Appendix N: Public Services and Utilities Resource Report

For Programmatic Environmental Impact Statement on Utility-Scale Onshore Wind 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
BLM	Bureau of Land Management
BMP	best management practice
CFR	*Code of Federal Regulations*
DNR	Washington Department of Natural Resources
Ecology	Washington State Department of Ecology
EMT	Emergency Medical Technician
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
gen-tie line	generation-tie transmission line
HAZMAT	Hazardous Materials Team
medevac	medical evacuation
MW	megawatt
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Administration
PEIS	Programmatic Environmental Impact Statement
PUD	public utility district
RCW	Revised Code of Washington
SCADA	Supervisory Control and Data Acquisition
USC	*United States Code*
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
UW	University of Washington

Executive Summary

This resource report describes the public services and utilities conditions in the wind energy study area. It also describes the potential impacts and actions that could avoid or reduce impacts.

The impacts on public services and utilities identified in this resource report include those from the construction, operation, and decommissioning phases of the wind energy facilities considered in the Programmatic Environmental Impact Statement (PEIS). This impact assessment considers whether wind energy facilities would result in a significantly increased demand for public services (e.g., fire and law enforcement response, emergency medical response, schools) such that the capacities of existing service providers would be exceeded. The assessment considers whether wind energy facilities would result in solid waste capacity exceedances or utility service interruptions and whether wind facility structures such as substations, meteorological towers, and generation-tie transmission lines (if overhead) may have the potential to obstruct or interfere with communications systems, aerial firefighting, or aerial medical evacuation capabilities.

A probable increase in the demand for emergency response public services would occur in the study area as utility-scale wind energy facilities would introduce new risks to remote areas during construction, operation, and decommissioning. Such facilities also likely require the construction of new facilities to connect the wind energy facilities to the energy grid. Construction and decommissioning of utility-scale wind energy facilities have the potential to result in service interruptions, which would require coordination and communication with local utility districts. Operation of wind energy facilities has the potential to result in interference with emergency alert systems and other communications signals. Decommissioning also has the potential to exceed solid waste capacities, due to turbine blade waste and other potentially hazardous materials likely to be present in wind energy components.

Findings for public services and utilities impacts described in this resource report 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** to fire response if activities required a large fire response in remote locations with limited response capabilities or if there are other unique aspects of a facility site.
- Depending on turbine recycling facilities, methods available at the time of decommissioning, and the volume of waste, facility decommissioning would result in **potentially significant adverse impacts** on solid waste and recycling if there are large volumes of solid waste.

Construction, operation, and decommissioning of utility-scale onshore wind facilities may result in a **potentially significant and unavoidable adverse impact** if activities require a large fire response in remote locations with limited response capabilities or if there are other unique aspects of a facility site that affect fire response. Determining if mitigation options would reduce or eliminate impacts below significance would be dependent on the specific project and site and local regulations and plans.

Crosswalk with Public Services and Utilities Resource Report for Utility-Scale Solar Energy

Two PEISs are being released at the same time, one for utility-scale solar energy facilities and one for utility-scale onshore wind energy facilities. This crosswalk identifies the areas with substantial differences between the public services and utilities resource reports for each PEIS.

Utility-Scale Solar Energy PEIS	Utility-Scale Onshore Wind Energy PEIS (this document)
• Differences in specific impacts on public service and utility providers • Some differences in actions to avoid and reduce impacts	• Potential for significant adverse impacts on fire response related to turbines • Potential for significant adverse impacts on solid waste and recycling during decommissioning or repowering • Some differences in actions to avoid and reduce impacts

1 Introduction

This resource report describes public services and utilities within the onshore wind energy program study area and assesses probable impacts associated with types of facilities (alternatives), including a No Action Alternative. Chapter 2 of the State Environmental Policy Act Programmatic Environmental Impact Statement (PEIS) provides a description of the types of facilities evaluated (alternatives). Where impacts are identified, the section identifies mitigation measures designed to reduce potential impacts.

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

1.1 Resource description

Key features of public services described in this resource report consist of considerations for emergency response including fire prevention and response, security and law enforcement, emergency medical, and public schools in the study area as potentially affected by onshore wind energy facilities. Key features of utilities and service systems described in resource report include natural gas, electrical and communications systems, water supply, wastewater, and solid waste management.

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 *United States Code* (USC) 6901 et seq., Solid Waste Disposal Act	Applicable to solid waste generated during construction, decommissioning, and operation and maintenance phases.
36 *Code of Federal Regulations* (CFR) 251, Subpart B, U.S. Department of Agriculture (USDA) U.S. Forest Service (USFS)	Includes USFS-administered lands; note the regulation stipulates that various plans, such as emergency action plans and site security plans, be implemented as conditions of approval.
43 USC 1701 et seq., Federal Land Policy and Management Act of 1976	Governs how the Department of the Interior's Bureau of Land Management (BLM) and USFS (under USDA) administer public lands, including grants of rights-of-way for the transmission lines associated with wind and solar facility development. See also the BLM Right-of-Way Regulations (43 CFR 2800).

Regulation, statute, guideline	Description
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	The regulations governing hazardous materials influence the destinations and process for solid waste reclamation.
29 CFR 1910.269, Occupational Safety and Health Act	Safe worker practices and training are applicable to wind energy facilities and associated electrical systems installation and maintenance.
47 USC 303(q) Antenna Tower Lighting and Marking Requirements; 47 CFR 17.21-17.58, Federal Aviation Administration (FAA) Advisory Circular 70/7460-1M	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 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 facilities and turbines may be subject to FAA standards (FAA 2020).
National Fire Protection Association 855 Standards for Installation of Energy Storage Systems	Applies to facilities with co-located battery energy storage system (BESS) in Alternative 3. Provides the minimum requirements for mitigating the hazards associated with BESS.
State	
RCW 36.70A.070, Washington State Growth Management Act	Requires cities and counties to include a utilities element in their comprehensive plans.
RCW 70.95.010 et seq., Solid Waste Management – Reduction and Recycling	Applicable mostly to decommissioning of wind energy facilities.
RCW 70.105.005 et seq., Hazardous Waste Management	Applies to storage, handling, transportation, use, and disposal of hazardous materials associated with the facilities.
RCW 70.118.010 et seq., On-site Sewage Disposal System	Applicable requirements pertain to on-site septic systems, if proposed.
RCW 80.28.440, Wildfire mitigation plan—Review/revision	Requires wildfire mitigation plan for investor-owned utilities.
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 the state regulations.

2 Methodology

2.1 Study area

The study area for public services and utilities is defined as the service territories of all relevant public services (emergency response, including law enforcement, fire prevention and response, emergency medical services and hospitals, and public schools) and utilities (communications, natural gas and electric, water and wastewater, and solid waste landfills and recycling) that provide service to areas within the overall PEIS geographic scope of study (Figure 1). The PEIS does not approve, authorize, limit, or exclude facilities on a site-specific basis. Future facility proponents would need to consider specific options available for public service and utility provision when considering potential facility siting.

