5.2.1 Permits, plans, and best management practices

- BESSs must comply with the latest Washington State Building Code Council regulations for batteries. This includes a requirement that, where mixed systems are approved, the aggregate nameplate kilowatt-hour energy of all energy storage systems in a fire area cannot exceed the maximum quantity specified for any of the energy systems in the code. A hazard mitigation analysis may also be required as part of this code to evaluate any potential adverse interaction between the various energy systems and technologies.
- When a battery reaches its end of life, the operator or decommissioner should follow Ecology's guidance for managing universal waste, which includes (Ecology 2024):
  - Storing lithium-ion batteries properly to prevent breakage and release of toxics to the environment
  - Labeling waste containers
  - Tracking accumulation time, as universal waste has a year limit for on-site accumulation
- Develop and implement the fire protection, prevention, and detection measures and design features in accordance with NFPA C855 Standards for Installation of Energy Storage Facilities and the current Washington Fire Code, including requirements for providing redundant separate methods of BESS failure detection.
- Develop and implement an emergency action plan in advance of construction to train local emergency response personnel on hazards specific to BESSs during development and operation of the facility.
- Develop and implement regular maintenance schedules and inspections for BESS components to ensure optimal performance and early detection of potential issues.

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.

Green hydrogen storage facilities would be standalone facilities and could be located at a transport terminal or be sited at an end-use location such as an industrial facility or fueling facility. Liquid hydrogen would be stored in double-walled, vacuum-insulated cryogenic storage tanks, with capacities ranging from 10,000 to more than 1,000,000 cubic feet. Gaseous hydrogen would be stored in a stationary, aboveground, cylindrical or spherical tank and stored between 350 and 700 bar gauge (5,000 to 10,000 psi gauge). While there could be higher concentrations of liquid hydrogen at a green hydrogen storage facility than described above in

Sections 3.4 and 3.5 for production facilities, they pose similar fire and explosion risks, which are discussed in detail in the *Environmental Health and Safety Technical Appendix*.

3.6.1 Impacts from construction, operation, and decommissioning

Potential construction and decommissioning impacts to public services and utilities 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.

The pressure required to store green hydrogen could create hazards for staff, firefighters, and emergency responders. The severity of these impacts could be wide ranging, depending on the type and quantity of hydrogen exposure. Incidents involving spills, fires, and uncontrolled releases of hydrogen can be prevented with operator training and proper system design. Developing an emergency response plan and training responders to be familiar with its implementation would reduce impacts from incidents.

Kilowatt hour requirements for each storage method were based on the range of electricity required to store 1 kg of hydrogen for small-scale (1,000 kg/day), mid-scale (10,000 kg/day), and large-scale (10,000 kg/day) storage levels, which are discussed in detail in the *Energy and Natural Resources Technical Appendix*. Both the gas and liquid storage method demands for electricity would require less than 1% of the 2023 total statewide electricity production (kilowatt hours).

A green hydrogen storage facility developer would need to ensure that there is sufficient electricity available for a project 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 able to operate.

The PEIS assumes that a developer has contracted for sufficient electricity, water supply, and renewable natural gas availability and coordinated on solid waste disposal, wastewater and stormwater disposal for storage methods. With this assumption, through compliance with laws and permits, and with implementation of actions that could avoid and reduce impacts, most construction, operation, and decommissioning activities associated with green hydrogen storage facilities would have **less than significant impacts**.

A storage facility would result in **potentially significant adverse impacts** to emergency response if activities require a large emergency response in remote locations with limited response capabilities, a fire or explosion during operations spreads rapidly or impacts large areas, or if there are other unique aspects of a facility site.

3.6.2 Actions to avoid and reduce impacts

Actions to avoid and reduce impacts described in Sections 3.4.3 and 3.5.2 are applicable to green hydrogen storage facilities. No additional measures are proposed for a green hydrogen storage facility.

3.7 No Action Alternative

Under the No Action Alternative, agencies would continue to conduct environmental review and permitting for green hydrogen 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 range from **less than significant** to **potentially significant adverse impacts**.

