PNNL-39328

Small Nuclear Reactors for Maritime Ports

A Feasibility Study

March 2026

Jeriah A. Whitley
Ryan A. Calkins
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Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

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Abstract

Maritime ports are entering a period of sharply rising electricity demand as operations are electrified, shore power adoption grows, and energy-intensive industries expand near ports. This report evaluates the feasibility of small nuclear reactors at U.S. ports, which could offer stable baseload power and reduced dependence on regional grids. The report describes the current state of advanced reactor technologies and other factors important for future deployment such as safety and operations, siting requirements, regulatory environments and policy, and other co-benefit considerations.

A structured evaluation across a diverse group of U.S. ports highlights the wide variation in feasibility. Fifteen ports were analyzed through port interviews and data collection to assess the port-specific conditions that most impact advanced reactor deployment. The analysis found that the most feasible ports for deployment have favorable geotechnical stability, supportive regulatory environments, and substantial energy loads in a grid-constrained environment. Additionally, an initial reactor size matching was done for the ports based on their reported energy consumption across different modes of operation. However, further analysis and detailed data will be required in the future to determine the optimal reactor-port matching. The economic viability to adopt this technology will be dictated by competitive cost of nuclear-generated electricity compared to other alternatives. Overall, small nuclear reactors present a promising but highly site-dependent pathway for ports seeking resilient, high-capacity energy solutions that support future energy demands.

This report identifies key areas for future research and highlights ports that warrant further evaluation to assess the viability of small nuclear reactor implementation. By establishing these priorities, the analysis provides support for the development of informed strategies for potential advanced nuclear technology deployment.

The inclusion of ports in this report does not imply their endorsement of nuclear energy generation, and the authors are grateful for the information, expertise, and perspectives they contributed.

Acronyms and Abbreviations

BOF	basic oxygen furnace
BTU	British thermal units
BW	brackish water
C	Celsius
CHE	cargo-handling equipment
CO_2	carbon dioxide
DOE	Department of Energy
EAF	electric arc furnace
EIA	U.S. Energy Information Administration
FNPP	floating nuclear power plant
gal	gallon
HMP	hot metal production
HPCR	heat-pipe-cooled reactor
HTGR	high-temp gas-cooled reactor
INL	Idaho National Laboratory
kg	kilogram
kWh	kilowatt-hours
LNG	liquefied natural gas
MED	multi-effect distillation
MSF	multistage flash
MW	megawatt
MWe	megawatts of electric power
MWt	megawatts thermal
NERC	North American Electric Reliability Corporation
NGNP	Next Generation Nuclear Plant
NIT	Norfolk International Terminals
NPRN	National Port Readiness Network
NRC	Nuclear Regulatory Commission
NWSA	Northwest Seaport Alliance
POLB	Port of Long Beach
PV	photovoltaic
PWR	pressurized water reactor
RMT	Richmond Marine Terminal
RO	reverse osmosis
Ro/Ro	roll-on/roll-off
SERC	Southeastern Electric Reliability Council
SMR	small modular nuclear reactor
SW	salt water
tbd	to be determined

TRL	technology readiness level
WECC	Western Electricity Coordinating Council

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1.0 Introduction

More than 90 percent of the world's freight is transported by water (Tan and Tao 2019; Iris and Lam 2019). Seaports are the critical link in goods transportation, serving as intermodal hubs that connect trade from road, rail, and air to ocean and inland waterway vessels. Maritime shipping demand is projected to increase between 40 and 115 percent by 2050 relative to 2020 levels (IRENA 2021). Port infrastructure will have to be scaled to meet the increasing demand.

In addition to growth, the transition toward electrification of equipment and provision of shore power for vessels at berth means that ports are increasing the forecasts for future electric power loads. Reliable power is critical, not only for terminal operations but also for the continuous operation of industrial facilities that are co-located with ports to facilitate. In an increasingly grid-constrained environment, ports are experiencing bottlenecks in electric power capacity (Collins 2026).

Ports also serve as nodes for energy. Port operations consume significant energy, both in terms of liquid fuel for vessels and shoreside equipment and also electrical load needed for cargo-handling equipment (CHE), buildings, and cold storage. As a result, ports often house energy infrastructure like fuel farms, substations, grid interconnections, and bunkering facilities to serve their own needs, as well as regional energy demand.

This report investigates the feasibility of small nuclear reactors as an alternative energy source for ports. For this report, the label of "small nuclear reactor" is meant to include both microreactors and small modular nuclear reactors (SMRs)—which can range from less than 1 megawatt (MW) to more than 100 MWs of electrical power generation. The report analyzes how reactor size, siting, and technology type align with port operational needs. Using a representative set of U.S. ports, the analysis assesses high-level energy demand profiles and evaluates whether advanced nuclear technologies could be a viable option for meeting port energy needs.

The attributes of ports will also dictate which small reactor design type would be best suited for a given location. Is there a baseload demand that remains relatively stable on a daily and annual basis? Is the utility that serves the port able to support current and future electricity needs? What is the port's current and future cost of electricity? Are there other energy-intensive facilities that could benefit from locally generated power nearby? What are the port's surroundings (i.e., urban industrial, rural/remote, densely populated)? These and other factors must be investigated to map the appropriate technology to each site and application.

1.1 Small Nuclear Reactor Technology

Nuclear fission, in which atoms of radioactive fuel are split, release large amounts of thermal energy. This heat is used to generate steam that drives a turbine to produce electricity. Commercial nuclear power plants are large facilities, with footprints around 1.3 square miles for a capacity of 1,000 MW of electric power (MWe) generation (Derr 2022). This would correspond to approximately 24 million kilowatt-hours (kWh) of electricity generated during a full 24-hour operating day at steady output.

Advancements in nuclear technology have expanded the range of nuclear-derived power options. Small nuclear reactors also produce electricity through nuclear fission but are designed with a smaller physical footprint and lower power output, from as low as hundreds of kilowatts (kW) to as much as 300 MWe. Reducing the size of the reactor could allow for deployment of reactors in places where a large reactor would not be suitable. In addition, small reactors could be serially manufactured in a single facility and transported to the deployment site, rather than constructed on site. This mass manufacturing process would create conditions for a dedicated workforce that remains in place and also provide static supply chains.

The designs of advanced small reactors, often classified as Generation III+ and Generation IV, incorporate “passive safety systems” that operate without human intervention, relying on natural regulating processes such as circulation, convection, gravity, and self-pressurization (CNSC n.d.).

The range and flexibility of power production among advanced nuclear reactor designs could facilitate distributed deployments, rather than centralized power production. Since ports already serve as energy nodes, ports might be a good candidate for deployment of the first wave of small nuclear reactors closer to load, along with industrial users and data centers.

1.2 Port Options for Small Nuclear Reactor Operating Location

While the current fleet of 94 major U.S. major nuclear power plants are located on land, small nuclear reactors could be installed on a barge or vessel. Floating nuclear power plant (FNPP) designs incorporate a barge or vessel with a small reactor and are optimized for marine conditions. FNPPs could allow ports to deploy a reactor when space constraints limit options on land. In addition, FNPPs are mobile, which means that they could be relocated periodically to serve multiple load sources. For instance, an FNPP might serve a cruise terminal during the summer tourism season and be moved to another location to heat facilities during the winter. The mobility of FNPPs would also allow for rapid relocation as an additional safety measure.

Power barges with internal combustion engine generators have already been in operation worldwide, so FNPP developers are able to model their systems on existing use cases. In addition to port activities, FNPPs could also be used for off-grid purposes like desalination plants, AI data centers, or supporting offshore oil and gas operations (Boe 2026). Table 1 lists some of the potential location-specific applications for small nuclear reactor technology relevant to maritime or co-located industrial applications.

Table 1. Examples of applications and types of advanced nuclear reactor deployments relevant to port operations. Adapted from Johnson et al. (2023) as demonstrations that either have been a Department of Energy (DOE)-authorized testing operation or Nuclear Regulatory Commission (NRC)-licensed first-of-a-kind deployment.

Land-Based	Offshore or Floating	Mobile
Small nuclear reactor for electricity	Small nuclear reactor for electric power (shore power)	Nuclear-electric river towboat
Small nuclear reactor for heat	Small-nuclear-reactor-powered data center	(International Transport) Nuclear-electric cargo, roll-on/roll-off (Ro/Ro), passenger, gas carrier, ice breaker with reverse cold ironing, or tanker vessels
Small nuclear reactor for synthetic fuel production	Small-nuclear-reactor-powered e-fuels production	(Domestic Transport) Nuclear-electric offshore support vessel, tanker, drill ship, dredging, container, dry cargo, gas carrier, Ro/Ro, passenger vessels
	Small-nuclear-reactor-powered desalination plant	

1.3 Small Nuclear Reactor Types

Advanced nuclear reactors vary widely based on their fuel, coolant, and power output. The following section will highlight some of the key reactor types, including both high technology readiness level (TRL), as well as those in earlier research and development stages. NRC defines both non-light water reactors and small modular light water reactors as advanced reactors (NRC n.d.). While uranium-enriched fuels are the most common for light-water-cooled small nuclear reactors designs (e.g., uranium-oxide ceramic fuel) there are many other fuel forms[1] that involve the fissile material itself or fissile material mixed with coolant (as in the case for molten-salts). These include metallic alloys, molten-salts, or other fuel forms as well as their corresponding coolants. For uranium-enriched fuels, the level of enrichment can vary depending on reactor design. Some small nuclear reactors are designed to use the same fuel used in the existing fleet of large water-cooled reactors, with enrichment levels below 5 percent. Other small reactors are designed to use more highly enriched fuels up to the highest permissible level of just under 20 percent. Table 2 lists these small nuclear reactor technologies that, while not yet deployed, have a high to moderate TRL that makes them relevant for conversations about potential future deployment at maritime ports.

Table 2. List of the most common small nuclear reactor types, their fuel and coolant, and level of readiness based on technology and regulatory certifications.

Small Nuclear Reactor Type	Fuel	Coolant	TRL	Regulatory Certification	Citation
Water-Cooled	Low Enriched Uranium	Light water	High[2]	NRC (only NuScale design)	Nuscale n.d.
Metal-Cooled	High-Assay Low Enriched Uranium (HALEU)	Liquid sodium	Medium[3]	Not certified	Nuscale n.d.
High-Temperature Gas-Cooled	HALEU (in tri-structural isotropic fuel particles)	Helium gas		Not certified	Nuscale n.d.
Liquid-Fueled Molten Salt	Uranium (dissolved in molten salt or used as solid fuel)	Molten salt (fluoride or chloride)	Low[4]	Not certified	Nuscale n.d.
Molten-Salt-Cooled	Solid Enriched Fuels	Molten salt	Medium-Low[5]	Not certified	ORNL n.d.
Heat-Pipe-Cooled	Uranium-Enriched Fuels	Passive heat pipes	Low (Liu and Fan 2014)	Not certified	Zhang et al. 2024

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[1] While not an exhaustive list, some of the SMR fuel forms being investigated, with the most common at the beginning of the list, include the following: uranium-oxide ceramics, molten fluorides, metallic uranium-zirconium alloys, molten chlorides, mixed oxide ceramics, uranium-silicide ceramic, liquid metallic uranium-chromium alloy, uranium-carbide ceramics (NEA 2025, p. 20).

[2] Over 60 years of history with successful operations. Currently makes up 90 percent of global fleet.

[3] Has been used in several experimental tests for research.

[4] Two reactors were tested in the 1950 to 1960s, and this technology remains experimental.

[5] There have been some experimental reactors already. Additionally, NRC has issued construction permits for Kairos Hermes 1 and Hermes 2C.

If a port is considering utilizing small nuclear reactor technology for their energy portfolio, they need to consider both the technology (fuel and coolant types) and the output capacity. Table 3 highlights different reactor types, their manufacturer, and operational specifics. Small nuclear reactors not only produce electrical power, denoted as MWe, but also have thermal outputs, megawatts thermal (MWt), that can be harnessed and utilized for other industrial purposes that are relevant to both maritime ports and their tenants.

Table 3. Examples of small nuclear reactor types, specific SMRs and their operational parameters, highlighted and adapted from Islam and Gabbar (2015), as well as examples of microreactors (SMR-Micro) and their type, adapted from FPSC (2025, Figure 10).

Name/Manufacturer	Type	Thermal Capacity	Electrical Capacity	Fuel	Refueling Cycle
Westinghouse SMR	Pressurized Water Reactor (PWR)	800 MWt	225 MWe	< 5% Enriched U235	2 years
mPower SMR	PWR	530 MWt	150–180 MWe	< 5% Enriched U235	4+ years
NuScale SMR	PWR	160 MWt	45 MWe	4.95% Enriched U235	2 years
IRIS SMR	PWR	300–1000 MWt	100–335 MWe	5% Enriched U235	5 years
Aurora SMR-Micro	Heat-Pipe-Cooled Reactor (HPCR)	–	1.5 MWe	–	7-10 years[6]
eVinci SMR-Micro	HPCR	–	0.2–5 MWe	–	7-10 years
NuScale micro	HPCR	–	1–10 MWe	–	7-10 years
MMR-5/-10 SMR-Micro	High-Temp Gas-Cooled Reactor (HTGR)	–	5 or 10 MWe	–	7-10 years
Holos Quad SMR-Micro	HTGR	–	3–13 MWe	–	7-10 years
BANR SMR-Micro	HTGR	–	50 MWe	–	7-10 years

Another key parameter for ports to consider for small nuclear reactor feasibility is the refueling time frame. Some small nuclear reactor designs require refueling less often than larger conventional nuclear power plants. However, it is important to consider other variables that impact the refueling time frame and fuel economics. Refueling intervals can depend on core design, fuel loading operations, enrichment levels, and burnup (the measure of how much energy is extracted from the fuel). On average, small nuclear reactor refueling cycles can have a range of years. The variant refueling timeframe is also important to consider for the associated costs and overall economics of the reactor. Table 3 lists the refueling time frames for specific small nuclear reactor examples.

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[6] For micro-reactors the refueling lifecycle can range between 7 and 10 years, with a larger refueling effort; the current process is that the reactor itself would be removed and replaced with a different one.