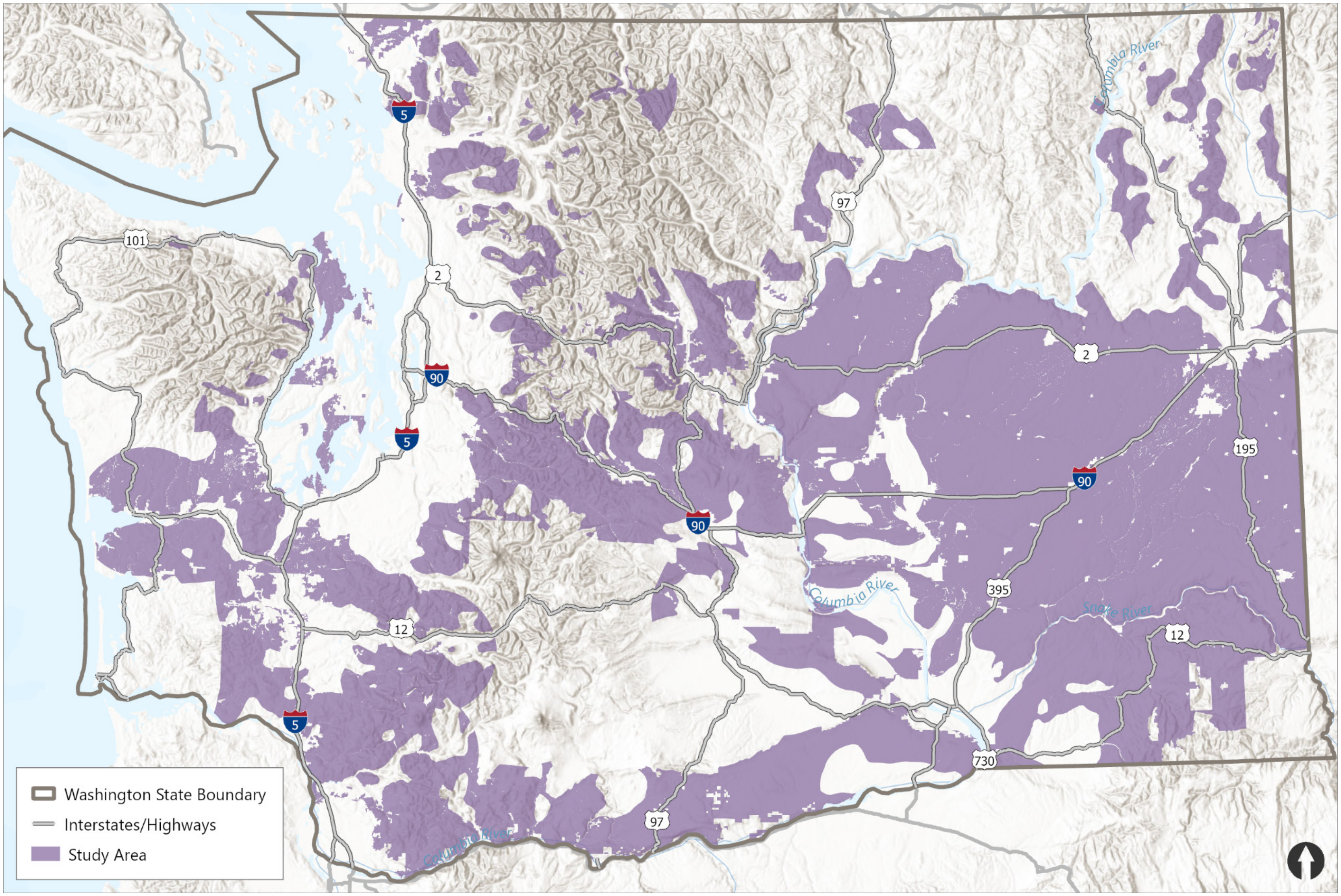

Figure 1. Onshore Wind Energy Facilities PEIS – geographic scope of study

2.2 Technical approach

To evaluate the potential impacts on public services and utilities, existing providers in the study area were identified using information obtained through public websites, mapped sources, and personal communications. Impacts associated with construction, operation and maintenance, and decommissioning were qualitatively analyzed.

This nonproject evaluation considered siting and design parameters, regulatory requirements, and plans and procedures intended to reduce effects. For analytical purposes, it is assumed that the onshore wind energy facilities would comply with existing regulations and that the requirements would be enforced by the applicable local, state, and/or federal jurisdictions.

The technical approach included a review of the typical siting criteria and assumptions for facilities considered in the PEIS. The desktop analysis used publicly available federal, state, and local planning documents and environmental impact statements from similar utility-scale onshore wind energy facilities. Available datasets, such as the wind energy environmental documents compiled by the State of Washington Energy Facility Site Evaluation Council, were accessed to inform high-level considerations.

The analysis assumed that facilities would be required to adhere to regulatory standards such as those in effect for solid waste and fire safety. 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. For example, fire risk is highly variable in Washington state, so public safety response would place variable demands on service providers depending on the facility location and associated risks. The analysis also considered climate change and its influence with respect to wildfire risk as related to 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, potential impacts and mitigation are cross-referenced from other PEIS 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 Resource Report* (ESA 2024a).

2.3 Impact assessment

The potential impacts on public services and utilities include those from the construction, operation and maintenance, and decommissioning phases of the wind energy facilities analyzed in the PEIS. This impact assessment considers if any phase would result in a significantly increased demand for public services (e.g., fire and law enforcement, emergency medical response, schools) such that the capacities of existing service providers would be exceeded. The assessment considers whether the wind energy facilities would result in relocation or prolonged service interruptions of existing utilities or interfere with emergency alert communication systems and whether any phase of the wind energy facilities would require construction of new or modified utilities. The assessment also considers whether structures associated with the wind energy facilities would have the potential to impact aerial firefighting and aerial medical evacuation capabilities. Significant impacts would occur if a facility would result in the following:

- Significantly increased demand for public services during construction or decommissioning that would exceed existing capacities of public service providers
- Significantly increased demand for public services during operation such that unplanned new or physically altered governmental facilities would be needed to serve the facility
- Facility would propose or require the relocation or construction of new or modified utilities or service systems during construction, operations, or decommissioning
- Facility would result in the presence of structures with the potential to obstruct or otherwise impact aerial emergency response capabilities

2.3.1 Construction and decommissioning

The use of construction workers from outside of locations where the wind energy facilities are proposed may result in a temporary increase in demand for public services, including police, providers of emergency medical services, and local fire departments. For example, blasting specialists may be needed prior to trenching in rocky areas. However, construction of wind energy facilities is not anticipated to require a permanent workforce. The analysis assumes that workers hired to construct wind energy facilities within the study area would not take up residence or relocate their families to the region as a result of this temporary construction employment.

Decommissioning is expected to include the dismantling and removal of aboveground facility components and is considered with relation to solid waste utilities. Removal of turbine components and related infrastructure would include dismantling the turbines, support towers, transformers, on-site substations and/or switching stations, buildings, battery energy storage system (BESS), and foundations; excavating them to a specified depth below grade; and removing them from the facility site to be reused, recycled, sold, or otherwise disposed of. Facility roadways no longer needed to access turbine sites (after the turbines have been dismantled and removed) are expected to be restored or naturally revegetate. Underground collection and communication cables may be disconnected and abandoned in place.

When a wind energy facility reaches the end of its design life, repowering may be an option instead of decommissioning. Repowering consists of replacing (partially or totally) the old wind turbines with more powerful and more efficient models using the latest technologies. This may include replacing the turbine blades, rotor, nacelle, and tower, or the tower may remain in place with a new nacelle, rotor, and blades added.

2.3.2 Operation and maintenance

The analysis assumes that wind energy facilities would not require permanent full-time staff for their operation or maintenance at a level that would meaningfully affect the available local labor supply. Based on other utility-scale wind energy facilities, facility operators would likely use remotely monitored security systems that tie into a facility's Supervisory Control and Data Acquisition (SCADA) system and private site security. Maintenance would likely entail periodic routine repair and replacement of system components, vegetation control, inspection, cleaning, turbine and equipment servicing, and access road maintenance. All of these activities could be accomplished using part-time or contracted personnel.

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 in the study area for the utility-scale onshore wind energy facility types analyzed in the PEIS. This section also evaluates actions that could avoid, minimize, or reduce the identified impacts and potential unavoidable significant adverse impacts.

3.2 Affected environment

The affected environment represents the conditions before any construction begins. The study area includes highly variable geography and public service and utility providers. For the purposes of the analysis, the temporal scope of affected environment considerations consists of 20 years within which potential wind energy facilities may be constructed and approximately 30 years of operation for each potential wind energy facility. The conditions described in this section include a high-level consideration of climate change over this time frame and its potential to alter conditions for public services and utilities in the study area.