3.8 Unavoidable significant adverse impacts

Potentially significant and unavoidable adverse impacts may occur if activities require a large emergency response in remote locations with limited response capabilities, if a fire or explosion during operations spreads rapidly or impacts large areas, or if there are other unique aspects of a facility site or operations that affect emergency response. Determining if mitigation options would reduce or eliminate impacts below significance would be dependent on the specific project and site.

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Attachment 1: First Responders Guide to Lithium-Ion Battery Energy Storage System Incidents

Source: American Clean Power 2023, https://cleanpower.org/resources/first-responders-guide-to-bess-incidents/

First Responders Guide to Lithium-Ion Battery Energy Storage System Incidents

1 Introduction

This document provides guidance to first responders for incidents involving energy storage systems (ESS). The guidance is specific to ESS with lithium-ion (Li-ion) batteries, but some elements may apply to other technologies also. Hazards addressed include fire, explosion, arc flash, shock, and toxic chemicals. For the purposes of this guide, a facility is assumed to be subject to the 2023 revision of NFPA 855 [B8][1] and to have a battery housed in a number of outdoor enclosures with total energy exceeding 600 kWh, thus triggering requirements for a hazard mitigation analysis (HMA), fire and explosion testing in accordance with UL 9540A [B14], emergency planning, and annual training. (The 2021 International Fire Code (IFC) [B2] has language that has been largely harmonized with NFPA 855, so the requirements are similar.)

This guide provides recommendations for pre-incident planning and incident response. Additional tutorial content is provided for each of the hazard categories. The Bibliography provides references to applicable codes and standards, and other documents of interest.

2 Abbreviations and acronyms

AHJ	authority having jurisdiction
BMS	battery management system
ERP	emergency response plan (designated in NFPA 855 as 'emergency operations plan')
ESS	energy storage system
HMA	hazard mitigation analysis
IDLH	immediately dangerous to life and health
LEL	lower explosive limit
LFL	lower flammable limit
LFP	lithium iron phosphate battery
Li-ion	lithium-ion
NCA	lithium nickel-cobalt-aluminum oxide
NFPA	National Fire Protection Association
NMC	lithium nickel-manganese-cobalt oxide
PPE	personal protective equipment
SCBA	self-contained breathing apparatus
SDS	safety data sheet
SME	subject-matter expert
UFL	upper flammable limit
UL	Underwriters Laboratories

[1] References in square brackets are to the Bibliography at the end of this guide.

3 Pre-incident planning

3.1 General

The pre-incident plan is used by first responders in effectively managing emergencies. It is required to be available to the incident commander during an event. The plan should be in accordance with the newly released NFPA 1660 [B9]. From the front matter of this new document: "The 2024 edition of NFPA 1660 integrates NFPA 1600, NFPA 1616, and NFPA 1620 into a single standard that establishes a common set of criteria for emergency management and business continuity programs; mass evacuation, sheltering, and re-entry programs; and the development of pre-incident plans for emergency response personnel." Pre-incident planning, formerly in NFPA 1620, is in Chapters 17 through 23.

Additional ESS-specific guidance is provided in the NFPA Energy Storage Systems Safety Fact Sheet [B10]. NFPA 855 requires several submittals to the authority having jurisdiction (AHJ), all of which should be available to the pre-incident plan developer. These include:

Results of fire and explosion testing conducted in accordance with UL 9540A

- Hazard mitigation analysis (HMA)
- Emergency response plan (ERP)

While the main document for development of the pre-incident plan is the ERP, the UL 9540A test results and HMA may provide useful additional information for the plan and associated training.

3.2 UL 9540A test results

Testing to UL 9540A provides information at a level of detail that may not be included in the ERP (see 3.4). Cell-level testing provides a breakdown of the composition of vented gas from cells in thermal runaway, including flammable gases and vapors. Potentially significant concentrations of highly toxic hydrogen fluoride may also be produced. Video recordings are made of testing at unit (rack) and installation levels (if the latter is performed). These test results and videos can be used in first-responder training (see 3.6) since they provide insight into system behavior in a thermal runaway event that cannot be gained from outside the enclosure.