1.4 The Current State of Small Nuclear Reactor Deployments

According to the World Nuclear Association (WNA 2026) database, there are two small nuclear reactors currently in operation worldwide—one HTGC reactor with a pebble bed module (HTGR-PM) in China, with a capacity of 105 MWe, and a PWR in Russia (KLT-40S), with a capacity of 35 MWe. However, there are over 100 small nuclear reactor projects worldwide that are in the development/construction phase. In the U.S., there are currently small nuclear reactor projects at different stages of development, construction permitting, or licensing with the NRC. Some to note include TerraPower's Natrium reactor (345 MW sodium fast reactor) in Wyoming (TerraPower n.d.); the SMR project in Seadrift, Texas, co-led by DOW and X-Energy Reactor Company LLC (X-energy 2025); the Hermes reactor project in Tennessee led by Kairos Power in partnership with Oak Ridge National Laboratory (ORNL 2026); and the General Electric Vernova Hitachi Nuclear Energy's BWRX-300 small modular reactor in Tennessee (GE Vernova 2025). There is a sodium-potassium-cooled microreactor at Idaho National Laboratory (INL), which is used for research as part of the Microreactor Application Research Validation and Evaluation (MARVEL) (DOE n.d.). Additionally, INL has a test-bed facility, Demonstration of Microreactor Experiments (DOME), where companies such as Westinghouse and Radiant were selected to test their microreactor designs in 2025. Table 4 is an updated list of reactors being developed in other countries, with a range of the reported minimum, maximum, and average electrical power capacity (MWe) for the specific reactor type. Globally, the most common reactor types in development are water-cooled small nuclear reactors (30.2 percent of ongoing small nuclear reactor projects) and gas-cooled reactors (24.5 percent), which can be seen in Figure 1. The U.S. currently has all five of the most common reactor types being developed—water-cooled, metal-cooled, gas-cooled, molten-salt-cooled, and heat-pipe-cooled.

As more small nuclear reactors come online in the next decade, more data and use case information will be available for a variety of fuel types and capacities. It is important for ports to begin assessing what reactor types, thermal/electrical capacity, and overall size of the small nuclear reactor, which will match their operational needs while meeting siting, political, and cost-benefit guidelines.

Table 4. SMR projects around the world currently in the "Design and Development" stage from World Nuclear Association (WNA 2026).

Reactor Type	Countries in Design+Dev.	Min. MWe	Max. MWe	Average MWe
Water-Cooled	U.S., U.K., France, South Korea, Russia, China, India	1.0	470	141.9
Metal-Cooled	U.S., Canada, U.K., Japan, France, South Korea, Russia, Switzerland, Sweden	0.2	450	110.4
Gas-Cooled	U.S., Canada, U.K., Japan, France, South Africa, Russia, Poland, Indonesia	0.4	288	60.0
Molten-Salt-Cooled	U.S., Canada, U.K., Japan, France, South Korea, China, Netherlands, Denmark	0.4	300	109.8
Heat-Pipe-Cooled	U.S.	0.3	5	2.65

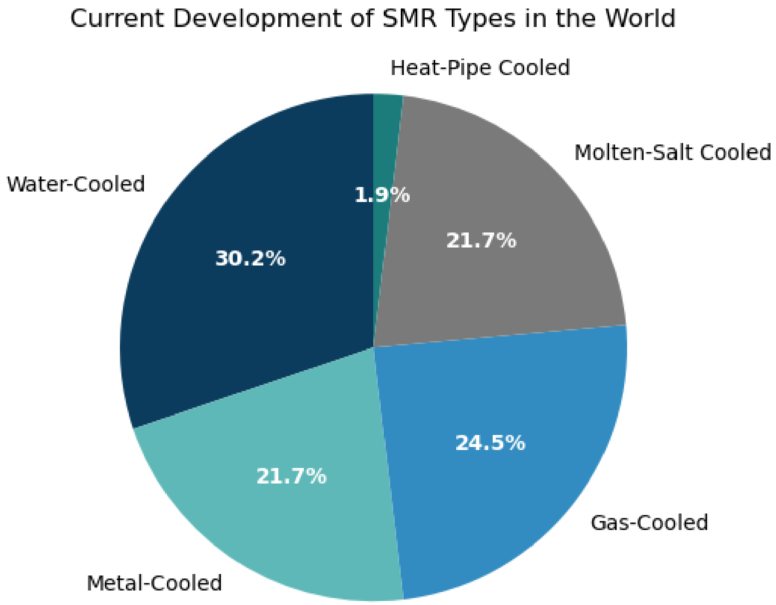

Figure 1. Summary of the World Nuclear Association database (WNA 2026) for the various SMR projects that are currently in the "Design and Development" stage around the world (2025). Data were collected only for SMR projects under the electricity application and ones where their electric capacity was listed (omitted approximately 8 data points out of 106, where capacity information was unavailable). The specific countries with certain reactor types can be found in Table 4.

2.0 Small Nuclear Reactor Operational Considerations

2.1 Safety, Security, and Safeguard Considerations

The threat to human life and the environment from radiation releases at nuclear power plants-highlighted by events like Chernobyl and Three Mile Island – or the release of contaminants like the accident in Fukushima, has made safety a principal concern for the public. These historical events have informed design improvements in regard to safety measures and also provided knowledge to avoid making similar mistakes. Small nuclear reactor designers are incorporating passive safety systems into their designs to achieve core cooling through systems that rely on physical processes like gravity or thermal diffusion for dissipating heat (Islam and Gabbar 2015), rather than relying on systems that require human intervention or external power. These “walk-away-safe” designs are intended to limit the potential for meltdowns or other radiation releases.

In addition to safety, developers must also consider how to harden their reactors against theft or sabotage. The location, facility, IT infrastructure, and workforce must be thoughtfully planned to prevent loss.

Finally, small nuclear reactors may be subject to international safeguards applied by the IAEA. Safeguards protocols are designed to ensure that fissile material and reactors are used for their legal purpose and not to produce weapons. Safeguards measures involve both in-person verification by international inspectors and deployment on-site technology (sensors, cameras, seals, and radiation monitoring equipment). Although IAEA safeguards apply to only a small selection of facilities in the U.S., there may be increased interest in safeguarding maritime reactors, especially those considered for export.

2.2 Siting Considerations

While small nuclear reactors have passive safety systems that mitigate some of the traditional concerns related to nuclear reactors, there are still many factors that should be evaluated for the siting of small nuclear reactors. An Idaho National Laboratory (INL 2013) report outlined some of the key aspects for determining site suitability and assessing hazards for small nuclear reactors as part of the Next Generation Nuclear Plant (NGNP) project. NGNP performed systematic site hazard assessments in the context of preparatory planning for the first commercial modular HTGR facility. The procedure used by NGNP to perform site assessments has been modified and adapted for use in this report as a generic small nuclear reactor technology site evaluation guide. While the site assessment parameters do not constitute an exhaustive list, it identifies key aspects that ports should consider when planning or assessing the feasibility of advanced nuclear technology for specific sites. Additionally, site selection and evaluation will need to be tailored to specific reactor technology and local environmental history.

From the NGNP report, sites were categorized as acceptable, constrained (requiring further evaluation), or not suitable based on the presence of specific factors. The intent of these parameters was to establish a standardized framework for quantitatively assessing whether a site could feasibly host a small nuclear reactor. These factors influence construction viability, operational safety, and the potential impacts on surrounding communities and infrastructure. The following criteria should be considered and were utilized in this report’s later assessment of ports and the feasibility of deploying small nuclear reactors.

2.2.1 Geology, Seismology, and Geotechnical Considerations

- Seismic risk is a primary screening factor; sites with peak ground acceleration exceeding approximately 0.30 g at low exceedance probabilities are generally avoided or down-ranked.
- Proximity to active faults, tectonic structures, or other geohazards (e.g., liquefaction, subsidence, landslides, volcanism) significantly affects site suitability.
- Sites without identified geohazards within approximately 25 miles are preferred; hazards within 5 miles are typically exclusionary. Geohazards include any fault displacement, tectonic deformation, subsidence (typically induced by groundwater withdrawal or mining), karst/dissolution, mechanically weakened zones (shear zones), liquefaction, irregular weathering, slope failure (landslides), unstable geologic deposits, and volcanism.
- Many geotechnical issues (e.g., weak soils, groundwater conditions) are not exclusionary but may require mitigation through standard engineering practices.
- Risk Mitigation: The risk associated with under prediction and/or poor characterization of seismic conditions can be reduced by (1) integration of experienced seismic experts in the site selection team; (2) collection and documentation of a robust database of existing information and querying of topical and regional seismic experts; (3) use of conservative assumptions for initial ground motion modeling/analyses; (4) geologic aerial and field reconnaissance in the site region and location; (5) obtain site-specific geologic, geophysical, and geotechnical information to evaluate seismic site response, dynamic properties, and ground failure potential.

2.2.2 Hydrology and Water Availability

- Adequate water must be available for cooling, emergency systems, fire protection, and normal operations, including considerations for low-flow conditions.
- Water use must comply with existing water rights, withdrawal limits, and regional water management plans.
- Sites may be challenged if alternative cooling strategies or mitigation measures are required to meet water demands.

2.2.3 Flooding and External Water Hazards

- Facilities must withstand worst-case flooding scenarios, including river flooding, storm surge, tsunamis, and extreme precipitation.
- Sites may require engineered protections (e.g., plant islands, barriers) if not naturally elevated or dry.

2.2.4 Nearby Hazardous Activities

- Proximity to industrial, military, or transportation facilities handling hazardous materials must be evaluated.
- Sites with hazardous activities within approximately 10 miles may require further evaluation because of potential impacts on safety-related systems.

2.2.5 Extreme Weather and Climate Conditions

- Site assessments must account for extreme weather risks such as hurricanes, tornadoes, high winds, snow loading, heat extremes, icing, and severe storms.

- Reliable, site-specific historical meteorological data is essential to establish design-basis conditions.
- Extreme weather alone is not typically exclusionary but may drive additional design or mitigation requirements.

2.2.6 Radiological Dispersion and Surrounding Land Use

- Population density, nearby population centers, land use, ecological sensitivity, and atmospheric dispersion characteristics influence emergency planning and regulatory acceptance.
- Lower population density and compatible land uses improve the siting feasibility.
- Impact on local environmental ecosystems. Containment of material is expected, but consideration of the impact to nearby habitats and remediation strategies should be given if there is unforeseen contamination from the nuclear reactor.

Overall, small nuclear reactor feasibility for specific sites and maritime application depends on balancing regulatory acceptance, safety, constructability, and operational resilience. Early screening should prioritize sites with low seismic and geohazard risk, adequate water resources, limited nearby hazards, manageable extreme weather conditions, and favorable land-use characteristics, while recognizing that some challenges may be mitigated through design or engineering solutions.

2.3 Small Nuclear Reactor Regulations and Policy

Small nuclear reactor deployment at maritime sites will require not only operational and geological considerations, but also overcoming hurdles regarding the handling, transportation, and accessibility of nuclear material. Both the reactor technology and the fuel are controlled entities to avoid proliferation, so nuclear regulators employ inspection regimes to ensure that neither the intellectual property nor the fuel are inappropriately handled. Some of the relevant policies and agencies that ports should consider when dealing with nuclear material in general (not specifically for small nuclear reactors) are included in the following sections.

2.3.1 Governing Laws (Calkins 2026)

- **Atomic Energy Act of 1954:** The foundational law for nuclear regulation, requiring civilian uses of nuclear materials to be licensed. It also sets policies for promoting peaceful uses of atomic energy.
- **Energy Reorganization Act of 1974:** Established the NRC to be an independent regulatory agency, empowering the NRC to enforce safety standards, and established the Energy Research and Development Administration (later becoming DOE). Before this act, the NRC was part of the Atomic Energy Commission, who was responsible for regulatory actions.
- **Nuclear Waste Policy Act of 1982:** Governs disposal and storage of high-level radioactive waste.
- **Energy Policy Act of 2005:** Provides incentives for new reactor construction, including loan guarantees and tax credits.
- **ADVANCE Act 2024:** Accelerates licensing and deployment of advanced reactors, reduces NRC fees, and incentivizes first-mover projects.

2.3.2 Licensing and Oversight (Calkins 2026)

- **Licensing Process:** NRC reviews reactor designs, construction permits, and operating licenses through a rigorous process. Applicants must demonstrate compliance with safety, security, and environmental standards.
- **Inspections and Enforcement:** NRC conducts regular inspections and can impose fines or revoke licenses for non-compliance.
- **Public Participation:** NRC regulations require opportunities for hearings and judicial review.

2.3.3 Federal Preemption and Emerging Reforms (Calkins 2026)

States may regulate economic aspects (e.g., cost, need for power) but cannot regulate radiological safety, which is exclusively under federal jurisdiction. Recent executive orders and DOE initiatives aim to modernize the regulatory framework for advanced reactors, streamline licensing, and accelerate deployment of small nuclear reactors and microreactors. States set land-use and economic policy for the nuclear industry.

2.3.4 Key Civilian Regulatory Agencies (Calkins 2026)

- **NRC:** Established by the Energy Reorganization Act of 1974, the NRC is the primary independent regulator for civilian nuclear power. It licenses and oversees all commercial reactors, fuel cycle facilities, and waste management operations.
- **DOE:** Department of Energy (DOE) manages nuclear research, advanced reactor development, and safety at DOE-owned facilities. It also funds research and development for next-generation technologies and oversees nuclear material security.

2.3.5 Emergency Response and Protection

Ports should consider the relevant training and coordination for personnel that may be exposed to radioactive material. This would include longshore workers, truck drivers, inspectors, and mariners who spend considerable time within port facilities. Additionally, first responders, such as fire, police, coast guard, and other emergency response groups, should be included in feasibility discussions and throughout the deployment process of small nuclear reactors.

Additionally, emergency response systems would include physical infrastructure to support the reactor, monitoring equipment, and systems for communication related to the reactor's operation. Formal emergency response plans would be required, to include specifications on the emergency planning zone (NRC 2023).

Information technology is critical infrastructure for both operations and security at ports. Safety, security, and safeguards requirements of small nuclear reactors rely on robust information technology to ensure sufficient redundancies and cybersecurity protections in a heightened threat environment.

2.3.6 Maritime Port Network

For successful small nuclear reactor deployment, ports must ensure coordination and compliance across all the relevant entities involved in the maritime port network. This could include stakeholders and other seaport agencies, along with federal, tribal, and state/local groups; terminal operators; and international trading partners.