3.2.1 Public services

The onshore wind energy facility study area is served by a variety of public service providers funded in part through public resources, such as sales and business tax revenue. Depending on the local conditions, public services may be provided by federal, Tribal, state, county, or local governments, as well as volunteer fire departments and other volunteer groups. Public services described in this section include fire protection, law enforcement, emergency or other medical services, and schools. The service areas for fire and emergency medical response providers in the study area (as described in this section) are depicted in Figures 2 and 3, respectively.

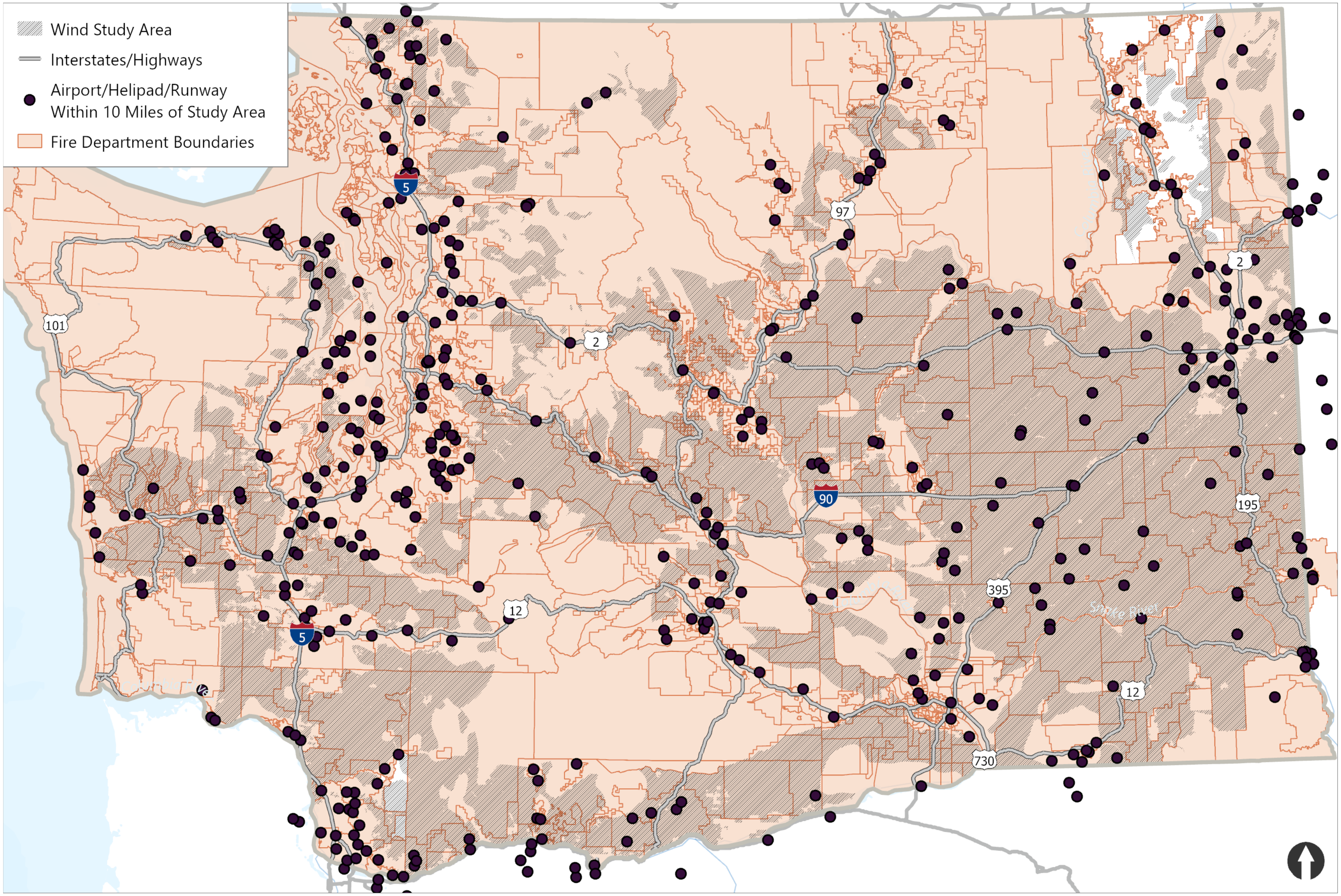

Figure 2. Fire response in the wind study area

Data sources: DNR 2023; FAA 2024; WSGDP 2024a

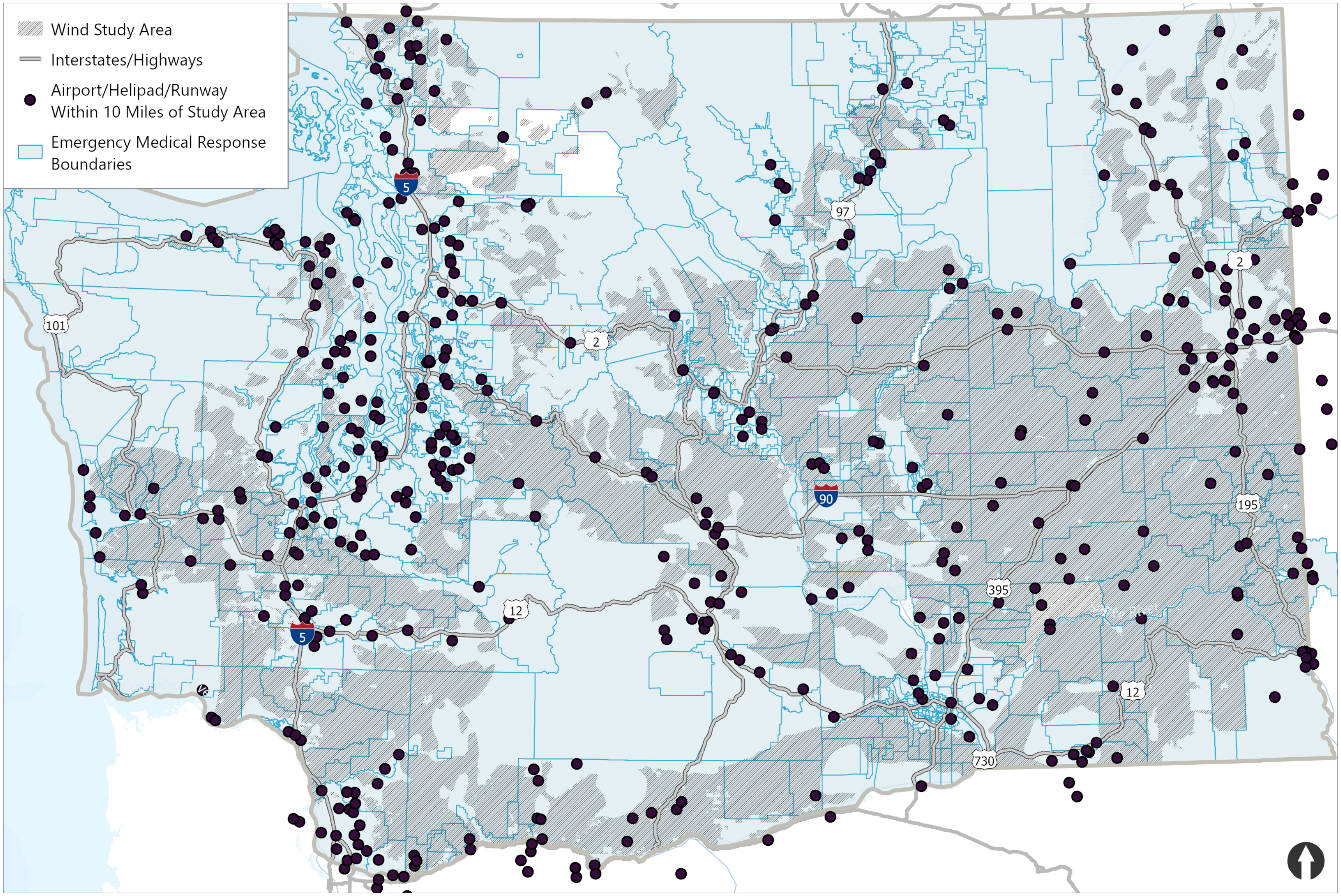

Figure 3. Emergency medical response in the wind study area

Data sources: FAA 2024; WSGDP 2024b

3.2.1.1 Emergency response

Emergency response in the study area includes fire departments, emergency medical services, and law enforcement. Coordination and emergency alert communication are conveyed 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, and fire and emergency management and response services (including 9-1-1 response) through centers within their respective divisions. Lands within the study area under state and federal jurisdiction also have emergency communication and dispatch networks that operate through the Washington Department of Natural Resources (DNR), U.S. Forest Service (USFS), and Bureau of Land Management (BLM).