3.3 HMA

While testing to UL 9540A is valuable, it involves initiation of thermal runaway in a limited number of cells. This method does not address larger-scale failures that could occur, for example, with a loss of insulation and subsequent arcing, or with mechanical damage potentially caused by vehicle impacts or flying debris. Such failures could result in a fire that consumes the entire enclosure. The HMA should address such an occurrence and should assess, at least by simulation or calculation, the maximum temperature rise of cells in adjacent enclosures. This information is used to justify limited spacing between enclosures and can also be used to determine whether first responders should intervene.

3.4 ERP

The ERP forms the basis for pre-incident planning. Among other information, the ERP should include details on the following:

- Site overview and ESS nameplate information
- Potential hazards
- Fire protection and safety systems
- Emergency response recommendations

- Emergency contacts, including subject-matter expert (SME)
- Safety data sheets (SDS)
- PPE

The firefighting philosophy should be outlined, whether that be to suppress the fire using built-in systems or to let it burn out safely (and in some cases, to make it burn. See 5.1.)

3.5 Availability of battery management system data

Access to battery management system (BMS) data is critical for informed incident response. Depending on the severity of the incident, it may be possible to observe the current conditions within the enclosure where the incident began, such as module temperatures and readings for any gas sensing systems that may be installed. If a fire is in progress, it is important to monitor module temperatures in adjacent enclosures, to determine whether additional actions should be taken.

BMS access may be direct, such as using a first responder's computer to access the local human-machine interface or a remote digital twin, or it may be indirect, such as through a voice connection to a network operations center or SME. Data may also be available on a screen local to each enclosure, but this should not be accessed if there is any danger of fire, explosion, or toxic emissions.

3.6 Training

NFPA 855 mandates initial and annual refresher training for facility staff (see section 4.3.2.2). First responders should be included in such training, either in person or via video recordings of the training sessions. Trainees should be familiar with the site layout, installed equipment, SDS contents, and emergency response recommendations of the ERP.

4 Incident response

4.1 General

An incident command system should be established immediately on arrival, and an appropriate incident command individual should have access to BMS data (see 3.5). Working with facility personnel, the scene should be assessed, and potential hazards should be communicated to all responders.

4.2 Personal protective equipment (PPE)

Full firefighter protective gear should be worn where there is any possibility of fire or explosion, including proper use of self-contained breathing apparatus (SCBA). If there is no risk of fire or explosion per the project incident command, protective clothing for arc-flash and shock hazards should be worn by anyone operating within the arc-flash boundary (see 4.5). Jewelry and other metallic items should be removed.

4.3 Fire

If a fire is in progress, flammable gases will be consumed as they are released, and an explosion is unlikely. The safest approach is to allow the enclosure to burn in a controlled manner, so that all fuel is consumed and the possibility of reignition is minimized. BMS data from adjacent enclosures should be monitored to verify that module temperatures remain at safe levels (typically up to around 80 °C/180 °F). Application of water should be limited to cooling and protecting nearby exposures (and adjacent enclosures if module temperatures are above thresholds identified in the ERP).

Once the fire has self-extinguished, there may be ongoing releases of flammable or toxic gases. Full protective gear and SCBA should continue to be used until releases (such as carbon monoxide) are measured to be at a safe level.

If an earlier fire has been extinguished by the enclosure's fire suppression system, there is a potential for ongoing release of flammable gases, with a corresponding explosion risk (see 4.4). See 5.1 for additional discussion of fire hazards.

4.4 Explosion

If system sensors (temperature, smoke, heat, and/or flammable gas) indicate that a thermal runaway event occurred, but there is no sign of fire, it should be assumed that an explosion risk is present.

Personnel should be stationed outside the potential blast radius, at an angle to the doors, and upwind of the enclosure. The enclosure should be inspected from a distance using BMS data to determine the status of the system, including module temperatures, gas sensing, and ventilation systems for gas exhaust. If the BMS is not functioning because of system damage, thermal scanning may provide an indication of ongoing thermal issues. However, responders should be aware that enclosure insulation may make it difficult to make an accurate assessment of internal temperature.

If the enclosure has been vented by automatic door or panel opening and there is no indication of high temperatures, the enclosure may be approached by responders using continuous gas monitoring to warn of any residual atmospheric risk.