2.4 Small Nuclear Reactor Co-Benefit Considerations

The following sections of this report highlight some of the other applications that ports can consider for small nuclear reactor technology. While serving the operational needs of electric equipment would be the primary use for small nuclear reactors at ports, surplus power in the form of thermal energy and electricity could support additional energy needs of the port and its neighbors. Capturing some of these benefits could also strengthen the economic case for deployment.

2.4.1 Heat for Industrial Processes

The excess heat from small nuclear reactors could be harnessed and used in other industrial processes (IAEA 2022). This could be advantageous in various processes (IAEA 2017, Table 7) that operate at high temperatures such as desalination (100 to 130 degrees Celsius [C]), oil refining (200 to 600 degrees C), petroleum refineries (450 to 500 degrees C), iron industry (600 to 1600 degrees C), steel making via direct (500 to 1,000 degrees C), hydrogen production via thermochemical reactions (600 to 1,000 degrees C), and coal processing or gasification (400 to 1,000 degrees C). SMRs are a unique way to provide heat to these processes without the need to use extra electrical energy to generate the thermal energy required. As reported in Table 3, small nuclear reactors are rated for a certain thermal power capacity (MWt), so the application of small nuclear reactors for high-temperature industrial processes could be a helpful deciding factor between the various types of small nuclear reactors to deploy.

2.4.2 Energy for Hydrogen Fuel Production

Hydrogen can be produced through five primary pathways (IAEA 2013, Table 1) that vary in feedstock, energy input, and technology maturity. Gasification is a thermochemical process that converts carbon-based feedstocks—such as biomass, coal, or other solid and liquid fuels—into synthesis gas (syngas), from which hydrogen is subsequently separated. Steam reforming, a specific form of gasification, produces hydrogen by reacting hydrocarbon gases (most commonly methane) with steam at high temperatures. Electrolysis generates hydrogen by using electricity to split water molecules, with the electricity supplied from a range of generation sources. These three pathways are technologically mature and commercially deployed. In contrast, two additional pathways remain at earlier stages of research and development and are not yet ready on a commercial level: thermochemical water-splitting cycles, which use very high temperatures—typically supplied by nuclear or concentrated solar energy—to separate water into hydrogen and oxygen, and biological hydrogen production, which relies on algae or bacteria to directly generate hydrogen.

One of the key advantages of nuclear-generated power (IAEA 2013, p. 4; Brook et al. 2014) is its ability to provide a stable baseload electricity supply, resulting in more predictable and fixed energy costs. This contrasts with the variability in electricity availability and pricing from the grid, as well as fluctuations in natural gas prices when gas-fired generation is used to produce electricity.

A 2022 report published by the International Atomic Energy Agency (IAEA 2022, p. 22) identified several opportunities where nuclear energy could be used to partially supply or supplement energy inputs for hydrogen production. These include nuclear-assisted natural gas reforming, coal gasification, and thermochemical conversion of biomass, as well as thermochemical water splitting, low-temperature electrolysis, and high-temperature steam electrolysis. While this report highlighted nuclear power plants as an energy source, small nuclear reactors could similarly be deployed to provide supplemental power.

2.4.3 Energy for Synthetic Fuel Production

E-fuels are synthetic liquid fuels (synfuel) made from carbon dioxide (CO_2) and hydrogen. Nuclear-generated electricity is well suited for e-fuel production because it provides steady reliable power and is an efficient way for producing hydrogen, which requires high temperatures and high energy for high-temperature electrolysis (HTE). Additionally, ports can be co-located with corn-ethanol facilities or sources of biogenic CO_2, and deploying a small nuclear reactor nearby can add value by avoiding extra transportation costs in the e-fuel production lifecycle.

While synfuel production costs can vary widely across current literature, there is a consensus that overall production costs are largely driven by electricity price and the hydrogen production pathway. One study found that synfuel production using hydrogen generated by renewable energies (hydropower, solar, offshore wind) generated syngas prices around $5.5 to $7 USD/gal (Choe et al. 2022).

A 2023 study by Delgado et al. (2023) investigated the production of syngas via Fischer-Tropsch process, using hydrogen generated via HTE with captured CO_2 from existing bioethanol plants and power from nuclear power plants of different capacities. While the power plants were not actually small nuclear reactors, the plant with the smallest electrical capacity was around 100 MWe and is within the relative size for a small nuclear reactor. Based on their assumptions for HTE[7] production of hydrogen, they found that the overall cost for producing synfuels (also including hydrogen production tax credits) ranged from around $3.6 USD/gallon (gal) for the 100 MW nuclear power plant and $2.7 USD/gal for the 1,000 MW nuclear power plant. Without the tax incentives, the price range for the synfuels was around $5.4 to $6.4 USD/gal. Compared to the previous study, this was slightly lower than the syngas produced via other renewables ($5.5 to $7 USD/gal).What these studies highlight is that some of the limiting factors related to costs for synfuel production, including hydrogen production and electricity, can be addressed by alternative energy sources, like small nuclear reactors. While the thermal and electrical energy generated by the small nuclear reactors did play a role in the reduction of fuel production costs, it is important to note that policy influence and tax credits also influence the economics of fuel production.

A 2025 study evaluated the feasibility of coupling a small modular reactor with hydrogen production (Buzzetti et al. 2025). Key considerations from this study for assessing the cost-effectiveness of applying small nuclear reactors to this application include determining the hydrogen production pathway, estimating the required hydrogen output, and determining the number of reactor modules needed to meet the thermal and electrical demands of the hydrogen production facility. Another recent study highlighted that the final levelized cost of hydrogen (LCOH) is influenced by several factors, including the capital cost of the small nuclear reactor, electrolyzer costs, uranium prices, and the overall operational lifetime of the reactor (Pompodakis and Papadimitriou 2025). While reducing the cost of fuel production is another benefit to the possible utilization of small nuclear reactor technology, questions remain regarding the small nuclear reactor's specific application, fuel type, and additional costs, which all impact the final LCOH.

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[7] Approximately 90 percent efficiency (high heating value basis); electrical demand: approximately 36.8 kWh/kilogram (kg)-H_2; thermal demand: approximately 6.4 kWh/kg-H_2.

2.4.4 Energy Storage Paired with On-Site Generation

When determining the appropriate size reactor for their energy needs, ports will need to determine whether to select energy output equivalent to baseload demand or to select a larger reactor that could be paired with energy storage. In that case, the stored energy could be used to meet peak demands.[8] In most cases, a reactor sited at a port would tie into a microgrid, which is a localized, small-scale energy network that generates, stores, and distributes power to a specific area.

Islam and Gabbar (2014) showed how the adoption of small nuclear reactors in a microgrid can lower the levelized cost of electricity when used in tandem with wind and solar for a total capacity of 100 MW. As the nuclear contribution to the generation capacity increased from 0 to 100 percent (with wind/solar contributing the remainder), the overall cost for electricity generation decreased.

Additionally, a report by INL noted that integrating small nuclear reactors into microgrids can diversify the energy mix and enhance resiliency by reducing reliance on fuel feedstocks—such as diesel or natural gas—that currently power many microgrids and may be subject to supply constraints (Poudel et al. 2021). In summary, small nuclear reactors can provide value, not only providing electrical power for port operations, but also other industrial processes, fuel production, and support for microgrid development. The next section of the report investigates what types of U.S. ports could be candidates for benefiting from and feasibly deploying small nuclear reactors in the near future.

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[8] Pacific Northwest National Laboratory maintains the Energy Storage Evaluation Tool (ESET) to determine the appropriate battery type and capacity for a given need (https://www.pnnl.gov/available-technologies/energy-storage-evaluation-tool-eset).

3.0 Small Nuclear Reactor Feasibility at Maritime Ports

The following section highlights the potential relevance for small nuclear reactor technology at maritime ports. Port operations, associated energy consumption, and nearby energy-intensive neighbors are part of the feasibility assessment for a small nuclear reactor. Additionally, various factors like siting, geography, and regulatory boundaries are important to consider if a small nuclear reactor deployment would be possible and beneficial to the port (Table 7).

3.1 Maritime Port Operations

Commercial maritime ports are all gateways to national and international trade. They handle various cargo types, utilizing various types of transportation—rail, trucks, smaller barges—and equipment to process the commodities. However, each port is unique because of the wide variety and combination of operations, throughput capacities, cargo, and regional responsibilities. There are over 300 commercial ports in the United States (Maritime Administration 2025), and each one has specific factors that influence the feasibility of a future small nuclear reactor deployment.

3.1.1 Port Categorization

This study selected a variety of national or territorial U.S. maritime ports based on criteria relevant to small nuclear reactor application. Criteria included port co-location, with areas that have or will have high energy demands from competing industries, which would limit the grid power available for port electrification efforts. These included nearby oil refineries (DOE-OE 2025; EIA 2024), the presence of cruise traffic (current or future shore power) (EPA 2022; All Things Cruise n.d.), or a high density of data centers (current or future) (Data Center Map n.d.; Aterio n.d.; Dgtl Infra n.d.). Ports were also prioritized if located in areas of grid vulnerability (North American Electric Reliability Corporation [NERC] grid vulnerability rating [NERC 2025]), are in states lacking renewably generated energy (EIA n.d.[a]), or if the ports serve strategic and defense-related operations (National Port Readiness Network [NPRN]) (Maritime Administration 2024). Additionally, ports subject to air quality mandates were prioritized, since nuclear-generated power could conceivably help these ports comply with air pollution restrictions.

Additionally, conversations with ports highlighted other factors influencing small nuclear reactor deployment. These included regulatory complexity and port governance structures, the region's current and historical socio-political context surrounding nuclear energy, and national security considerations. The ports evaluated in this report can be found in Table 5, organized by their regional location.

From an initial list of 27 ports identified for consideration, this study completed a detailed analysis on 14, based on correspondence with the ports and publicly available data. In Table 5, the ports that were able to respond and provide data in the time frame for this report's analysis were indicated by an asterisk (*). The remaining ports from the initial 27 were included for future expansion of this work, labelled as *to be determined* (tbd) (Table 5).

As a background on each port, researchers created high-level summaries of the operations, cargo processing, relevant energy-intensive neighbors, and other factors that would impact the feasibility of deploying a small nuclear reactor at the port. Data for these summaries were acquired through publicly accessible and port/tenant-provided information. These details were used to determine high-level annual energy estimates of the ports and informed the assessment of small nuclear reactor feasibility. These can be found in Appendix A. The remaining ports recommended for future analysis are listed in Appendix B, along with supporting details that highlight the potential relevance of small nuclear reactors and the rationale for further feasibility assessment.

Table 5. List of national and territorial U.S. ports that were identified for analysis based on categorization factors relevant to small nuclear reactor deployment. More than half were used for small nuclear reactor feasibility assessments (*), and the other half are included for future expansion of this work (tbd).

Maritime Port Name	State	Port Responses + Port Summary + Energy Analysis	Contacted Port + Recommended for Future Research
West Coast			
Port of Juneau	AK	*	-
Port of Long Beach	CA	*	-
Port of Oakland	CA	*	-
Port of Honolulu	HI	*	-
Port(s) of Seattle/Tacoma	WA	*	-
Port of Anacortes	WA	*	-
Port of Everett	WA	*	-
East Coast			
Port of Baltimore	MD	*	-
Port of Boston	MA	-	tbd
Port of Newark (NY)	NJ	-	tbd
Port of Philadelphia/Camden	PA	-	tbd
Port of Detroit	MI	*	-
Gulf			
Port of Corpus Christi	TX	*	-
Port of Houston	TX	-	tbd
Port of Galveston	TX	-	tbd
Port of Beaumont	TX	*	-
Port of New Orleans	LA	-	tbd
South			
Port of Miami	FL	*	-
Port of Everglades	FL	*	-
Port of Savannah	GA	*	-
Port of Wilmington	NC	-	tbd
Port of Charleston	SC	-	tbd
Port of Virginia	VA	*	-

Maritime Port Name	State	Port Responses + Port Summary + Energy Analysis	Contacted Port + Recommended for Future Research
U.S. Operated			
Port of Apra Harbor	GU	*	-
Port of San Juan	PR	-	tbd
MOTCO (Military Ocean Terminal Concord)	CA	-	tbd
MOTSU (Military Ocean Terminal Sunny Point)	NC	-	tbd

3.1.2 Energy Demand Estimations

Annual energy estimates were done for 14 ports and an additional terminal operator located across nine different states and five different geologic regions: U.S. West and East Coasts (including a Great Lakes port), the South and Gulf regions, and islanded ports. These are all listed in Table 5 under the column “Port Responses + Port Summary + Energy Analysis.”

The scope of this report did not seek to create detailed quantitative energy baseline calculations, but to provide general ranges of energy demand across different port operations. Data was collected from publicly accessible reports and provided by the port directly or through terminal operators. While future work could expand on the scope of operations included in the high-level approximations, the following modes were included in the scope of analysis:

- **Infrastructure Energy Demands:** buildings, lighting, gates, security, HVAC systems, and generators (electric).
- **Cargo Processing Demands:** conveyor systems, refrigerated container storage, fuel docks.
- **Electrification Demands:** shore power, level I/II electric chargers, direct current fast chargers, tugboat electric chargers, ship-to-shore cranes (electric or grid connected), rubber tyre gantry cranes (electric or grid connected).

These areas were determined to be in scope for this analysis because they account for potential electrical energy demands that are large, ongoing, or could disrupt normal electricity rates and be met by a small nuclear reactor; the loads that are in scope represent common denominators across the majority of U.S. ports, and they are likely to have accessible data available for analysis without requiring detailed experimental or engineering assessments (which would be less common among ports generally).

To protect any proprietary information that was provided by the ports, the energy used across different operations was included as a net sum. A black asterisk (*) was indicated for any of the areas that contributed to the final energy estimate. This was done to compare ports fairly, since not every port had recorded electrical consumption for certain modes, or did not have the specific operational component.

The resulting energy estimates for various port operations are reported in Table 6, along with estimated electrical demand for 2030 (only included if the information was provided/available). An orange asterisk (*) alongside the black asterisk indicates that the 2030 energy estimate includes a general increase in energy for that mode because of general port growth. An orange asterisk in a square without a black asterisk indicates new anticipated loads that the port might have in the future (e.g., shore power, electric chargers, updated infrastructure).

Many of the ports could have other operational areas of energy demand, have data for certain areas that are not included in this analysis, or could be planning electrification initiatives or other infrastructure upgrades, both of which could affect the current and projected energy demands. However, only publicly available information and the data shared by the port at the time of analysis were included in these estimates; therefore, the reported energy values should be considered approximate and not official figures.