Certain characteristics of onshore wind energy facilities can complicate emergency response. The height of wind turbines, aviation restrictions near wind turbines, and potential safety hazards on the ground beneath wind turbines during accidents can all contribute to emergency response challenges. Wind turbine accidents are uncommon but can be dangerous. Emergency responders need to have knowledge of the hazards associated with wind turbine and other energy facility infrastructure, in order to safely respond to these accidents. Limited data on onshore wind energy facility accidents are available, but a study of onshore wind turbine accidents from 1995 to 2012 estimated that, each year, 0.07% (7 out of 10,000) of wind turbines experience blade failure, 0.06% (6 out of 10,000) have structural fires, and 0.03% (3 out 10,000) experience structural failure (Uadiale et al. 2014).

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 are patrolled by the Washington State Patrol. The Washington State Patrol provides traffic enforcement on state highways, drug enforcement, Hazardous Materials Team (HAZMAT) oversight, and incident response. Washington State Department of Ecology (Ecology) also has a spill response team.

Portions of the study area include federal lands under USFS or BLM jurisdiction and these agencies have law enforcement capabilities. DNR also provides ranger patrol on properties it manages.

Fire prevention and response

Fire prevention and response for facilities in the study area are under the control of local county fire departments with support from volunteer units and other response teams depending on the jurisdiction. Counties and local 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). Figure 2 depicts fire response providers in the wind energy facility study area.

Wildfire response

Portions of the study area are not under local jurisdictions for fire response. Locations in or near national forests or on BLM land are under the jurisdiction of USFS or BLM jurisdiction for fire response. At the state level, DNR provides fire protection on properties it manages. DNR works with other state, federal, and local agencies to respond to wildfires and offers local fire districts and volunteer units with support with 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. 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 4).

Figure 4. Example of type of helicopter used to respond to wildfires

Image source: DNR 2024

DNR Wildfire Aviation is a highly trained air-ground firefighting team available for initial attack rapid response to wildland fires (Figure 5). Wildfire Aviation has 10 UH-1H(M) Huey helicopters modified for water/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).

Figure 5. Example of aerial firefighting response

Image source: DNR 2024

DNR implements industrial fire precaution levels to limit certain activities as conditions warrant in a given region. USFS and BLM also provide aerial fire response through aviation and helitack operations for lands under federal jurisdiction.

As discussed in the *Environmental Health and Safety Resource Report*, the combination of longer fire seasons, population growth, declining forest health, and other threats in recent years 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 fire response workforce, and the need to prepare for expected increases in wildland fires in future years (DNR 2019).

Climate change considerations for wildfire risk

The utility-scale onshore wind PEIS considers facilities constructed in Washington from the year 2025 through 2045. Once constructed, the assumed operational life of the facilities is 30 years. The analysis in this report therefore includes a consideration of climate change effects on wildfire risk over this extended time frame, as related to emergency response. 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 emergency response.

As discussed in the *Environmental Health and Safety Resource Report*, the University of Washington (UW) has conducted climate resilience mapping to model wildfire risk across the state through time. The map shows the projected increase in high fire danger days[1] across the state compared to historical (1971 to 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 wellbeing (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 significant increase in the projected number of high fire days between the years 2040 and 2069, roughly coinciding with the extended time frame of the wind energy facilities.

Emergency medical services
Fire departments throughout the state maintain a staff of paramedics to respond to medical emergencies. The Washington State Department of Health coordinates emergency medical services and trauma care in various regions throughout the state. Emergency Medical Technician (EMT) dispatch is handled through county Emergency Management divisions. Figure 3 depicts emergency response providers in the wind energy facility study area.

Hospitals and other medical facilities
At a local level, there are multiple healthcare 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. 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 and USFS).

3.2.1.2 Public schools

A variety of public education 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

The study area includes utility service areas and areas without services. Utilities described in this section include communications, gas and electrical, water, wastewater, and solid waste management. Depending on the area, utilities may be provided by county, city, Tribal, or private

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[1] A high fire-danger 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.

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.

3.2.2.1 Communications

Internet, broadband, and cell phone services are available in portions of the study area, generally aligning with the more populated regions. In the rural or unpopulated parts of the study area, cell phone and internet service is limited or unavailable. Public emergency alert systems report natural hazards (such as flooding or wildfire) through local radio stations, cell phones, and email notifications. The various counties in the study area provide emergency alert and notification systems allowing subscribers to access alerts in real time. In unpopulated or sparsely populated areas (where these cell service and internet systems are unavailable), these jurisdictions also utilize radio signals to broadcast alerts and communicate information pertaining to fire, police, severe weather, and other public hazards. There are stand-alone 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.

3.2.2.2 Gas and electric

Four natural gas companies operate in Washington state. The gas systems, including storage and distribution pipelines, are owned and managed by Avista Utilities, Cascade Natural Gas Corporation, Northwest Natural Gas Company, and Puget Sound Energy, with distribution supported through various public utility districts (PUDs) throughout the state. 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. There are 28 PUDs providing electric, water, sewer, communications, renewable natural gas, and renewable hydrogen (in some cases via retail service agreements) in the state. PUDs are not-for-profit community-owned entities governed by locally elected commissioners who live in the communities they serve (WPUDA 2024). With regulatory oversight from the Washington Utilities and Transportation Commission and the Federal Energy Regulatory Commission, these utilities maintain natural gas systems and energy transmission and distribution networks in various geographies throughout the state. Generally, wind energy facilities are unlikely to require gas service connections; however, locations of existing subsurface utilities including gas lines would need to be identified prior to construction to reduce potential ground-disturbance conflicts.

3.2.2.3 Water and wastewater

Water supply in the study area is provided through various sources, including groundwater wells, surface water, and other supplies depending on the geographic location. The Washington Departments of Health 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 PUD, 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 Report* (ESA and Anchor QEA 2024).

It is expected that most onshore wind facilities may utilize septic systems or portable sanitary systems if day-to-day operational staff are needed for a facility. The analysis assumes that if septic or sanitary systems are employed as part of a wind energy 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.

3.2.2.4 Solid waste landfills and recycling

Solid waste generated throughout the study area is collected and managed by the various cities, counties, and private waste management entities in the study area. 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 2021). 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 2021). Metals and other materials capable of reuse may be collected and sold for reuse, recycled, or otherwise managed separately consistent with state requirements.

Wind turbine waste is an emerging area of concern due to the number of facilities that have come online globally in recent years. In 2017, it was estimated that by 2050 global wind assets would approach 100 gigawatts per year. It is estimated that 43 million tons of cumulative blade waste will be generated by then, with China leading at 40% of global waste generated, followed by Europe at 25%, the United States at 16%, and the rest of the world at 19%. Based on this, it is estimated that there could be 6.88 million tons of turbine blade solid waste generated in the United States by 2050. To address the problem of solid waste capacity challenges in disposing of these materials, there have been initiatives in Washington state and globally to make composite materials recyclable and provide end-of-life strategies to limit turbine blade discharge into landfills (ACP 2023a).