If the enclosure appears to be sealed – for example, if gas venting is accomplished through a magnetic flap or if there is no provision for gas venting – BMS data and external visual assessment should be reviewed with the SME before attempting to open the enclosure.

See 5.2 for additional discussion of explosion hazards.

4.5 Arc flash and electric shock

Even when disconnected from external circuits, batteries retain their stored energy and should be considered to be energized. A battery may be partially destroyed by fire yet retain stranded energy at hazardous levels. All batteries, whatever their visual condition, should be treated as fully charged with respect to arc flash and electric shock hazards.

Appropriate PPE should be worn by properly trained individuals when working within the arc flash boundary. See 5.3 for additional discussion of arc flash and shock hazards.

4.6 Toxic chemicals

Toxic chemicals, including hydrogen fluoride, hydrogen chloride, hydrogen cyanide, and carbon monoxide, may be released during an incident. Spraying water on smoke or vapor released from the battery, whether burning or not, may cause skin or lung irritation and contaminated run-off similar to plastic fires [B1]. This is one additional reason for allowing the battery to burn in a controlled manner. The site perimeter should be entered only by trained firefighters wearing full protective gear and using SCBA. See 5.4 for additional discussion of toxic chemical hazards.

5 Discussion of Li-ion hazards

5.1 Fire

There is ongoing debate in the energy storage industry over the merits of fire suppression in outdoor battery enclosures. On one hand, successful deployment of clean-agent fire suppression in response to a limited event (for example, an electrical fire or single-cell thermal runaway with no propagation) can limit damage to the system, which can then be expeditiously returned to service. On the other hand, actuation of the same system in response to a large event, such as a multicell arcing fault, may knock out or prevent a fire but allow ongoing release of flammable gases, thus creating an explosion hazard.

Some ESS designs employ a 'make it burn' strategy, in which a sparker ignites flammable gas when the lower flammable limit (LFL) is exceeded but before the lower explosive limit (LEL) is reached. Such designs do not include fire suppression, on the basis that the loss of an enclosure through controlled burning is preferable to increasing the risk of an explosion. This strategy can be effective for Li-ion technologies based on transition metal oxides, such as lithium nickel-cobalt-aluminum oxide (NCA) and lithium nickel-manganese-cobalt oxide (NMC) materials, which release oxygen during thermal runaway, thus maintaining a flammable gas mixture. The same arrangement would potentially be less effective for batteries using lithium iron phosphate (LFP) material, as discussed in 5.2.

There are pros and cons to each of the common fire-suppression media in use today, including clean agents, inert gases, aerosols, and water.

- Clean agents, such as Novec 1230®, and inert gases, such as nitrogen, will extinguish small fires without causing extensive damage within the enclosure; they also have a cooling effect, which can assist in limiting thermal runaway propagation. In a larger-scale event, such as a multi-cell arcing fault, their effect may be temporary and may result in ongoing propagation with the risk of reignition or explosion. Also, inert gases are oxygen-depleting and cannot be used in structures where personnel may be present.
- Aerosol devices, such as Stat-X®, can be self-actuating, releasing based on elevated temperature without the need for control systems. They are effective on small fires and can help to limit initiation of thermal runaway. The aerosol itself is typically alkaline and may damage BMS and other electronic components in the enclosure. These devices are unlikely to be effective in larger-scale events or when thermal runaway is freely propagating between cells or modules.
- Water is the most efficient medium for cooling cells below the level at which thermal runaway can occur. However, to be effective, the water must be able to reach cells that may be otherwise shielded within closely spaced modules. This means that directed spray across the top of each module is more likely to achieve full extinguishing and arresting of propagation than can be realized with ceiling-mounted sprinklers, and this precise coverage may not always be feasible to achieve. Liberal use of water may also serve as the initiator for electrical arcing that may cause thermal runaway in otherwise unaffected modules. Additionally, the combination of water and highly energized battery systems could electrolytically generate more explosive hydrogen gas. Finally, similar to plastics fires [B1] use of water for directly targeting a fire will also create contaminated run-off [B11], which must be contained and removed for treatment.