Table 6. Areas that were determined to be in scope for annual port electrical demands across various ports in the United States or U.S. territories. For current annual energy demand, a black asterisk (*) was used to indicate any of the areas that contributed to the final energy estimate. For projected energy demands in certain areas, an orange asterisk (*) alongside the black asterisk indicates that the 2030 energy estimate includes an increase in energy for that mode because of general port growth. An orange asterisk in a square without a black asterisk indicates new anticipated loads that the port might have in future (e.g., shore power, electric chargers, updated infrastructure). The bottom section of the table includes the energy-intensive neighbors near the port (y = present), with an orange "y" indicating a new facility that has been confirmed and is in development stages.

Scope: Relevance to Energy Baseline	Possible types of loads at/near port	Data Source	Port of Juneau, AK	Port of Long Beach, CA	Port of Miami, FL	Port of Everglades, FL	Northwest Seaport Alliance (NWSA), WA	Terminal Operator, Honolulu HI	Terminal Operator (West/East Coast)	Port of Corpus Christi, TX	Port of Anacortes, WA	Port of Oakland, CA	Port of Baltimore, MD	Port of Everett, WA	Port of Guam, GU	Port of Detroit, MI	Port of Savannah, GA	Port of Beaumont, TX	Port of Virginia, VA
Infrastructure	Buildings & Lighting & Gates & Security	Port/Tenant		*	*	*	**	*	*	**	**	**	*	*	*		*		**
On-going loads	HVAC Systems	Port/Tenant						*		**				*			*		**
	Generators	Port/Tenant																	
Cargo Processing	Conveyor Systems	Port/Tenant								**				*	*				
Operations	Refrigerated Container Storage	Port/Tenant		*	*	*	*	*	*			**					*		**
	Fuel Docks (pump systems)	Port/Tenant		*	*				*		**	**	*		*				**
Electric Modes	Shore Power	Port/Tenant	*	**	**	**	**					**					*		
May disrupt normal electricity rates	Level I/II electric chargers	Port/Tenant		**	*		**	*				**							**
	DC fast electric chargers	Port/Tenant		*			*					*	*				*		
	Tugboat electric chargers	Port/Tenant			*		**												
	Ship to Shore Cranes (STS)	Port/Tenant		*	*		*	*	*			*			*		* *		**
	Rubber Tyre Gantry Cranes (RTG)	Port/Tenant			*	**	**					*							**
Approximate Annual Energy Demand (MWh)			7E+03	2E+05	3E+05	6E+04	2E+05	2E+03	6E+03-8E+03	1E+04	1E+03	8E+04	2E+04	2E+03	2E+01-1E+02	Data unavailable	9E+05	Data unavailable	1E+05
Estimated Demand by 2030 (MWh)			n.a.	4E+05-2E+06	8E+05	2E+05	5E+05-1E+06	4E+03	n.a.	2E+04	2E+03	2E+05	n.a.	n.a.	n.a.	n.a.	1E+06	n.a.	2E+05
Co-Located Operations	Bulk Metals Production	Co-Located or within 10 mi			y		y			y	y	y	y	y		y	y	y	y
Significant energy use, limits grid	Chemical/Petrochemical Manufacturing	Co-Located or within 10 mi		y			y			y		y	y			y	y	y	y
	Crude/Petroleum Refinery	Co-Located or within 10 mi		y			y			y	y		y			y		y	
	Cement Manufacturers	Co-Located or within 10 mi		y	y		y	y	y	y		y	y	y		y	y	y	y
	LNG Facility or Production	Co-Located or within 10 mi			y		y			y									
Other Industries	Desalination Plants	Other (within 10 mi)			y					y									
Significant energy use, limits grid	Waste Water Treatment Plants	Other (within 10 mi)	y	y	y	y	y	y	y	y	y	y	y	y		y	y	y	y
	Data Centers	Other (within 10 mi)		y	y	y	y	y	y	y		y	y			y			
Security and Depense Operations	Aiports	Co-Located or within 10 mi	y		y	y	y	y	y	y	y	y	y				y	y	y
Utilizing reserve energy, aids resilience	Navy/Coast Guard/Military Bases	Co-Located or within 10 mi	y	y	y	y	y	y	y			y		y	y	y	y	y	y
	NPRN or Critical Response Site	Port/Tenant		y			y			y	y	y		y			y	y	

3.2 Maritime Port Co-Located Industries

Maritime ports serve as critical nodes within transportation and shipping networks. This makes them prime locations for large industrial facilities, whether as tenants or nearby neighbors. Such industries include crude oil and petroleum refineries and distributors, cement manufacturing, liquefied natural gas (LNG) production plants and distributors, and hydrogen production facilities.

Small nuclear reactor feasibility assessments should include the energy consumption baseline for port operations, but it is also important to consider the other industries surrounding ports. Other nearby or co-located entities can place significant energy demands on the surrounding grid and further motivate the relevance of small nuclear reactor deployment; also, ports including possible co-users for nuclear-generated energy at or near the port could help to offset the siting and cost challenges for small nuclear reactor deployment.

Industries that were included in the scope of this analysis were based on their large and relatively continuous energy consumption or demand for high temperatures (which could also be supplied by a small nuclear reactor). These included bulk metal production plants, chemical and petrochemical manufacturing, crude and petroleum refineries, cement manufacturers, LNG plants, desalination plants, wastewater treatment plants, and data centers. This is not an exhaustive list of large energy users; however, they are some of the most common across the ports evaluated in this study. Future analysis would be needed for an expanded scope.

Google maps and online research were used to determine the presence and number of these industries near the ports in scope of this study. Industries were included as being near or co-located with the port if the distance was approximately 10 miles or less. The selected distance ensures industries would be in a similar grid and utility region and within range of relevance to port operations. Industries located within this scope are listed in the summaries for each port in Appendix A.

The estimated annual energy consumption ranges for these various industries, calculation details, assumptions, and summary tables can be found in Appendix D. Energy information for military or coast guard installations was not included because the information is often proprietary and not available for wide distribution. Since this study is designed to be publicly accessible to inform ports and stakeholders, that energy information was omitted in the approximations done in this study. The industrial energy estimations can provide useful insight for future decisions on the SMR size/capacity to serve not only the port but also provide advantages to nearby/co-located energy users.

3.3 Evaluation Criteria for Small Nuclear Reactor Integration at Ports

The goal of this report is to review a subset of maritime ports in the U.S. to determine whether small nuclear reactor deployment is suitable based on key safety/policy factors for small nuclear reactor or microreactor deployment, the utility and suitable application of small nuclear reactor for port operations, and the current/future electrical needs for the port (including operational and nearby industrial neighbors). Table 7 highlights these factors, their importance for this assessment, and what makes a port a good candidate for possible small nuclear reactor deployment.

Table 7. General guidance on assessing the feasibility and utility of small nuclear reactor technology at a maritime port.

Factor	Why It Matters	High Priority (Good Candidate)	Notes/Cautions
Port Energy Demand (current & projected)	Small nuclear reactors make sense only where there's large, steady, and growing demand (shore power, hydrogen production, electrified equipment).	> 100 MW sustained demand; growing with electrification mandates.	High-level estimates are a good starting point, but detailed assessments would be needed in future.
Grid Capacity & Reliability	If local grid is weak, small nuclear reactors could fill a gap. If grid is strong, small nuclear reactors may be redundant.	Weak grid + major growth in demand.	Critical distinction: Are small nuclear reactors filling a *real gap* or competing with easier grid upgrades?
Proximity to Population/Critical Infrastructure	Nuclear power near population centers is politically sensitive. But being close to demand centers reduces transmission needs.	Dense metro nearby, high industrial loads, limited space for renewables.	Critical to evaluate the minimum emergency planning radius needed for the chosen small nuclear reactor.
Available Siting Space/Security Buffer	Ports are land-constrained and often prioritize space for commercial use. Small nuclear reactors also need secure perimeters and controlled access.	Ports with adequate secure land.	Protections can be implemented in small nuclear reactor design and deployment process.
Site Stability	While small nuclear reactors are compact and walk-away safe, they still require resilience to flooding, storm surges, geologic events.	Dense soil sites, far away from volcanic activity, with flood mitigation strategies in place.	Small nuclear reactor technology is still being developed. Important to have thorough geology, seismology, hydrology, weather, and ecology assessments.
Political Acceptance/ Regulatory Complexity	State-level nuclear regulation, environmental laws, and port governance structure can add to delayed deployment.	Communities with history of nuclear facilities, strong industrial acceptance; states with nuclear-friendly regulators and precedent (e.g., South Carolina, Tennessee, Idaho).	States with nuclear memorandums that prohibit establishing new nuclear generation may halt small nuclear reactor adoption.
Energy Transition Goals	Some ports have aggressive emissions goals and small nuclear reactors could be useful to meet those.	Ports who seek to electrify certain modes of operation and require more power.	There are alternatives to small nuclear reactor technology for additional backup power.
Strategic/ Defense and Resiliency	Ports with military or national security functions may justify small nuclear reactors for resilience plays.	Navy or Coast Guard hubs, critical transportation/supply location that requires certain operations to operate if grid goes down.	

4.0 Conclusion

4.1 Relative Port Readiness

Based on the categories from Table 7, five major parameters were used to evaluate the feasibility and/or benefits of small nuclear reactor technology at specific ports selected for this study. Ports were given a qualitative coloring from low or fair (red), medium or average (yellow), and high or good (green), with the color scale indicating if the category showed more of an advantage/disadvantage for the small nuclear reactor at each port. The more categories in which the port ranked good or high, the higher the likelihood of small nuclear reactor deployment being beneficial to the port.

1. Annual Energy Use Ranking

Ports were assessed based on the baseline operational energy estimates. A ranking of “low” meant they are on the smaller end of total energy use (x ≤ 2E+03 MWh/yr), a ranking of “medium” is in the middle energy use range (2E+03 ≤ x ≤ 6E+04 MWh/yr), and a score of “high” means a larger energy consumption (x ≥ 6E+04 MWh/yr). These rankings provide a level of energy demand required for certain operational modes at ports, as well as how nuclear-generated energy from a small nuclear reactor could be applicable; these rankings are not intended to give an estimate of the full energy demand across the entire port nor all of its tenants.

2. Co-located or Nearby Industries

Ports were evaluated based on the number of nearby or co-located industries close to the port. If ports have a significant number of the highest energy users (i.e., refineries, petrochemical manufacturing, desalination plants, steel production plants) then they received a “high” ranking in this category; if the ports only have some of the highest energy users or some of the other industrial players, such as wastewater plants, LNG plants, or cement manufacturers, they received a “medium” ranking. If the port has few industrial neighbors, they received a “low” ranking. Data centers were not included in the assessment. It was difficult to determine whether the data centers near the ports were large-scale facilities—which would align with the data center energy estimate done in the appendix of this report—or if they were simply support locations, which would not have as high of an energy impact in this analysis. Ports with a large number of high-energy-use neighbors could be an advantageous environment for the deployment of the steady electrical output of a small nuclear reactor.

3. Regulatory & Site Security Ranking

Ports were given a “fair” ranking if there are difficulties in the state’s policy regarding new nuclear projects, local history, and fervent community opposition against nuclear technology, or if there would be potential difficulties in safeguarding the nuclear material at the port site (e.g., if a major naval/military base was nearby). Ports were given rankings of “average” or “good” on a sliding scale for reduced nuclear technology socioeconomic hurdles. Ports were given a “good” ranking if there exists open support for investigating or developing nuclear technology which would be advantageous for the potential deployment of small nuclear reactors.

4. Strategic Site Ranking

Ports were ranked based on the ways that advanced nuclear technology could support resiliency or strategic capabilities by providing reliable power. If a port has two or more of a set of characteristics—it is an NPRN port, an emergency response/support site, would provide supplies to isolated areas, or is near critical coast guard/military/navy infrastructure—it was given a “good” ranking. If the port has one of the characteristics, it was ranked as “average.” If the port has none of these characteristics, it was ranked as “fair.”

5. Site Stability & Siting Space Ranking

Ports were ranked based on the area around and location of the port and any hazards or siting challenges for future small nuclear reactors (based on parameters highlighted in Section 2.2). A ranking of “fair” indicates there are major challenges or disadvantages of the area that would require great consideration (e.g., tsunami or tectonic event risks), a ranking of “average” indicates the site has challenges (e.g., soil integrity, space limitations) and further evaluation would need to be done to engineer potential solutions. A ranking of “good” indicates there are no immediate, major geologic factors that would cause initial concern for deployment; however, thorough engineering and environmental assessments would still be required in the future. The scoring and final sum for each port can be found in Table 8.

Table 8. Five major parameters were used to evaluate the feasibility and/or benefit of small nuclear reactor technology at specific ports. Ports were given a qualitative coloring from low or fair (red), medium or average (yellow), and high or good (green) for different ranking categories, with the color scale indicating if the category showed more of an advantage/disadvantage at the port for deploying small nuclear reactors at that site.

Maritime Port Name	State	Annual Energy Use Ranking (Low, Med, High)	Co-located or Nearby Industries (Low, Med, High)	Regulatory & Site Security Ranking (Fair, Avg, Good)	Strategic Site Ranking (Fair, Avg, Good)	Site Stability & Siting Space Ranking (Fair, Avg, Good)
West Coast						
Port of Juneau	AK	🟨	🟥	🟩	🟩	🟨
Port of Long Beach	CA	🟩	🟩	🟥	🟩	🟩
Port of Oakland	CA	🟩	🟨	🟥	🟩	🟩
Port of Honolulu	HI	🟥	🟥	🟥	🟩	🟩
Port(s) of Seattle/Tacoma	WA	🟩	🟩	🟨	🟩	🟩
Port of Anacortes	WA	🟨	🟩	🟨	🟨	🟩
Port of Everett	WA	🟥	🟥	🟥	🟩	🟩
East Coast						
Port of Baltimore	MD	🟨	🟩	🟩	🟥	🟥
Port of Detroit	MI	n.a.	🟩	🟨	🟩	🟥
Gulf						
Port of Corpus Christi	TX	🟨	🟩	🟩	🟩	🟨
Port of Beaumont	TX	n.a.	🟩	🟨	🟩	🟩

South						
Port of Miami	FL	🟩	🟥	🟩	🟥	🟩
Port of Everglades	FL	🟨	🟥	🟩	🟥	🟩
Port of Savannah	GA	🟩	🟩	🟨	🟩	🟥
Port of Virginia	VA	🟩	🟥	🟨	🟩	🟥
U.S. Operated						
Port of Apra Harbor	GU	🟥	🟥	🟥	🟩	🟩
Color Legend: level of advantage for SMR			🟥 **Low/Fair**	🟨 **Medium/Avg**	🟩 **High/Good**	

4.2 Potential Nuclear Technology Matching

The previous sections outlined key factors for deploying small nuclear reactors and the considerations that may make them more or less suitable for specific ports and their operations. While identifying the optimal reactor type and size for any individual port would require substantially more site-specific information, this analysis illustrates an initial, simplified approach to potential technology matching based solely on annual electricity demand.