3.3 Potentially required permits

The following permits related to public services and utilities could be required for construction, operation, or decommissioning of typical wind energy facilities and activities described in the alternatives:

- **Right-of-way or lease(federal or state land manager):** Placement of facility infrastructure on lands under federal or state management would require approval from the federal or state land manager.
- **Federal Aviation Administration (FAA)**: The Federal Communications Commission (FCC) requirements for filing with 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, communication facilities and turbines may be subject to FAA standards.
- **Conditional Use Permit (local county or municipality):** Operation of a utility-scale wind energy facility may require a use permit or a conditional use permit subject to review and approval by the jurisdiction (county or municipality) of its proposed operation. New or modified utilities proposed as part of a wind energy facility may require a conditional use permit; the use permit process would also include review of public services impacts.
- **Local permits (county or municipality):** Various construction activities and placement of new or modification of existing utilities proposed as part of a wind energy facility would be subject to local permits to ensure compliance with grading and drainage, stormwater management, septic system conformance, building standards, etc.

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

3.4.1 Impacts from construction

Probable adverse impacts associated with site characterization and construction of wind energy facilities could consist of those related to emergency response capacity exceedances, conflicts with other existing utilities, and potential prolonged service interruptions that may occur over portions of the facility construction period.

3.4.1.1 Emergency response

An impact during facility construction and site characterization could occur if significantly increased demands were placed on emergency services providers that exceed response capacities. Construction of small- to medium-scale onshore wind energy facilities considered in Alternative 1 would entail employment of a temporary workforce (estimated to range from 100 to 400 workers for a typical 150-megawatt [MW] facility) that could result in an increased demand for public services including law enforcement, fire departments, and emergency medical service response within and near the study area.

Law enforcement

Construction and site characterization activities would entail the use of equipment and presence of materials, which may increase the potential for theft, vandalism, trespass, fire, safety issues, and/or accidents requiring law enforcement or other emergency response services. Facilities are assumed to include provisions for site security, including restricting access to portions of the facility. High-voltage electrical equipment within the facility would be separately fenced and access-controlled for safety and increased security. Lighting would likely be provided at construction trailers or buildings and facility entrances as necessary for the safety and security of employees and the facilities. Materials and equipment staging areas would be fenced and security cameras installed and monitored to protect the site during construction. The presence of workers during the site characterization and construction phases may also deter incidents that would require a law enforcement response.

Fire prevention and response

Activities during site characterization and the development and construction of wind energy facilities could include the introduction of ignition sources (such as blasting, welding, and use of vehicles and equipment) and fuel sources (such as vehicle fuels and flammable building materials), all of which introduce fire risks during construction. Wildfire risks are discussed in the *Environmental Health and Safety Resource Report*. Further, the presence of wind turbine towers can limit an aerial response to fire at a wind facility to the edges of the facility and can affect aerial access to other wildfires in the vicinity. The potential for increased fire response demand at construction of any particular facility would vary by facility and location.

Emergency medical services

A probable increase in the demand for emergency response services would occur in the study area as utility-scale wind energy facilities would introduce new risks and specialized response equipment needs to remote areas during construction, operation, and decommissioning. For example, a fire in a wind turbine nacelle or a maintenance worker's medical emergency (e.g., heart attack) at a height of 400 feet or greater above ground level requires a different kind of response than the demands for response at ground level. Winter conditions can exacerbate medical response access considerations if, for example, snow, ice, or other weather conditions prevent a medevac landing or access roads are closed. The presence of wind turbines and other tall structures (depending on the phase of construction completed) can prolong transport time for medevac flights by causing pilots to skirt a landscape that could be crossed more directly if the wind energy facility were not sited there.

Wind energy facilities are frequently sited in remote locations, away from hospitals or other emergency treatment facilities. This can be a concern with regard to the provision of timely medical treatment if a worker falls, gets trapped, or otherwise is hurt. The interior dimensions of wind turbines vary among manufacturers, but in general they all involve close enough quarters that a person 6 feet tall with a trim build would have to crouch and bend to access interior spaces. Entrapment is possible. Estimates of emergency medical service response times should be considered by facility operators for all times of the day and night when workers could be on duty or needed to respond to an unscheduled facility maintenance need. Fire and personal injury are the principal emergency situations that could affect a wind energy facility and require emergency service response; however, the kinds of risks attendant to all electrical and high-voltage work must be considered and planned for to manage potential impacts related to an increased demand for emergency response services. Additional discussion is included in the *Environmental Health and Safety Resource Report*.

As described for law enforcement, construction of small to medium facilities would increase the potential for accidents and incidents requiring emergency medical response services. Compliance with Occupational Safety and Health Administration (OSHA) requirements and appropriate site construction management would alleviate demand on local EMT response services and reduce such risks. Worker safety training and adherence to safety procedures during construction, for example, would limit potential emergency response demands. Consultation or early coordination with emergency response providers to ensure access and other proactive safety planning would also 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 activities would likely result in **less than significant impacts** on law enforcement, emergency medical response, and most fire response.

A facility would result in **potentially significant adverse impacts** to fire response if activities required a large fire 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 because few out-of-area construction workers would be likely to permanently relocate their families to the community where a wind energy facility is being developed. For this reason, construction-related impacts on school enrollment are expected to be minor and temporary. Most workers are unlikely to be permanently relocated into the wind energy study area for long enough to require and obtain such services. Therefore, impacts on school enrollment during construction would be **less than significant**.

3.4.1.3 Gas, electric, and communications systems

The onshore wind facilities would not require natural gas lines; however, existing gas lines would need to be located, marked, and avoided prior to ground-disturbing activities during site characterization and construction. For these reasons, it is anticipated that potential impacts associated with gas systems would be **less than significant** and are not discussed in further detail.

Wind facilities are likely to require the relocation of electrical and communications facilities and/or the construction of new facilities to connect the facilities to the energy grid. Construction and decommissioning of utility-scale wind energy facilities have the potential to result in service interruptions, which would require coordination and communication with local utility districts.

During construction, there is the potential for temporary service interruptions as electrical and communications systems or other utilities may require disengagement or rerouting to connect the facility's collection system to generation-tie transmission lines (gen-tie lines) and the electrical grid. Occasional and temporary service interruptions could occur during construction duration of each facility, which would be considered a **less than significant impact**. It is recommended that measures be implemented to reduce conflict with existing electrical and communication systems or other subsurface utilities (such as existing or planned electric, gas, or water lines).

Additionally, due to the height and nature of wind turbines, interference with communications systems may occur, starting from the point at which these tall structures are erected. For example, the specific location of wind turbine generators could affect existing electronic communications infrastructure, including emergency response-related communications capabilities associated with federally licensed (FCC) microwave and fixed station radio frequency facilities, and broadcast AM radio and television signals. Large metallic structures, such as wind turbines, can adversely affect the transmitted signals of AM broadcast stations up to 1.8 miles (3 kilometers) away. Television receiver locations can be affected to some extent within 3 miles of a large turbine when the turbine is between the television station and the receiver. Rotating electrical machines generate a certain amount of electrical noise as a combination of various frequencies. As a result, each generator and its associated systems can interfere with existing signals. Potential wind-turbine-caused interference at land mobile/public safety radio transmitter stations typically occurs only within 425 meters, or about 1,400 feet, of a turbine site (Angulo et al. 2014). The potential for earth satellite stations depends on satellite arc; generally, a 65-mile study radius of a proposed new wind energy facility site would encompass any stations that could have impacts from wind facilities (ESA 2020). Other design considerations relate to turbine siting to avoid interference with communications infrastructure, in light of the critical function of effective communications during an emergency response and because interference with cell, radio, television, and other communications could adversely affect human health and the physical environment if emergency response communications were prevented, interrupted, or delayed. FCC-licensed microwave and fixed station radio frequency facilities may be adversely impacted depending on the location of individual wind turbines introduced into the landscape.

Microwave communication also can be affected by wind turbines. Microwaves are a type of electromagnetic wave used to carry information such as radio, cellular phone, and digital communications at high speeds. Microwaves travel along direct line-of-sight paths, and their transmission requires the use of multiple towers to receive, amplify, and retransmit signals over long distances. It is recommended that siting and design for wind energy facilities consider existing emergency response communications frequencies and locate turbines and other structures (with the potential to generate signal interference) outside the range of these signals to ensure minimal or no disruption of signals conveying emergency response information. FCC requirements for communications towers include antennae structure registration, compliance with FCC rules and implementing regulations, lighting, marking and tower construction requirements, and applicable rules based on FAA Advisory Circulars (FAA 2020). An evaluation of specific potential communications conflicts would occur as part of the FCC review or during the conditional use permit/land use approval process. With appropriate siting and design, potentially signal interference impacts on low-wave radio and communications systems would be **less than significant**.