5.2 Explosion

Venting of all Li-ion cells results in the release of a gas mixture with high levels of hydrogen, carbon monoxide, and carbon dioxide. Depending on the circumstances, there may also be a fog of unreacted flammable organic compounds, and hydrogen fluoride (normally in trace amounts, but can be higher). The volume of gas released is typically orders of magnitude greater than the cell volume. In the absence of fire, this gas mixture poses an explosion risk.

NFPA 855 requires design provisions for either explosion prevention in compliance with NFPA 69 [B5], or explosion management according to NFPA 68 [B4]. However, systems only complying with NFPA 68 can present explosion hazards to first responders if the following conditions are met: 1) the atmosphere in the enclosure is above the upper flammable limit (UFL), 2) the system has no remote means to ventilate its contents, 3) and a door is opened. Caution and deliberation with the project SME should be taken in situations where gas has accumulated, and automatic ventilation is either not present or not functioning.

The '**make** it burn' strategy for explosion prevention is discussed in 5.1. This approach may be less effective for batteries using LFP technology, from which minimal amounts of oxygen are released during thermal runaway. In a multi-cell arcing fault and in the absence of emergency ventilation with outside air, the available oxygen in the enclosure would be quickly consumed. Further cell venting would drive the gas concentration above the UFL, creating the same hazard described in the previous paragraph.

Ventilation for explosion prevention may be accomplished by the automatic opening of doors or other panels. While this measure is unlikely to meet the requirements of NFPA 69, it addresses the intent of the standard and can be important for protecting first responders. It should be noted that this procedure will reduce the effectiveness of airborne fire suppressants and is more compatible with a 'let it burn' philosophy.

5.3 Arc flash and shock

Battery strings in an enclosure involved in an incident should have been tripped by the BMS, but as detailed in 4.5, they can continue to present arc-flash and shock hazards. Many ESS designs now operate at dc voltages up to 1500 V, representing a significant risk to untrained personnel. At the time of preparing this guide, there is ongoing work on characterization of dc arc-flash hazards, and it is likely that this work will inform future changes to NFPA 70E [B7].

5.4 Toxic chemicals

Recommendations for first responders are detailed in 4.6. Emissions from battery fires vary by battery chemistry and state of charge. Toxicity issues are discussed at length in [B1], where it is stated that hydrogen chloride is the chemical that reaches its IDLH (immediately dangerous to life and health) value fastest. In terms of 30-minute average release rates as a function of IDLH, the greatest concern is with hydrogen fluoride, followed by hydrogen cyanide, hydrogen chloride, and carbon monoxide.

6 Bibliography

The following documents are discussed in this guide:

[B1] DNV-GL, Considerations for ESS Fire Safety, Report for Consolidated Edison and NYSERDA, 2017

[B2] International Fire Code (IFC), 2021, International Code Council, Inc.

[B3] NFPA 1, Fire Code, 2021

[B4] NFPA 68, Standard on Explosion Protection by Deflagration Venting, 2018

[B5] NFPA 69, Standard on Explosion Prevention Systems, 2019

[B6] NFPA 70, National Electrical Code, 2023

[B7] NFPA 70E, Standard for Electrical Safety in the Workplace, 2021

[B8] NFPA 855, Standard for the Installation of Stationary Energy Storage Systems, 2023

[B9] NFPA 1660, Standard for Emergency, Continuity, and Crisis Management: Preparedness, Response, and Recovery, 2024

[B10] NFPA Energy Storage Systems Safety Fact Sheet, available from the NFPA website

[B11] Quant, M., Willstrand, O., Mallin, T., Hynynen, J., Ecotoxicity Evaluation of Fire-Extinguishing Water from Large-Scale Battery and Battery Electric Vehicle Fire Tests. *Environ. Sci. Technol.* https://doi.org/10.1021/acs.est.2c08581

[B12] UL 1973 Ed. 3, ANSI/CAN/UL Batteries for Use in Stationary and Motive Auxiliary Power Applications, 2022

[B13] UL 9540 Ed. 2, Energy Storage Systems and Equipment, 2020

[B14] UL 9540A Ed. 4, ANSI/CAN/UL Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems, 2019