Small nuclear reactors are typically characterized by their electrical and thermal capacities (MWe or MWt), but their annual energy production depends on operating hours. Assuming continuous operation (24 hours per day, 365 days per year), an idealized annual electricity output can be estimated for each reactor type (excluding ramp-up and ramp-down constraints and other inefficiencies that would, in reality, lower the total energy output).

Using the reactor types previously listed (Table 3), an estimated minimum and maximum annual electrical energy output was calculated and summarized in Table 9. Four representative small reactor designs were selected to span a range of capacities (in MWh per year). These output ranges were then compared with estimated annual port electricity demand (MWh) across different operating modes (Table 6) and plotted in Figure 2. Based on this comparison, Table 10 identifies potential technology matches—i.e., reactor types that could plausibly meet the electricity demand associated with particular port operations.

Table 9. For representative small reactor designs and assuming continuous operation (24 hours per day, 365 days per year), an idealized annual electricity output was estimated for each reactor type (in MWh per year).

Name/Manufacturer	Type	Electrical Capacity (MWe)	Approximate Annual Electrical Energy Output[9] (Min-Max MWh)
IRIS SMR	PWR	100-335	9E+05 - 3E+06
NuScale SMR	PWR	45	4E+05
Holos Quad SMR-Micro	HTGR	3-13	3E+04 – 1E+05
eVinci SMR-Micro	HPCR	0.2-5	2E+03 – 4E+04

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[9] Annual electrical output was estimated assuming continuous operation conditions of 24 hours a day, over 365 days per year.

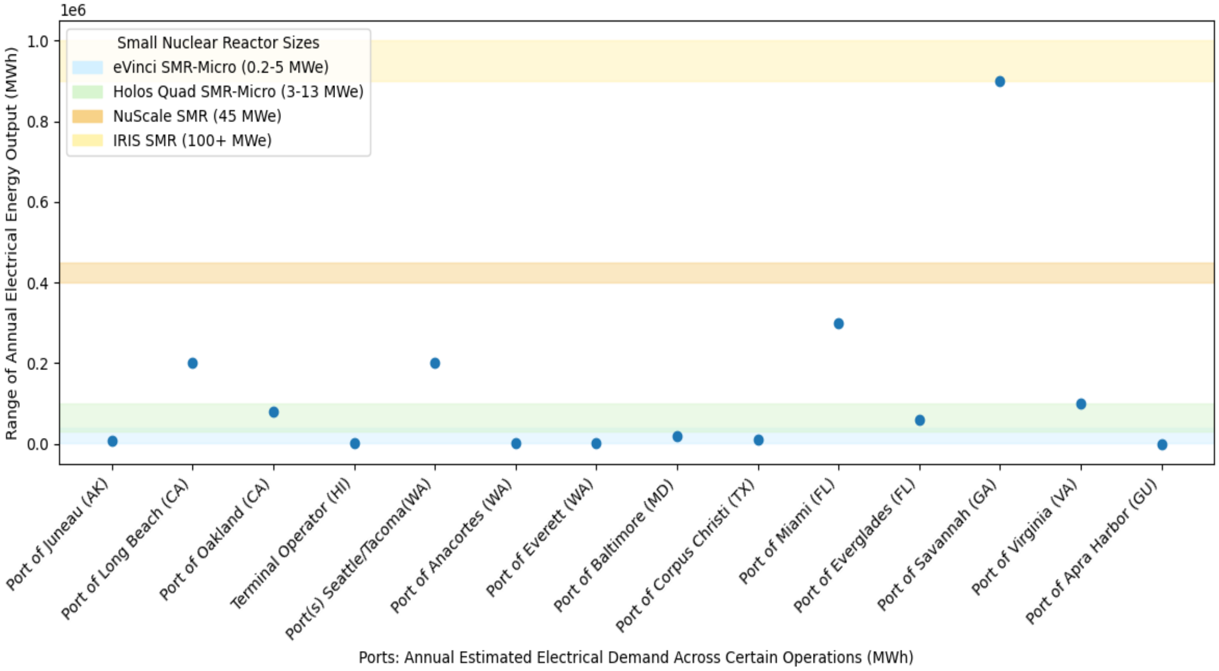

Figure 2. Four representative small reactor designs and their estimated annual energy output ranges (MWh) compared to the total electrical demand (points) for certain operational modes at each port, found from Table 6.

The Port of Juneau (AK), a terminal operator in the Port of Honolulu (HI), the Port of Anacortes (WA), the Port of Everett (WA), the Port of Baltimore (MD), the Port of Corpus Christi (TX), and the Port of Apra Harbor (GU) could meet their estimated annual electricity needs with an eVinci microreactor. Even under projected growth scenarios at Corpus Christi, demand for the modes assessed remains within the eVinci output range.

For the Port of Oakland (CA), Port Everglades (FL), and the Port of Virginia (VA), electricity demand in certain operating modes aligns with the Holos Quad microreactor output range. However, projected demand growth over the next decade may warrant either a larger SMR (e.g., NuScale) or deployment of multiple microreactors.

For the remaining ports—Long Beach (CA), Seattle/Tacoma (WA), Miami (FL), and Savannah (GA)—estimated demand may require a larger SMR such as NuScale, though multiple microreactors could also be a viable alternative. Additional port-specific analysis is needed to determine the most cost-effective configuration for current and future electrical demand at the ports.

This analysis intends to demonstrate the general evaluation process. A final determination of feasible reactor type and size would require further research and a more detailed assessment of operational requirements, siting constraints, regulatory considerations, and cost-benefit performance.

Table 10. Potential technology matches made based on the comparison between annual electrical energy output of representative small nuclear reactor types and their ability to plausibly meet the annual electricity demand associated with current and future port operations.

Maritime Port Name	**State**	**Approximate Annual Electrical Energy Demand (MWh)**	**Estimated Demand by 2030 (MWh)**	**Possible Port-Reactor Match** (*Annual Reactor MWh Output ≥ Port MWh Demand*)
Port of Juneau	AK	7E+03	n.a.	eVinci SMR-Micro
Port of Long Beach	CA	2E+05	4E+05-2E+06	NuScale SMR/multiple micro-SMR
Port of Oakland	CA	8E+04	2E+05	Holos Quad SMR-Micro
Port of Honolulu	HI	2E+03	4E+03	eVinci SMR-Micro
Port(s) of Seattle/Tacoma	WA	2E+05	5E+05-1E+06	NuScale SMR/multiple micro-SMR
Port of Anacortes	WA	1E+03	2E+03	eVinci SMR-Micro
Port of Everett	WA	2E+03	n.a.	eVinci SMR-Micro
Port of Baltimore	MD	2E+04	n.a.	eVinci SMR-Micro
Port of Detroit	MI	Data unavailable	n.a.	n.a.
Port of Corpus Christi	TX	1E+04	2E+04	eVinci SMR-Micro
Port of Beaumont	TX	Data unavailable	n.a.	n.a.
Port of Miami	FL	3E+05	8E+05	NuScale SMR/multiple micro-SMR
Port of Everglades	FL	6E+04	2E+05	Holos Quad SMR-Micro
Port of Savannah	GA	9E+05	1E+06	NuScale SMR/multiple micro-SMR
Port of Virginia	VA	1E+05	2E+05	Holos Quad SMR-Micro
Port of Apra Harbor	GU	2E+01-1E+02	n.a.	eVinci SMR-Micro

4.3 Future Deployment Research Questions

While this report provides a high level of assessment of the feasibility of deployment of small nuclear reactors, additional research is needed to assess additional factors at specific ports.

4.3.1 Site-Suitability

- Port sites that are identified as potentially viable for small nuclear reactor deployment should have detailed, field-oriented assessments to confirm if the site is suitable based on the site selection and evaluation criteria listed in Section 2.2.
- Define the size of the necessary Emergency Planning Zone based on the size and type of small nuclear reactor.

4.3.2 Policy and People

- Determine the necessary policy and regulations that will be relevant for small nuclear reactor deployment.
- Determine necessary governing bodies or groups involved in the construction, transportation, refueling, and monitoring of the small nuclear reactor. This could include port tenants, nearby industries, and nearby city, workforce, and emergency response groups.
- Engagement should separately be done with nearby communities about adopting the particular advanced nuclear technology (e.g., port, community, utility) via surveys or educational seminars.

4.3.3 Size and Fuel

- Determine the capacity (thermal and energy output) that would be applicable to the port site.
  - This requires greater detailed energy estimates for port.
- Determine the reactor type and fuel type.
- Assess fuel supply challenges:
  - Frequency of refueling
  - Fuel storage or regional network supply
  - Handling of fuel
  - Disposal of spent fuel
  - Transportation of fuel

4.3.4 Costs

- Cost of constructing and maintaining small nuclear reactor types requires identifying specific location because of various construction requirements based on the integrity of the soil, hazard mitigation, and supporting infrastructure.
- Fuel costs.

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Appendix A – Port Executive Summaries

A.1 Port of Juneau, Alaska

The Port of Juneau is located in Juneau, Alaska, and is primarily known as a major cruise hub in the United States, serving 1.7 million passengers each year (Unis n.d.). Two of the four cruise docks, four small boat harbors and yards, and a commercial loading facility are operated by the City and Borough of Juneau (n.d.).

Resilience Considerations

- City of Juneau is only accessible by boat or plane (Alaska Air Forwarding n.d.).
- **US Coast Guard Base Juneau:** Located within 10 miles of the port fenceline (USCG – Pacific Area n.d.).

Regional Grid and Utility

- **Grid:** Hydropower supplies most of the electricity consumed at the port. The local grid has ample power supply, and an interview with the port indicated any new grid developments or expansions for new power would encounter challenges because of the regional geography.
- **Electric Utility:** Alaska Electric Light and Power

Context for Small Nuclear Reactors – Pros

- **Port Energy Use: Table 6**
- **Growing Electric Demand:**
  - Future cruise shore power berths
- **Large Energy Neighbors (co-located or within 10 miles):**
  - Juneau-Douglas Waste Water Treatment Plant
  - Juneau International Airport
- In 2022, Senate Bill 177 was enacted, which makes it easier to obtain permits for microreactors in the state of Alaska (FPSC 2025, p. 49).

Context for Small Nuclear Reactors – Cons

- Based on feedback from a port interview, locals may be hesitant to introduce new forms of electrical power, including nuclear, because of the already existing and reliable source of energy via hydropower.
- Restricted transportation access could make nuclear material transport difficult.

A.2 Port of Long Beach, California

The Port of Long Beach (POLB) is located in San Pedro Bay, California, adjacent to the Port of Los Angeles. Together, the two ports form one of the largest port complexes in the United States, handling some of the highest volumes of containerized cargo nationwide and supporting trade with more than 200 seaports worldwide (POLB n.d.[a]). In addition to containers, POLB processes a diverse range of cargo, including dry and liquid bulk, breakbulk, and Ro/Ro shipments. The port is owned by the City of Long Beach and operates as a landlord port, leasing terminal space to tenants who conduct cargo operations. The POLB has been widely known for its efforts to modernize and electrify its operations, including shore power and the adoption of the Clean Trucks initiative (POLB n.d.[b]to motivate hydrogen and electric drayage activity.

Resilience Considerations

- **NPRN Port:** Designated a strategic commercial port supported by a nine-agency federal committee[10] to ensure operational continuity and support national defense during routine and emergency conditions (Maritime Administration 2024).
- **US Coast Guard Base Los Angeles/Long Beach** (USCG n.d.[a]): Located on Terminal Island within the port fenceline (America’s Power 2024).

Regional Grid and Utility

- **Western Electricity Coordinating Council (WECC) CA/MX Grid – Elevated Risk:** WECC analysis (2024) showed that, in the near future (5–10yrs), with the continued rapid transformation of the power grid—forecasted demand growth, substantial resource additions, and the retirement of gas-fired generation—could lead to some periods of supply shortfalls (especially during summer evenings because of the resource portfolio having a substantial amount of solar photovoltaic [PV]).
- **Electric Utility:** Southern California Edison

Context for Small Nuclear Reactors – Pros

- **Port Energy Use: Table 6**
- **Growing Electric Demand:**
    - Increasing fleet of electric and alternatively fueled drayage trucks as part of Clean Trucks Program and Clean Air Action Plan (2020) (POLB n.d.[b]).
    - Increasing electrification of cargo-handling fleet and ship-to-shore cranes.
    - Forecasted increased shore power calls.
- **Large Energy Neighbors (co-located or within 10 miles):**
    - Co-located hydrogen production facility (Tri-Gen) (Toyota Newsroom 2024)
    - Valero Wilmington Refinery
    - Phillips 66 Los Angeles Refinery
    - AK Warren Water Resource Facility
    - Terminal Island Water Reclamation Plant
    - CenterServ: Long Beach Data Center

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[10] The NPRN consists a steering group and working group with committee members from Maritime Administration, U.S. Coast Guard, Military Sealift Command, U.S. Army Forces Command, U.S. Transportation Command, U.S. Army Corps of Engineers, U.S. Northern Command, Transportation Security Administration, and Surface Deployment and Distribution Command.

Context for Small Nuclear Reactors – Cons

- Nuclear Memorandum against the development or construction of new nuclear power facilities in California (NCSL 2025).
- High-tectonic activity area and limited water availability are not ideal for SMR operations and would require additional considerations to mitigate challenges.

A.3 Port of Miami, Florida

The Port of Miami is located in Miami, Florida, and is a major hub for both cruise and commercial operations. In 2024, more than 8 million passengers traveled through its cruise facilities (Port Miami n.d.), and the port supports trade with 149 nations—approximately half of which is with Latin America and the Caribbean (Port Miami 2024). The port features nine cruise terminals, four seaboard berths, and six cargo berths and handles a wide range of cargo, including containers, bulk, and dry-bulk goods, and key commodities such as fruits and vegetables. The port is owned by Miami-Dade County, operated by the County's Seaport Department, and functions as a landlord port, leasing land and terminal facilities to private cruise lines and terminal operators.