3.4.1.3 Water and wastewater

Water demand during construction would include supply needed for construction, for activities such as concrete mixing and dust control, fire control, or initial revegetation efforts. Water for non-potable uses may be accessed through reclaimed/recycled water supplies where available. Potable water would be needed for drinking water and could be supplied by a commercial supplier, on-site well, or a public or community water system.

Sanitation and wastewater could be managed through contracted portable systems or septic systems. Compliance with water discharge permit conditions and site certification review would limit construction-related impacts and would not be expected to compromise stormwater systems.

Additional discussion regarding water impacts is provided in the *Water Resources Report*. Potential conflicts with existing subsurface water and wastewater lines could be addressed through utility mark and locate activities, which would be required prior to construction ground disturbances. Through compliance with laws and permits and with implementation of actions that could avoid and reduce impacts, construction activities would likely result in **less than significant impacts** on water and wastewater utilities.

3.4.1.4 Solid waste and recycling

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 limited 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. As noted previously, there are nearly 1,000 solid waste providers in the state and 14 landfills that could likely accommodate the level of waste generated during construction. Through compliance with laws and permits and with implementation of actions that could avoid and reduce impacts, construction activities would likely result in **less than significant impacts** on solid waste and recycling.

3.4.2 Impacts from operation

3.4.2.1 Emergency response

Law enforcement
As with construction, wind energy 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 substations and equipment; employing security personnel; providing motion-triggered lighting and facility monitoring systems) would typically be in place as part of normal operations to protect the facilities. Such measures would reduce demand for external security or law enforcement response services.

Fire prevention and response
Fire risks associated with facility operations are described in the *Environmental Health and Safety Resource Report*. Fire risks during facility operation include those caused by wind energy facility equipment or operational activities and fires started outside of facilities that have altered behavior (i.e., spread, movement, or ability to suppress) due to the presence of a wind energy facility. This analysis assumes that wind energy facilities would be regularly maintained and monitored to reduce these risks. However, accidents and fires could still occur.

Due the rural nature of much of the study area, responding fire departments can be several miles away and may need to travel over roads that require four-wheel-drive vehicles. Other challenges that can limit fire department intervention in a turbine fire include the height of the fire and the extremely limited vertical access inside the tower. A turbine fire actively fought, controlled, and extinguished by fire department personnel would be a rare event. The general rule established in standard operating procedures for wind energy facility fire response is not to attempt to physically attack a fire inside the tower and generator assembly, but rather to establish an exterior defensive that protects exposed structures and vegetation near the affected area. Preparedness and training can result in better outcomes, including advance interaction of emergency responders with wind energy facility operators to create, implement, and maintain pre-emergency response planning; to familiarize responders with wind energy facilities in their jurisdiction; and to engage in simulation emergency exercises.

Wind turbines are anticipated to be 750 feet or taller with blades extended. Given the height of the structures, wind energy facilities could also introduce obstacles affecting air navigation for aerial firefighting capabilities. Aerial firefighting within the site would likely be limited for safety reasons, particularly on lands along ridgelines or near steep slopes. Depending on the site layout, turbine spacing, and topography, surrounding lands may also be affected. FAA advisory guidelines for obstruction lighting and marking would apply to wind turbine siting and design.

Although spacing between turbines could be large and areas in use would be much smaller than the overall site perimeter, development of a wind energy facility represents a change of land use warranting site-specific fire prevention and response planning. It is not likely that wind facilities would include overall perimeter fencing, but other access and response challenges are likely, especially in mountainous regions of the study area.

Emergency medical services

Emergency medical services could be needed for employees. For example, periodic routine maintenance activities could 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. However, the operational staffing for wind energy facilities would likely be small and not regularly on site. Additionally, facility operators would be expected to use appropriately trained technicians to operate and maintain the equipment. These considerations should result in a minimal increase in emergency medical service needs.

Emergency response impact summary

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

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

3.4.2.2 Public schools

Small to medium facilities would not be expected to require full-time permanent staff for facility operation and maintenance. Operations could occur in tandem with remote facility (SCADA system) monitoring; periodic maintenance could occur through temporary or contracted staff. A small to medium facility would not increase the population such that new or modified public schools would be needed and impacts on local school enrollment during the operations phase would be **less than significant**.

3.4.2.3 Communications systems

Onshore wind energy facilities involve special communications siting and design considerations that could impact emergency response communications. As discussed in Section 3.4.1 (in the context of construction), the placement of turbines and other tall structures, and the operation of rotating turbines, may obstruct or interfere with existing electronic communications signals (i.e., radio transmission, microwave, cellular, digital, and their boosting signal components). Local emergency response teams may have a system in place that notifies registered cell phones in the event of emergency situations or critical community alerts, such as emergency evacuation notices, bio-terrorism alerts, and missing child reports. Such notification systems, if specific to cell phones, may be affected by wind energy facility-caused interruptions in microwave communications. FCC-licensed microwave and fixed station radio signals may also be affected by wind energy facilities. An evaluation of specific potential communications conflicts would occur as part of the FCC review or during the conditional use permit/land use approval process.

With appropriate siting and design, potential signal interference impacts on communications systems would be **less than significant**.

3.4.2.4 Gas and electric

Once operational, the wind facilities would not be anticipated to increase demand for gas or electricity services. New and modified electrical facilities (such as the facility substation systems, gen-tie lines, and interconnections) would be operated and maintained to connect, convert, and transmit the generated wind energy to the electrical grid; however, these systems would not increase demand such that new transmission lines or other electric systems would be required. Through compliance with laws and permits and with implementation of actions that could avoid and reduce impacts, operations of facilities would likely result in **less than significant impacts** on gas and electric services.

3.4.2.5 Water and wastewater

During the operation and maintenance period, water may be needed for dust control, irrigation of on-site vegetation, fire water supply, and plumbed facilities such as sinks or toilets, if installed. If consistent with public health requirements and available supply, reclaimed water may supply some of these water demands. Potable water also may be needed for on-site drinking water, which could be supplied by a well or trucked to the site, as needed.

If wind energy facilities include on-site septic systems during operation, such systems would conform to the state requirements for siting and design (Chapter 70.118.010 Revised Code of Washington et seq.) for the protection of water resources and public health. Septic systems or portable units, if utilized, would typically be maintained by a licensed service provider. As discussed, the small number of expected operational staffing would limit impacts associated with wastewater capacity.

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

3.4.2.6 Solid waste and recycling

A small amount of solid waste would be generated as part of normal operation and maintenance activities. Periodic replacement of wind components, which could include large items (such as damaged turbine blades) may occur over the 30-year operational timeframe. Typical waste includes broken or rusted metal, defective or malfunctioning equipment, electrical materials, empty containers, miscellaneous solid waste, and typical refuse from operations and maintenance staff. Approximately 1 cubic yard of waste per week would be expected, which should be able to be collected by a commercial waste management service. The volume of waste anticipated from periodic replacement of damaged components would not be expected to exceed the capacities of solid waste management providers or landfills.

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

3.4.3 Impacts from decommissioning

The decommissioning process generally mirrors the construction process in reverse and involves the use of large equipment to dismantle structures and return the site to a condition similar to those of pre-construction. In this respect, decommissioning of wind energy facilities could generate similar impacts as those identified in Section 3.4.1 for construction. If an onshore wind facility is repowered instead of decommissioned, there would still be some dismantling and removal of components to be replaced, but less removal of other materials.

3.4.3.1 Solid waste and recycling

Solid waste generated during decommissioning is assumed to consist of all aboveground components not capable of being reused or repowered. It is assumed that decommissioning of wind energy facilities would occur in a manner consistent with the state requirements, and that scrap metal and other materials of value would be recycled to the extent feasible, and thereby reduce solid waste effects. Concrete foundations would be removed to the extent feasible and dismantled for recycling or disposal. Restoration or remediation of the substation and electrical sites could be necessary due to the use of oils and other hazardous materials during wind energy facility operation. As noted in the *Environmental Health and Safety Resource Report*, shredding wind turbine blades can generate airborne particulate matter that can act as an irritant to the skin, lungs, and eyes due to the hazardous substances contained in these materials. For this reason, it is recommended that measures be implemented to limit solid waste disposal of wind turbine blades and other hazardous materials (such as glass fiber reinforced polymers) associated with wind energy facility decommissioning or repowering.

Most turbine blades consist of glass fiber reinforced polymers and may lack an established market for reuse and/or recycling. These components may be disposed of in landfills, disassembled, and repurposed, as permitted by law. Recycling wind turbine blades is not currently a viable option in Washington, with no industrial-scale recycling options available within cost-feasible transportation distances. A feasibility study commissioned by the Washington State Legislature and conducted in 2023 assessed the feasibility and cost of multiple methods of recycling wind turbine blades. It is estimated that under existing conditions, thousands of tons of turbine blade waste will soon reach the end of its useful life in the state. Based on the growing wind energy industry and lack of alternatives in the region, recycling options for wind turbine blades might be available by the time of decommissioning of facilities (Booth and Nath 2023).

There are recent developments in recycling or upcycling of turbine waste materials; however, with each of the methods, there are tradeoffs in terms of energy use and transportation challenges. Further, it is unclear whether such technologies will operate at a scale adequate to address the cumulative solid waste challenges posed during future decommissioning.

3.4.3.2 Decommissioning impact summary

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

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

Depending on turbine recycling facilities, methods available at the time of decommissioning, and the volume of waste, facility decommissioning would result in **potentially significant adverse impacts** on solid waste and recycling if there are large volumes of solid waste.

3.4.4 Actions to avoid and reduce impacts

Site-specific mitigation actions would be developed during facility-specific reviews and permitting for each facility proposed in the future. Implementation of various plans designed to proactively address security, safety, and hazards before they rise to emergency situations would alleviate impacts on public services and utilities.

An evaluation of potential public services and utilities impacts associated with wind energy facilities would consider the identified siting and design parameters (including interior wind energy setbacks from perimeter fencing), regulatory requirements, and the plans and procedures intended to reduce effects. For the purposes of the environmental analysis, it is assumed that the facilities would comply with existing regulations and that the requirements would be enforced by the local, state, and/or federal jurisdictions.

3.4.4.1 Siting and design considerations

Selection of the site location and layout for a utility-scale onshore wind energy facility represents the best tool available to reduce the potential for impacts on public services and utilities.

Siting and design considerations for emergency response

- Coordinate with the local fire district, emergency management departments, and/or DNR (as applicable, if facility siting is proposed on or near forests or wildlands) prior to and during construction and throughout the life cycle of the facility. Consultation should include considerations for aerial fire response capabilities.
- Coordinate with the local fire district and DNR (as applicable, if the wind energy facility would be located in or near forests or wildlands) to ensure that adequate water supply is available for fighting fires. The facility proponent may also be able to demonstrate that adequate water supply is available for firefighting via an on-site well or other water storage.
- Identify available access routes and distances to existing public safety facilities and emergency response providers. Wind energy facilities should maintain emergency ingress

and egress in all phases of operation. To allow for emergency ingress and egress once operational, it is recommended that fencing be limited to the perimeter of critical wind energy infrastructure (rather than the whole of a given site). Additionally, it is recommended that access roads be maintained to allow ground access and emergency ingress and egress. Additional transportation-related considerations are provided in the *Transportation Resource Report* (ESA 2024b).

- Fire preparedness planning should include the identification of a likely water supply for fire suppression. It is recommended that mitigation include consultation with USFS, BLM, and DNR to ensure that siting and design of wind energy facilities is consistent with aerial fire response systems serving wildlands throughout the state.
- Siting and design for wind energy facilities should conform to all applicable building and fire code requirements pertaining to setback distances for public safety related to turbine failure or blade throw. Adherence to such existing regulatory controls would avoid some public services and utilities impacts (as discussed in more detail in Section 3.4.4.2).

Siting considerations to reduce communications signal conflicts

- Siting and design measures including consultation with the applicable emergency management agencies are recommended to address potential communication signal conflicts.
- To address the issue at the design level, it is recommended that information regarding the frequency spectrum of electrical noise generated by a given facility-level application be requested as part of the application process to inform potential wind energy facility impacts specific to the proposed location and existing communications systems used for emergency response alerts.
- To address the potentially significant adverse communications interference impact, siting and design measures should include the preparation of a communications interference report. The communications interference report should evaluate the proposed wind energy facility site plans prior to site approval relative to the proposed locations for facility communication system infrastructure and provide the information necessary to avoid interference and resulting impacts. Generally, a search radius of 2 miles from a proposed wind energy facility's turbine sites would identify the microwave signal paths potentially at risk from the proposed facility. To reduce satellite communications interference, an interference study with a 65-mile search radius is recommended, as described in Section 3.4.4.3.

3.4.4.2 Permits, plans, and best management practices

- Fire protection equipment must be consistent with the International and Washington State Fire Codes and OSHA and electrical code requirements.
- Apply 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.
- Hazardous Materials Management Plan
- Spill Prevention and Countermeasure Control Plan
- Decommissioning and Site Reclamation Restoration Plan
- Construction and Operational Site Security Plans
- Site-specific Medical Emergency Response Plan
- Implement measures recommended to reduce utility service interruptions and conflicts, including, but 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.
- 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.

3.4.4.3 Additional mitigation measures

- 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 electrical systems down 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.
- Conduct regular maintenance and testing for wind turbine generators, including electrical systems and safety devices for fire detection, automatic switch-off, and fire extinguishing systems in the nacelle of each wind turbine.
- Measures are recommended to reduce conflicts with existing communications systems, including those that convey emergency alerts to residents and businesses in the study area. To address and reduce potential siting conflicts, a communications interference report is recommended to be developed as mitigation. It is also recommended that consultation with emergency response providers and emergency management districts be conducted as part of the due diligence application process. Additional specific recommendations for inclusion into the communications interference report include the following:
    - Identify potential wind-turbine-caused interruptions to microwave signals. Microwaves travel along direct line-of-sight paths, and their transmission requires

the use of multiple towers to receive, amplify, and retransmit signals over long distances. Interruptions to microwave signals may generate interference with radio, cellular phone signals, and high-speed communications signals.
    - Identify potential wind turbine interruptions within line-of-sight of FCC-licensed microwave and fixed station radio frequency facilities.
    - Identify potential wind-turbine-caused interference at land mobile/public safety radio transmitter stations, which typically occurs only within 425 meters, or about 1,400 feet, of a turbine site.
    - Identify potential wind turbine satellite interference. The potential for earth satellite stations depends on satellite arc; generally, a 65-mile study radius of a proposed new wind energy facility site would encompass any stations that could have impacts from a proposed facility.
    - Identify potential wind turbine AM radio interference. Large metallic structures, such as wind turbines, can adversely affect the transmitted signals of AM broadcast stations up to 3 kilometers (1.8 miles) away.
    - Identify potential wind turbine television signal interference. For television broadcast facilities, approximately 10% of receiver locations can be affected to some extent within 3 miles of a large turbine when the turbine is between the TV station and the receiver.
    - Interference with aircraft navigational communications is not anticipated from structures more than 10 miles from a navigational radio beacon. Nonetheless, the distance between proposed wind turbines and navigational radio beacons should be considered among other design considerations.
- Mitigation measures are recommended to reduce the overall quantities of potentially hazardous solid waste associated with wind energy components. It is uncertain whether regulations will come into effect to require stewardship and takeback for turbine blades in future years within the decommissioning time frame for the wind energy facilities. It is recommended that a turbine blade end-of-life stewardship plan be prepared as part of a proponent’s application and incorporated into a required Decommissioning and Site Reclamation Plan. Mitigation is recommended to require strategies for procurement of nontoxic and/or recyclable turbine blades, and that the proponent prepare a turbine blade stewardship end-of-life plan to address turbine blade waste as part of the application/certification process. The Decommissioning and Site Reclamation Plan should outline the expected quantities and types of solid waste the wind energy facility would generate, including but not limited to turbine blade waste, as well as the likely destinations for this waste. Such a plan would include specific measures pertaining to potentially hazardous materials associated with wind energy facility components, requiring specialized procedures for handling, transporting, management, and disposal.