Resilience Considerations

- **US Coast Guard Base:** Located beside MacArthur Causeway within 10 miles of the Port of Miami, fenceline (USCG n.d.[a]).

Regional Grid and Utility

- **Southeastern Electric Reliability Council (SERC) Grid Risk – Normal:** SERC analysis (2024) concluded that the area would have sufficient resources across a range of operating conditions to maintain continuity of power supply in the near future (5 to 10 years) (America's Power 2024).
- **Electric Utility:** Florida Power and Light

Context for Small Nuclear Reactors – Pros

- **Port Energy Use: Table 6**
- **Growing Electric Demand:**
  - Increasing electrification of cargo-handling equipment and ship-to-shore cranes.
  - Forecasted increased shore power calls.
  - Construction of new cruise facilities.
- **Large Energy Neighbors (co-located or within 10 miles):**
  - JP Custom Metals
  - CEMEX Downtown Concrete Plant
  - New Fortress Energy LNG Plant
  - Hialeah Reverse Osmosis Desalination Plant
  - Central District Wastewater Treatment Plant
  - Miami International Airport

  - CoreSite MI1 Data Center
  - Recent High-Density Residential Communities
- In 2025, Florida Public Service Commission was required to study and evaluate the technical and economic feasibility of advanced nuclear power (SMR and microreactors) (FPSC 2025, p. 69).
- Florida public utilities have experience regarding the operation and ownership logistics for larger-scale nuclear power plants (FPSC 2025, p. 63).

Context for Small Nuclear Reactors – Cons

- High risk of adverse weather such as hurricanes and flooding.
- Coastal sandy soil and highly permeable and porous limestone bedrock would require additional engineering considerations to mitigate foundation issues.

A.4 Port of Everglades, Florida

The Port of Everglades is located in an area that spans Dania Beach, Fort Lauderdale, and Hollywood in southeastern Florida, owned by Broward County but operated as a landlord port that leases property to its tenants (Port Everglades n.d.[a]). The port carries out global trade with more than 150 ports in 70 different countries, acting as the major import, storage, and distribution center for petroleum products in southern Florida; the port handles containers, perishable goods, breakbulk and other specialized cargo like yachts and automobiles (Port Everglades n.d.[b]). The port also contributes to global travel as another major cruise port in Florida with over 4 million travelers passing through the cruise terminals in 2025 (Port Everglades 2025).

Resilience Considerations

- **US Coast Guard Station Fort Lauderdale:** Located within 10 miles of the port fenceline.

Regional Grid and Utility

- **SERC Grid Risk – Normal:** SERC analysis (2024) concluded that the area would have sufficient resources across a range of operating conditions to maintain continuity of power supply in the near future (5 to 10 years) (America's Power 2024).
- **Electric Utility:** Florida Power and Light

Context for Small Nuclear Reactors – Pros

- **Port Energy Use: Table 6**
- **Growing Electric Demand:**
  - Shore Power
- **Large Energy Neighbors (co-located or within 10 miles):**
  - Port petroleum distribution terminals
  - CEMEX and Lehigh cement storage and distribution
  - George T. Lohmeyer Regional Wastewater Treatment Plant

  - 365 Data Centers-Fort Lauderdale
  - Fort Lauderdale-Hollywood International Airport
- In 2025, Florida Public Service Commission was required to study and evaluate the technical and economic feasibility of advanced nuclear power (SMR and microreactors) (FPSC 2025, p. 69).
- Florida public utilities have experience regarding the operation and ownership logistics for larger-scale nuclear power plants (FPSC 2025, p. 63).

Context for Small Nuclear Reactors – Cons

- High risk of adverse weather such as hurricanes and flooding.
- Coastal sandy soil and highly permeable and porous limestone bedrock would require additional engineering considerations to mitigate foundation issues.

A.5 Port of Honolulu, Hawaii

The Port of Honolulu is located in Honolulu on the island of O‘ahu and serves as one of the main commercial gateways for the Hawaiian Islands. Approximately 90 percent of all goods entering the state pass through the port. Although Hawai‘i’s nine commercial ports operate as a coordinated statewide system, Honolulu is the principal hub for containerized cargo (Find a Port n.d.). The port also handles liquid bulk and breakbulk cargo and accommodates cruise ships and fishing vessels. The Port is owned by the Hawai‘i Department of Transportation, Harbors Division, and operates as a landlord port, leasing facilities to tenants who manage terminal operations. According to an interview with a representative from Hawai‘i Department of Transportation, port electrification has historically been challenging because of limited grid capacity and the state’s heavy reliance on imported fossil fuels for electricity generation.

Resilience Considerations

- **US Coast Guard Base Honolulu:** Located within 10 miles of the port fenceline.
- **Naval Station Pearl Harbor:** Major base for the U.S. Navy and is located within 10 miles of the port fenceline.

Regional Grid and Utility

- **O‘ahu, Hawai‘i Grid – Moderate Risk:** Hawai‘i’s grid is shaped by a high dependence on fossil fuels and aging infrastructure amid accelerating electrification. In 2023, 75 percent of the state’s energy use (93.15 trillion British thermal units [BTU]) came from fossil fuels (Hawai‘i State Energy Office 2025), with other renewables—solar (8 percent), geothermal (6 percent), onshore wind (1 percent), and biodiesel (1 percent)—contributing to the mix. O‘ahu’s five generating stations are meeting current demand but with limited expandable capacity, and the almost 60-year-old infrastructure faces challenges with implementing more modern, renewable assets.
- **Electric Utility:** Hawaiian Electric Co. (HECO)

Context for Small Nuclear Reactors – Pros

- **Port Energy Use: Table 6**
- **Growing Electric Demand and Grid Updates:**
  - Transportation electrification is projected to significantly increase by 2050 (Hawaiian Electric n.d., p. 19).
- Hawaiʻi's 100 percent renewable portfolio standard by 2045 (Hawaiian Electric n.d., p. 31 & 51) has motivated the Public Utilities Commission to build a road map aiming to replace aging fossil plants with modern, resilient, and more integrated renewable resources (Public Utilities Commission of the State of Hawaii 2024).
- Policy Act 15 (2018), which sets emission targets by 2030 to motivate alternative energy resources (Hawaiʻi State Legislature §225P-5).
- Policy Act 238 SLH (2022) encourages the adoption of clean energy, electrification, and reducing emissions associated with air travel and shipping (Hawaiʻi State Energy Office 2023).
- **Large Energy Neighbors (co-located or within 10 miles):**
  - Hawaiian Cement
  - HC&D Cement
  - Endeavor Data Center
  - Sand Island Wastewater Treatment Plant

Context for Small Nuclear Reactors – Cons

- Nuclear Memorandum against the development or construction of new nuclear power facilities in Hawaiʻi (NCSL 2025).
- High risk of adverse weather such as hurricanes, flooding, or tsunamis.
- Coastal silt and clay make the produce conditions and would require additional engineering considerations to mitigate foundation issues (NRCS 2020).

A.6 Port(s) of Seattle/Tacoma, Washington

The Northwest Seaport Alliance (NWSA) is a large West Coast trade hub, which was formed through a strategic partnership between two of the neighboring largest ports in Washington State, the Port of Seattle, and the Port of Tacoma. The NWSA has a governance that is shared between the two ports (Fawcett 2006), and cargo operations are coordinated by five commissioners from each port, which make up the governing body. The NWSA is a landlord port with terminal operators that handle container, breakbulk, Ro/Ro, and some bulk terminal cargo types. The Port of Seattle also operates a cruise terminal that connects to other ports on the West Coast. In 2024, it managed a combined throughput of 3 million twenty-foot equivalent units (TEUs) across its facilities (Northwest Seaport Alliance n.d.[a]). The three port entities—Port of Seattle, Port of Tacoma, and the NWSA—have demonstrated coordinated and driven efforts related to port electrification and the adoption of alternative marine fuels (Port of Seattle n.d.).

Resilience Considerations

- **NPRN Port:** Port of Tacoma is a designated strategic commercial port supported by a nine-agency federal committee[11] to ensure operational continuity and support national defense during routine and emergency conditions (Maritime Administration 2024).
- **US Coast Guard Base, Sector Puget Sound:** Located within 10 miles of the port of Seattle fenceline.

Regional Grid and Utility

- **WECC NW Grid Risk – Normal:** WECC analysis (2024) concluded that the area would have sufficient resources across a range of operating conditions to maintain continuity of power supply in the near future (5 to 10 years) (America's Power 2024).
- **Electric Utility:** Seattle City Light (Seattle) and Tacoma Public Utilities (Tacoma)

Context for Small Nuclear Reactors – Pros

- **Port Energy Use: Table 6**
- **Growing Electric Demand and Grid Updates:**
    - Electrification of port operations for both CHE and drayage trucking (Port of Seattle 2025).
    - Forecasted growth in shore power demand.
- The 2020 Northwest Ports Clean Air Strategy (Northwest Seaports Alliance n.d.[b]), which aims to have net-zero emissions by 2050, motivates the adoption of low emission forms of alternative energy.
- **Large Energy Neighbors (co-located or within 10 miles):**
    - Seaport Steel Manufacturing (Seattle)
    - McKinstry Manufacturing (Seattle)
    - Jesse Engineering Co, Steel fabrication (Tacoma)
    - Streich Bros Inc, Steel fabrication (Tacoma)
    - US Oil and Refining Co (Tacoma)
    - Pacific Functional Fluids LLC, petrochemical/chemical facility (Tacoma)
    - Concrete Technology Corporation (Tacoma)
    - Ash Grove Cement Manufacturing (Seattle)
    - Heidelberg Materials and Cement (Seattle)
    - Puget LNG Plant (Tacoma)
    - Arcosa Specialty Materials (Seattle)
    - Strategic Materials Glass Recycling (Seattle)

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[11] The NPRN consists of a steering group and working group, with committee members from Maritime Administration, U.S. Coast Guard, Military Sealift Command, U.S. Army Forces Command, U.S. Transportation Command, U.S. Army Corps of Engineers, U.S. Northern Command, Transportation Security Administration, and Surface Deployment and Distribution Command.

  - Metro Metals Recycling (Tacoma)
  - West Point Treatment Plant (Seattle)
  - Central Wastewater Treatment Plant (Tacoma)
  - IBM, Sabey, Digital Fortress, Cyxtera/Csquare Data Centers (Seattle)
  - Cogent Communications Data Center (Tacoma)

Context for Small Nuclear Reactors – Cons

- High-tectonic activity area and proximity to an active stratovolcano (Mount Rainier).
- Mixed community support regarding nuclear technology.

A.7 Port of Corpus Christi, Texas

The Port of Corpus Christi is the largest energy export gateway in the United States and the third-largest crude oil export port in the world (Port of Corpus Christi n.d.[a]). The port is co-located across two counties, Nueces and San Patricio County, which accommodates many industrial neighbors, such as oil refineries and chemical and metal manufacturers, as well as a major LNG production facility. Additionally, future projects include an expansion in capacity of the LNG facility (Cocklin 2025), as well as a brackish water desalination plant (City of Corpus Christi 2026). Given the geographical location and concentration of surrounding industrial facilities, energy commodities dominate cargo throughput at the port. Crude oil accounts for 62 percent of annual volume, followed by other refined products (16 percent), LNG (8 percent), and liquefied petroleum gas (1 percent). The remaining cargo mix includes bulk liquids (7 percent), agricultural goods (1 percent), breakbulk (1 percent), dry bulk (3 percent), and Ro/Ro cargo. The port operates as a landlord port (Port of Corpus Christi n.d.[b]), leasing terminal space to terminal operators. Governance is overseen by a seven-member commission, with three representatives each from Nueces County and San Patricio County and one from the City of Corpus Christi. The port is also a recognized environmental leader, implementing an Environmental Management System to monitor and improve environmental performance, and became the first Texas port to earn the Green Marine certification (Port of Corpus Christi n.d.[c]).

Resilience Considerations

- **NPRN Port:** Designated a strategic commercial port supported by a nine-agency federal committee[12] to ensure operational continuity and support national defense during routine and emergency conditions (Maritime Administration 2024).
- **U.S. Coast Guard Air Station Corpus Christi:** Located within 10 miles of the port fenceline.

Regional Grid and Utility

- **Texas Reliability Entity Energy Reliability Council of Texas (ERCOT) Grid Risk – Elevated:** ERCOT's analysis (2024) projects rapid demand growth in the near future (5 to 10 years), driven by data centers, Bitcoin mining, oil and gas development, and industrial

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expansion. The increasing share of variable, less-dispatchable resources (e.g., solar PV) heightens the risk of future supply shortfalls and creates significant challenges for transmission system planning (America's Power 2024).

- **Electric Utility:** American Electric Power (AEP) Texas Central (transmission and distribution) and TXU Energy (provider)

Context for Small Nuclear Reactors – Pros

- **Port Energy Use: Table 6**
  - The port plans to electrify some of their operations; however, the energy for these upgrades was not included in the projected energy use because sufficient data was unavailable.
- **Growing Electric Demand and Grid Updates:**
  - Electrification of port operations for CHE, tugboats, and locomotives (EPA 2024).
- In 2023 the Texas Governor gave a directive to the public utility commission to sponsor the advanced nuclear task force for Texas (FPSC 2025).
- **Large Energy Neighbors (co-located or within 10 miles):**
  - SSP Metal Works
  - Federal Iron and Metal Inc.
  - Bill Greehey Refinery East and West (Valero)
  - Citgo Corpus Christi Refinery (Citgo)
  - Buckeye Corpus Christi Refinery (Magellan Midstream)
  - Corpus Christi East and West Refineries (Flint Hills Resources)
  - Eagle Ford Chemical Plant
  - LyondellBasell Ethylene and Propylene Plant
  - Corpus Christi Polymers LLC
  - VIP Chemical Plant
  - OxyChem
  - Elementis Chromium
  - Excalibar Minerals
  - Port of Corpus Christi Bulk Materials
  - Vulcan Materials Company
  - Air Liquide America Corporation
  - South Texas Cement
  - Texas Lehigh Cement Company
  - Alamo Concrete Plant 11 and 44
  - Cheniere LNG Production
  - Broadway Wastewater Treatment plant

  - Corpus Christi Inner Harbor Desalination Project (in process)
  - Base Line Data Inc.
  - Duos Edge AI (in process)

Context for Small Nuclear Reactors – Cons

- High risk of adverse weather such as hurricanes and flooding.
- Limited availability on port land for non-commercial or port-related operations.