3.4.5 Unavoidable significant adverse impacts

Construction, operation, and decommissioning of small to medium utility-scale onshore wind facilities may result in a **potentially significant and unavoidable adverse impact** if activities require a large fire response in remote locations with limited response capabilities or if there are other unique aspects of a facility site that affect fire response. Determining if mitigation options would reduce or eliminate impacts below significance would be dependent on the specific project and site and local regulations and plans.

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

3.5.1 Impacts from construction, operation, and decommissioning

Large facilities would entail a larger-scale wind energy facility with an increased overall footprint. Impacts as described for small to medium facilities would be similar for large facilities but would be expected to occur at an increased scale. For this analysis, estimates for solid waste generated are assumed to be up to twice those estimated for small to medium facilities. The maximum estimated number of wind turbines and estimated number of inverter/transformers under Alternative 2 is considerably greater than that described for small to medium facilities (up to 127,500 acres versus 21,250 acres), with a higher potential maximum number of wind turbines (up to 1,000 versus 167). The erection of these structures under large facilities would likely involve an increase in workforce or extension of construction duration, both of which present potentially increased public services and utilities impacts, relative to small to medium facilities.

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.

For fire response and solid waste, the range of impacts is variable depending on the location, site layout, and other factors and would be **less than significant** to **potentially significant adverse impacts** for large facilities associated with fire response and solid waste capacity during decommissioning and repowering.

3.5.2 Actions to avoid and reduce impacts

Recommended actions to avoid and reduce impacts would be the same as those identified for small to medium facilities. Although the scale of potential impacts would be proportionally increased for large facilities, there would be no change to the conclusions, recommended actions, or mitigation measures stated in Section 3.4.4.

3.5.3 Unavoidable significant adverse impacts

Construction, operation, and decommissioning of large utility-scale onshore wind facilities may result in a **potentially significant and unavoidable adverse impact** if activities require a large fire response in remote locations with limited response capabilities or if there are other unique aspects of a facility site that affect fire response. Determining if mitigation options would reduce or eliminate impacts below significance would be dependent on the specific project and site and local regulations and plans.

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

3.6.1 Impacts from construction, operation, and decommissioning

Facilities with BESSs would include the same systems as those considered in Sections 3.4 and 3.5, with the addition of one or two co-located BESSs, each capable of storing up to 500 MW of energy. 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 facilities without BESSs.

Co-location of the BESS(s) introduces an additional fire risk management and emergency response consideration. The types of BESSs evaluated in this PEIS rarely start fires if properly installed and maintained. Flow batteries and zinc-bromide batteries are generally not flammable. 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. Some battery types may contain hazardous materials that pose potential risks for environmental release if not handled correctly and could introduce hazards for first responders. BESS facilities could create extreme hazards for firefighters and emergency responders with the possibility of explosions, flammable gases, toxic fumes, water-reactive materials, electrical shock, corrosives, and chemical burns. Utility-scale energy storage requires specialized and reliable equipment to perform firefighting operations safely and effectively to the Washington Fire Code, National Fire Protection Association (NFPA), OSHA, and Underwriters Laboratories codes and standards, as discussed in the *Environmental Health and Safety Report*, as well as the applicable county fire protection district codes and standards.

Specialized advanced planning and procedures for enhanced fire response training would be required to ensure that the wind energy facilities and co-located BESSs do not generate hazards that could interfere or exceed emergency response capabilities. For additional details regarding emergency response for BESSs, see Attachment 1, the *First Responders Guide to Lithium-Ion Battery Energy Storage System Incidents* (ACP 2023b). The recommended approach from the American Clean Power guidance for firefighting is not to 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 utility-scale onshore wind facilities, with additional fire response considerations for BESSs.

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

3.6.2 Actions to avoid and reduce impacts

Available actions for facilities with BESSs would be the same as those proposed for utility-scale facilities without BESSs, with additions noted below.

3.6.2.1 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.

3.6.2.2 Additional mitigation measures

Additional mitigation measures to address potentially significant impacts specific to BESS safety training and emergency response are listed as follows:

- 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.

3.6.3 Unavoidable significant adverse impacts

Construction, operation, and decommissioning of utility-scale onshore wind facilities with BESSs may result in a **potentially significant and unavoidable adverse impact** if activities require a large fire response in remote locations with limited response capabilities or if there are other unique aspects of a facility site that affect fire response. Determining if mitigation options would reduce or eliminate impacts below significance would be dependent on the specific project and site and local regulations and plans.

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

3.7.1 Impacts from construction, operation, and decommissioning

For a facility that includes agricultural land uses, any existing agricultural lands would be maintained, or new agricultural use could be co-located with the utility-scale onshore wind facility. Facilities may entail a different fencing system to potentially accommodate grazing or other agricultural activities. Therefore, there could be access limitations to portions of the site, presenting challenges for first responders. The scale of wind energy facilities with co-located agricultural uses are assumed to be similar to facilities without agricultural use; therefore, most potential impacts on public services and utilities would be similar. Construction, operation, and decommissioning of a facility with co-located agricultural land use is anticipated to include generally the same impacts to most public services (law enforcement, public schools, and healthcare) and utilities (gas and electric, and water and wastewater) as those described for the facilities without agricultural uses. For solid waste and recycling, there could be a similar range of impacts as described for large facilities without agricultural use, from **less than significant** to **potentially significant adverse impacts** associated with solid waste and recycling capacity during decommissioning and repowering.

Additional considerations for fire protection and emergency response are discussed below.

3.7.1.1 Fire protection and emergency response

Because these facilities would include active management of the vegetative landscape (e.g., grazing, crop production, pollinator habitat) and provide a beneficial cooling effect to the land, it is assumed that fire risk for the agricultural energy sites could generally be reduced compared to facilities without agricultural use. Emergency fire response demand may correspondingly decrease due to this type of land management.

Facilities with co-located agricultural uses could entail a different fencing design to potentially accommodate grazing or other agricultural activities, which could pose challenges for first responders if they were to need to access portions of a facility site that are fenced.

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** to fire response, if activities required a large fire response in remote locations with limited response capabilities, or if there are other unique aspects of a facility site.

3.7.2 Actions to avoid and reduce impacts

The actions to avoid, reduce, and mitigate impacts for facilities with co-located agricultural uses would be the same as those identified in Section 3.4.4. As noted in Section 3.4.2, there are standard operating procedures to enhance training for emergency responders, which would also proactively reduce impacts for onshore wind facilities with agricultural use.

3.7.1 Unavoidable significant adverse impacts

Construction, operation, and decommissioning of utility-scale onshore wind facilities with agricultural uses may result in a **potentially significant and unavoidable adverse impact** if activities require a large fire response in remote locations with limited response capabilities or if there are other unique aspects of a facility site that affect fire response. Determining if mitigation options would reduce or eliminate impacts below significance would be dependent on the specific project and site and local regulations and plans.

3.8 No Action Alternative

Under the No Action Alternative, the city, county, state, and federal agencies would continue to conduct environmental review and permitting on a facility-by-facility basis in accordance with existing laws, regulations, plans, and standards. The potential impacts from facilities developed under the No Action Alternative would be similar to the impacts for the types of facilities described previously for construction, operations, and decommissioning, depending on facility size and design, and would range from **less than significant** to **potentially significant adverse impacts**.

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