A.8 Port of Anacortes, Washington

The Port of Anacortes (n.d.[a]) is a municipal corporation that generates regional economic activity and tourism while serving as a gateway to the Pacific Rim, Canada, and Alaskan shipping routes (Washington State Transportation Commission 2022). Located along the Guemes Channel within the Puget Sound, the Port of Anacortes encompasses approximately 80 acres of commercial property, a Category I airport (Port of Anacortes n.d.[a]), a marine terminal, and a marina (Washington State Transportation Commission 2022). The marine terminal supports diverse operations (EDASC n.d.), including seafood processing and the handling of high-and-heavy lift and dry-bulk cargo. Key exports—such as petroleum coke and prilled sulfur (Port of Anacortes n.d.[b])—are shipped to markets in China, Japan, India, Brazil, and Mexico. The terminal also accommodates commercial and short-term vessel moorage, including barges, tugboats, and vessels up to 1,200 feet in length (EDASC n.d.). The marina provides smaller leased buildings that support cargo operations and offers approximately 1,000 boat slips for local commercial fishing vessels and other recreational vessels. While the port operates as a landlord to its tenants, the commissioning body is active in advancing sustainability initiatives. It recently completed a Marine Terminal Modernization Feasibility Study that evaluates infrastructure upgrades and shore power adoption. As a certified member of Green Marine, the port is committed to reducing and preventing adverse impacts on the local and regional environment (Port of Anacortes n.d.[b]).

Resilience Considerations

- **Critical Response Site:** The port is strategically located as a gateway to the remote communities within the San Juan Islands and is also deemed an emergency response site for Skagit County and the San Juan communities (Idso et al. 2024).

Regional Grid and Utility

- **WECC NW Grid Risk – Normal:** WECC analysis (2024) concluded that the area would have sufficient resources across a range of operating conditions to maintain continuity of power supply in the near future (5 to 10 years) (America’s Power 2024).
- **Electric Utility:** Puget Sound Energy

Context for Small Nuclear Reactors – Pros

- **Port Energy Use: Table 6**
  - The port plans to electrify some of their operations; however, the energy for these upgrades was not included in the projected energy use because sufficient data was unavailable.

- **Growing Electric Demand and Grid Updates:**
  - Electrification of port operations.
  - Shore power development.
  - Washington State Ferry Electrification.
- **Large Energy Neighbors (co-located or within 10 miles):**
  - T Bailey LLC Steel Fabrication
  - North Coast Iron Corporation
  - Marathon Refinery
  - HF Sinclair Puget Sound Refining
  - Anacortes Waste Water Treatment

Context for Small Nuclear Reactors – Cons

- High-tectonic activity area and proximity to an active stratovolcano (Mount Baker).

A.9 Port of Oakland, California

The Port of Oakland is located in Northern California, adjacent to San Francisco, and ranks as the fourth-largest container port on the U.S. Pacific coast—behind the ports of Los Angeles, Long Beach, and the Northwest Seaport Alliance—and was the ninth busiest container port in the U.S. in 2023. The port's trade is predominantly with Asia (74 percent), followed by Europe (17 percent), with additional connections to Australia, the Pacific Islands, and Hawaiʻi (Port of Oakland n.d.[a]). Cargo throughput is dominated by imported and exported containers, with agricultural products and perishable foods from California and Nevada, breakbulk, bulk, heavy machinery, and Ro/Ro cargo included in the overall throughput (Hongocean n.d.). Governed by a seven-member board of port commissioners, the port leases land to tenants under a landlord model while also operating as a publicly owned utility (Port of Oakland n.d.[b]). It is a member of the Northern California Power Agency (Port of Oakland 2025). The port has committed to advancing alternative energy and zero-emission strategies, including participation in a 400 MW battery energy storage project located in San Bernardino County (Port of Oakland 2025).

Resilience Considerations

- **NPRN Port:** Designated a strategic commercial port supported by a nine-agency federal committee[13] to ensure operational continuity and support national defense during routine and emergency conditions (Maritime Administration 2024).
- **U.S. Army Base, Oakland:** Located within 10 miles of the port fenceline.
- **Naval Air Station Alameda:** Located within 10 miles of the port fenceline.
- **U.S. Coast Guard Base Alameda:** Located within 10 miles of the port fenceline.
- **U.S. Coast Guard, Sector San Fransico:** Located within 10 miles of the port fenceline.

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[13] The NPRN consists of a steering group and working group, with committee members from Maritime Administration, U.S. Coast Guard, Military Sealift Command, U.S. Army Forces Command, U.S. Transportation Command, U.S. Army Corps of Engineers, U.S. Northern Command, Transportation Security Administration, and Surface Deployment and Distribution Command.

Regional Grid and Utility

- **WECC CA/MX Grid Risk – Elevated:** WECC analysis (2024) showed that, in the near future (5 to 10 years), with the continued rapid transformation of the power grid—forecasted demand growth, substantial resource additions, and the retirement of gas-fired generation—could lead to some periods of supply shortfalls (especially during summer evenings because of the resource portfolio having a substantial amount of solar PV) (America's Power 2024).
- **Electric Utility:** Port of Oakland (transmission and distribution) and Pacific Gas and Electric Company (provider)

Context for Small Nuclear Reactors – Pros

- **Port Energy Use: Table 6**
- **Growing Electric Demand:**
  - Growing electrification of CHE and drayage trucks (Simpson 2021, p. 33).
  - Adding reefer power and growing shore power utilization (Simpson 2021, p. 33).
  - Adding approximately 300 more heavy-duty electric chargers.
  - Electrification of ship-to-shore Cranes (Magli 2026).
- **Large Energy Neighbors (co-located or within 10 miles):**
  - CASS Inc. Aluminum Manufacturing and Recycling
  - Emerald Steel
  - Alameda Chemical
  - Chemical Compounding Co.
  - Alco Iron & Metal Co.
  - Radius Metals Recycling
  - Aaron Metals Co. Recycling
  - CEMEX Oakland Concrete Plant
  - East Bay Municipal Utility District Wastewater Treatment Plant
  - Upper San Leandro Water Treatment Plant
  - 365 Main Inc Data Center
  - Cogent Communications
  - Digital Realty Data Center-SF
  - Lumen Data Center

Context for Small Nuclear Reactors – Cons

- Nuclear Memorandum against the development or construction of new nuclear power facilities in California (NCSL 2025).
- High-tectonic activity area.

A.10 Port of Baltimore, Maryland

The Port of Baltimore supports both regional and international trade and is consistently ranked among the top 20 U.S. ports by total tonnage (Bureau of Transportation Statistics 2024). In 2024, it led all U.S. ports in throughput of Ro/Ro cargo, as well as imported forest products and gypsum (Maryland Manual On-Line n.d.). The port is capable of handling tens of millions of tons of coal and general cargo annually, in addition to moving hundreds of thousands of containers each year (Maryland Manual On-Line n.d.). It is also a major cruise hub, with more than 400,000 passengers passing through in 2023.

Governance is provided by the six-member Maryland Port Commission, which establishes policies and strategic direction to enhance the economic performance of the port's public and private marine terminals, shipping channels, and commercial activities (State of Maryland n.d.[a]). The Maryland Port Administration, a state agency operating in coordination with the Maryland Department of Transportation, manages the public terminals. In 2024, the Maryland Port Administration released its first sustainability report (MPA 2024) under its EcoPort initiative (State of Maryland n.d.[b]), reinforcing its commitment to reducing environmental impacts and supporting surrounding communities.

Resilience Considerations

- U.S. Coast Guard Yard (Hawkins Point Road) located within 10-mile radius from the port.

Regional Grid and Utility

- **Pennsylvania-New Jersey-Maryland Interconnection (PJM) Grid Risk – Elevated:** PJM's analysis (2024) shows that, in the near future (5 to 10 years), the rising demand and ongoing retirements of aging fossil and nuclear units will create challenges for planning and resource coverage for the system (America's Power 2024). Supply shortage risks are greatest during extreme cold events, when high loads coincide with reduced thermal performance, fuel constraints, and limited solar output.
- **Electric Utility:** Baltimore Gas and Electric Company

Context for Small Nuclear Reactors – Pros

- **Port Energy Use: Table 6**
- **Growing Electric Demand and Grid Updates** (EPA n.d.):
  - Future electrification of CHE.
  - Future installation of direct current fast chargers.
  - Microgrid development.
  - Planning for future shore power.
- **Pro-Nuclear Sentiment in Maryland Leadership and Industry:**
  - X-energy and Amazon co-leading the largest commercial deployment of small nuclear reactors to date (2025) (Office of Governor Wes Moore 2025).
  - Constellation has invested $1 billion in wind, hydro, and nuclear energy resources for Maryland residential power consumption (Constellation 2025).

- **Large Energy Neighbors (co-located or within 10 miles):**
  - Marlin Steel
  - Hydro Aluminum Metals USA LLC
  - PMC Manufacturing
  - Elemental Metalworks
  - BA Steel LLC
  - WR Grace & Co – Curtis Bay
  - Vibrantz Technologies Inc.
  - USALCO Chemical Manufacturer
  - Yara US
  - Maryland Chemical Co. Inc.
  - Praxair
  - Sunoco LP
  - Motiva Enterprises LLC (Petroleum Co.)
  - Apex Oil
  - Kinder Morgan-Baltimore
  - Buckeye Terminals LLC
  - Argos Cement
  - US Concrete Products
  - Patapsco Waste Water Treatment
  - AiNET data center
  - Baltimore/Washington International Thurgood Marshall Airport

Context for Small Nuclear Reactors – Cons

- N/A

A.11 Port of Everett, Washington

The Port of Everett is home to international shipping terminals and ranks as the third-largest container port in Washington State (Port of Everett n.d.[a]). It handles a diverse mix of breakbulk cargo and specializes in over-dimensional, high-and-heavy cargoes serving the construction, manufacturing, agriculture, and forest products sectors (Port of Everett n.d.[b]). The port also supports the regional aerospace supply chain, transporting materials and parts used for constructing both military and commercial aircrafts. In addition to its cargo operations, the port supports U.S. Coast Guard and U.S. Navy vessels through its industrial shipyard and proximity to Naval Station Everett. Beyond maritime commerce, it manages a public marina with approximately 2,300 slips (Martin Associates 2020), along with significant real estate holdings that contribute to regional economic development. The port is governed by three locally elected commissioners (Port of Everett n.d.[c]) and is a certified Green Marine participant (Port of

Everett n.d.[b]), demonstrating its commitment to environmental stewardship and sustainable port operations.

Resilience Considerations

- **NPRN Port:** Designated a strategic commercial port supported by a nine-agency federal committee[14] to ensure operational continuity and support national defense during routine and emergency conditions (Maritime Administration 2024).
- **Puget Sound Naval Complex:**
  - Naval Station Everett
  - Port Security Unit: A specialized unit based in Everett that provides security for strategic port locations and deployable maritime force protection.

Regional Grid and Utility

- **WECC NW Grid Risk – Normal:** WECC analysis (2024) concluded that the area would have sufficient resources across a range of operating conditions to maintain continuity of power supply in the near future (5 to 10 years) (America's Power 2024).
- **Electric Utility:** Snohomish County Public Utility District (PUD)

Context for Small Nuclear Reactors – Pros

- **Port Energy Use: Table 6**
- **Growing Electric Demand and Grid Updates:**
  - Future CHE electrification and charging stations.
- **Large Energy Neighbors (co-located or within 10 miles):**
  - Everett Steel
  - Pathfinder Manufacturing
  - Onamac Industries
  - Heidelberg, Materials, and Asphalt
  - Everett Wastewater Treatment Plant
  - Paine Field Airport

Context for Small Nuclear Reactors – Cons

- High-tectonic activity area.
- Possible higher safeguard complexities due to the naval station co-located with the port.

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A.12 Port of Apra Harbor, Guam

The Port of Apra Harbor is located on Guam, the largest and southernmost island of the Mariana Islands in the western Pacific Ocean (EIA 2025). Since Guam sits atop an undersea mountain, surrounding waters deepen rapidly, making offshore anchorage impractical and concentrating maritime activity within the harbor (GDO 2024). The port consists of two primary areas: the Inner Harbor (South Apra), home to a major U.S. Naval facility, and the Outer Harbor (North Apra), which supports commercial operations (GDO 2024). More than a quarter of the island is dedicated to U.S. military use, reflecting Guam's strategic importance (NREL 2024, p. 1). Commercial activities are managed by the Port Authority of Guam (GDO 2024), an autonomous entity of the Government of Guam. The port operations include containerized cargo, breakbulk, fishing vessels, and cruise vessels, which support the island's tourism economy. The port also serves as the sole entry point for imported petroleum products (EIA 2025), which supply the majority of Guam's energy needs.

Resilience Considerations

- **NPRN Port:** Designated a strategic commercial port supported by a nine-agency federal committee[15] to ensure operational continuity and support national defense during routine and emergency conditions (Maritime Administration 2024).
- **USO Naval Base Guam:** Located within 10 miles of the port fenceline.
- **U.S. Marine Corps Base Camp:** Located within 10 miles of the port fenceline.
- **U.S. Coast Guard Station, Apra Harbor:** Located within 10 miles of the port fenceline.
- **Naval Computer and Telecommunications Station:** Located within 10 miles of the port fenceline.

Regional Grid and Utility

- **Grid Risk – High:** Guam's electric grid faces elevated risk (GDO 2024) because of its near-total reliance on imported petroleum for power generation (EIA 2025), leaving it exposed to supply chain disruptions and volatile fuel markets. Infrastructure shocks—including the 2015 fire at the Cabras Power Authority and typhoon damage to replacement generation in 2024—have further highlighted the systems' vulnerability to extreme events. In response, Guam is accelerating renewable energy development (Guam Power Authority 2021, pp. 70–72.to improve resilience, stabilize costs, and meet clean energy goals (Guam Power Authority n.d., p. 17), particularly given that the U.S. military installations account for roughly one-fifth of the island's total electricity demand (NREL 2024, p. 1).
- **Electric Utility:** Guam Power Authority

Context for Small Nuclear Reactors – Pros

- **Port Energy Use: Table 6**
  - No energy values were provided via port directly. Range of annual energy consumption (NREL 2024, Tables A-2.1 and A-2.2, p. 13) was estimated from the reported values for

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  Guam's airport energy consumption in 2021 (21.3 MWh) and from the 2021 annual commercial energy use divided by the total commercial energy users for that year (129.1 MWh).

- **Growing Electric Demand and Grid Updates** (NREL 2024):
  - Military and Navy expansions.
  - Aging infrastructure requiring modernized upgrades.
- **Large Energy Neighbors (co-located or within 10 miles):**
  - Guam CDC pharmaceutical cold storage
  - Apra Harbor Wastewater Treatment Plant
  - Guam Exchange Data Center
  - Antonio B. Won Pat International Airport

Context for Small Nuclear Reactors – Cons

- High risk of earthquakes and adverse weather such as hurricanes, typhoons, flooding, or tsunamis (GDO 2024).
- Varied geology (U.S. Department of the Navy 2009) would require strategic siting of SMRs—northern areas of Guam have limestone plateaus that could provide greater foundations, but southern regions with volcanic rock create less permeable soils and erosion-prone terrain, which would require additional engineering considerations to mitigate foundation issues.
- Possible higher safeguard complexities because of the military base co-located with the port.

A.13 Port of Detroit, Michigan

As a major industrial hub, the Port of Detroit processes millions of tons of cargo annually (Neussendorfer 2015) and is a key node within the Great Lakes–St. Lawrence Seaway—a deep-draft waterway that runs through the Great Lakes, along the U.S.–Canada border, and links the Great Lakes region to the Atlantic Ocean (Great Lakes St. Lawrence Seaway 2025). The port's location also connects the upper and lower Great Lakes, making it a critical gateway for regional and international trade.

Port leadership, also known as the Detroit Wayne County Port Authority (DWCPA), operates as a landlord authority, overseeing a marine terminal tenant. While DWCPA maintains a small public cargo dock, most terminals are privately owned and operated. The port handles general cargo, liquid bulk, and dry-bulk commodities such as steel, stone, coal, and cement (Port Detroit n.d.[a]). It is one of the top steel-handling ports in the United States and plays a vital role in supporting the automotive industry (Evans Distribution Systems 2024). In addition, the port accommodates moderate cruise traffic and other excursion vessels (Cruise the Great Lakes n.d.).

Despite its heavy industrial footprint, the Port of Detroit is Green Marine Certified (Port Detroit n.d.[a]), reflecting its commitment to reducing environmental impacts in surrounding communities, with a goal of achieving net-zero emissions by 2040 (Port Detroit n.d.[b]).

Resilience Considerations

- **U.S. Coast Guard, Sector Detroit:** Located within 10 miles of the port fenceline.

Regional Grid and Utility

- **Midcontinent Independent System Operator (MISO) Grid Risk – Elevated** (America's Power 2024): MISO analysis (2024) ran probabilistic assessments to determine the grid's response and adaptability to extreme weather events or above-normal generator outages. The results showed that the grid is at a higher risk of load loss in these scenarios. Additionally, overall resource adequacy was at greater risk because of the slower resource additions recently (because of market pressures and constraints from the complexities of interconnection agreements), various generators nearing retirement, and the growth of future loads coming on-line.
- **Electric Utility:** DTE Energy (n.d.)

Context for Small Nuclear Reactors – Pros

- **Port Energy Use:** No data provided.
- **Growing Electric Demand and Grid Updates:**
  - No near-term planning of electrified equipment nor shore power installments.
- **Large Energy Neighbors (co-located or within 10 miles):**
  - US Steel 80" Hot Strip Mill
  - Marathon Refinery
  - EES Coke Battery
  - Petro-Chem Processing
  - Diversified Chemical Technologies Inc.
  - PVS Chemicals Inc
  - Air Products & Chemicals Inc.
  - Abbvie Inc Pharmaceutical plant
  - SRM Concrete
  - Green Circle Cement
  - Cleveland Cliffs Steel Plant
  - St. Marys Cement
  - Amrize (cement)
  - Detroit Salt (salt mine)
  - Kronos Concrete
  - ADM Agri-Industries
  - GLWA Wastewater treatment plant
  - Van Buren TWP Data Center (In-Progress)

Context for Small Nuclear Reactors – Cons

- Mixed community support regarding nuclear technology (DeLacey 2024) and nuclear waste (Carmody 2025).

A.14 Port of Savannah, Georgia

The Port of Savannah is located on the Savannah River in Georgia and is a deepwater seaport that provides a key gateway for national and international trade. The U.S. Georgia Ports Authority is a state-level entity that owns and operates Georgia's two deep-water ports- Port of Savannah and Port of Brunswick. In 2025 the Georgia Ports Authority (GPA) handled around 5.7 million TEUs (Georgia Ports Authority 2026). Various cargo types are processed across the two major Georgia ports including containers, Ro/Ro, breakbulk, oversized/specialized project cargo and refrigerated cargo (Georgia Ports Authority n.d.(a).).

The Port of Savannah primarily runs operations moving containerized supporting entities that handle "retail, manufacturing, agriculture, refrigerated, and construction materials" (Georgia Ports Authority n.d.(b).). The large-scale container cargo handling operation has led the Port of Savannah to be considered among the top busiest container ports in the entire U.S. (Georgia Ports Authority n.d.(a).). Across its major facilities it also has access to two, Class 1 on-terminal rail facilities (Georgia Ports Authority n.d.(b).). South of the Port of Savannah, one of the seven major LNG export terminals in the U.S. operates on Elba Island and is run by Southern LNG Co. LLC. For this report, this facility was not included among the list of the port's major industries since it's located more than about 15 miles from the main port complex and was outside the set scope for the analysis. However, it remains an important consideration for the Port of Savannah's operations.

Resilience Considerations

- **NPRN Port:** Designated a strategic commercial port supported by a nine-agency federal committee[16] to ensure operational continuity and support national defense during routine and emergency conditions (Maritime Administration 2024).
- **U.S. Hunter Army Airfield:** Located within 10 miles of the port fenceline.

Regional Grid and Utility

- **SERC Grid Risk – Normal:** SERC analysis (2024) concluded that the area would have sufficient resources across a range of operating conditions to maintain continuity of power supply in the near future (5 to 10 years) (America's Power 2024).
- **Electric Utility:** Georgia Power

Context for Small Nuclear Reactors – Pros

- **Port Energy Use: Table 6**
- **Growing Electric Demand and Grid Updates:**
  - Growth in electrical power consumption once Ocean Terminal Project is completed- including increased electrified equipment and more fast-charging systems.
  - Future shore power installation.
- **Large Energy Neighbors (co-located or within 10 miles):**

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[16] The NPRN consists of a steering group and working group, with committee members from Maritime Administration, U.S. Coast Guard, Military Sealift Command, U.S. Army Forces Command, U.S. Transportation Command, U.S. Army Corps of Engineers, U.S. Northern Command, Transportation Security Administration, and Surface Deployment and Distribution Command.

  - Steel Fabrication, MacAljon Inc.
  - Chatham Steel
  - Delta Metals
  - Kraton Corporation Chemical Manufacturing
  - Southern States Chemical
  - General Chemical
  - Solenis Savannah Manufacturing Facility
  - Arboris LLC
  - Axeon Specialty Products LLC
  - Thomas Concrete Riverside Plant
  - Giant Cement Co.
  - SRM concrete
  - City of Pooler Wastewater Treatment Plant
  - City of Port Wentworth Wastewater Treatment Plant (WWTF)
  - Savannah/Hilton Head International Airport
  - U.S. Sugar Savannah Refinery, LLC

Context for Small Nuclear Reactors – Cons

- High risk of adverse weather such as tropical storms, hurricanes and flooding.

A.15 Port of Beaumont, Texas

Port of Beaumont is located in the southeastern part of Texas which is accessible from the Gulf and the Gulf Intracoastal Waterway via the Sabine-Neches waterway (Wooster, R. 1995). The Port of Beaumont is an important node of trade for both the Texas economy and international trade as it connects inland sections of Texas to deep-water access in the Gulf. The port is governed by a board of commissioners and is both an operational and lease port.

The port has nine terminal facilities and access to three Class I railroads, all of which support the processing of a variety of cargo including liquid bulk, dry bulk, breakbulk, food goods, metals, woods, Ro/Ro, and miscellaneous cargo. Additionally, the Port of Beaumont processes specialized types of cargo including military and heavy lift items (Port of Beaumont n.d.).

The Port of Beaumont is considered “the number 1 strategic military port in the nation” (McFaddin-Ward House Museum n.d.; Port of Beaumont n.d.) hosting the 842nd Transportation Battalion for the U.S. Army and managing the various types of military related cargo (Texas Comptroller of Public Accounts 2016). There is development of a major AI datacenter on Pleasure Island near Port Arthur (National Today 2026). For this report, the datacenter is located outside the defined geographical scope to be included in port’s industrial or large-energy using neighbors. However, the future data center remains an important consideration, as both it and the port could benefit from and utilize nuclear-generated electricity.

Resilience Considerations

- **NPRN Port:** Designated a strategic commercial port supported by a nine-agency federal committee[17] to ensure operational continuity and support national defense during routine and emergency conditions (Maritime Administration 2024).
- **842nd Transportation Battalion, U.S Army:** Located within 10 miles of the port fenceline.

Regional Grid and Utility

- **Midcontinent Independent Transmission System Operator (MISO) Grid Risk –** n.a.
- **Electric Utility:** Entergy Power

Context for Small Nuclear Reactors – Pros

- **Port Energy Use:** No data provided.
- **Growing Electric Demand and Grid Updates:** No data provided.
- **Large Energy Neighbors (co-located or within 10 miles):**
  - Optimus Steel
  - Sabel Steel
  - Colgan Industries
  - Beaumont Iron & Metal Corp
  - ExxonMobil Lube Plant
  - Beaumont Lube Plant
  - ExxonMobil Blade Chemical Plant
  - Arkema Beaumont Plant
  - ExxonMobil Refinery
  - Ash Grove Cement
  - Modern Concrete and Materials
  - Beaumont Waste-Water Treatment Plant
  - Jack Brooks Regional Airport

Context for Small Nuclear Reactors – Cons

- Limited availability on port land for non-commercial or port-related operations.

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[17] The NPRN consists of a steering group and working group, with committee members from Maritime Administration, U.S. Coast Guard, Military Sealift Command, U.S. Army Forces Command, U.S. Transportation Command, U.S. Army Corps of Engineers, U.S. Northern Command, Transportation Security Administration, and Surface Deployment and Distribution Command.

A.16 Port of Virginia, Virginia

The Port of Virginia is a major international trade hub, with approximately 30 shipping lanes connecting to more than 200 countries. It ranks among the top ten U.S. ports for containerized cargo and also handles breakbulk, bulk, tanker, roll-on/roll-off (Ro/Ro), and export coal shipments. The port supports significant rail-based freight movement and includes both public and private terminals. The Port of Virginia has six major facilities including Norfolk International Terminals (NIT), Virginia International Gateway, Portsmouth Marine Terminal, Newport News Marine Terminal, Richmond Marine Terminal (RMT), and the Virginia Inland Port. The Virginia Port Authority operates four of these major facilities. NIT is the largest container terminal at the Port of Virginia, and RMT is the inland barge facility. The port also has a large U.S. Naval base nearby which emphasizes the region's strategic importance (Hampton Roads Alliance 2026).

The port has also prioritized sustainability and modernization in recent years, setting a goal in its 2023 sustainability report to achieve net-zero Scope 1 and 2 emissions by 2040 (The Port of Virginia 2024(a)). Since 2024, the port and its major tenants have deployed a range of electric and hybrid equipment, including electric forklifts, utility trucks, cantilever rail-mounted gantry cranes, terminal tractors ("grunts"), and hybrid-electric shuttle trucks (The Port of Virginia 2024 (a)). According to the port, almost all stacking cranes have been replaced with electric semi-automated units, and over fifty percent of equipment now operates on either electricity, hybrid systems, or alternative, non-fossil based fuels. Additionally, all ship-to-shore and rubber-tired gantry cranes are fully electric.

Resilience Considerations

- **U.S Naval Station, Norfolk:** Located within 10 miles of the port fenceline.
- **U.S. Coast Guard Base, Portsmouth:** Located within 10 miles of the port fenceline.
- **Craney Island U.S. Naval Supply Center:** Located within 10 miles of the port fenceline.

Regional Grid and Utility

- **PJM Grid Risk – Elevated:** PJM's analysis (2024) shows that, in the near future (5 to 10 years), the rising demand and ongoing retirements of aging fossil and nuclear units will create challenges for planning and resource coverage for the system (America's Power 2024). Supply shortage risks are greatest during extreme cold events, when high loads coincide with reduced thermal performance, fuel constraints, and limited solar output.
- **Electric Utility:** Dominion Energy
  - Port of Virginia has been noticed as a leader in modern power on the East Coast for establishing a power purchase agreement with Dominion energy and Rappahannock Electric Cooperative. This agreement aims to ensure that, over the next decade, 100% of electricity supporting both current and future operations is from renewable energy sources (The Port of Virginia 2024(b)).

Context for Small Nuclear Reactors – Pros

- **Port Energy Use: Table 6**
- **Growing Electric Demand and Grid Updates:**
  - Growth in electrical power consumption from electrified equipment.
  - On-going construction for additional charging for battery powered equipment.

  - Large and growing number of intensive energy users, including AI data centers.

- **Support for Nuclear Technology Advancement**: In 2023, $10 million was provided to the Virginia Power Innovation fund to support the advancement of nuclear technology like small nuclear reactors (FPSC 2025, p. 50).
- **Large Energy Neighbors (co-located or within 10 miles):**
  - Steel America, Norfolk
  - Precision Sheet Metal
  - Virginia Carolina Steel Inc.
  - AdvanSix
  - Roanoke Cement Company
  - Norfolk Naval Shipyard’s Industrial Wastewater Treatment Plant
  - Hampton Roads Sanitation District (close to NIT)
  - Norfolk International Airport
  - U.S. Gypsum Industrial Products Manufacturer

Context for Small Nuclear Reactors – Cons

- High risk of adverse weather such as tropical storms, hurricanes and flooding.
- Environmental justice neighborhoods and expensive real estate are located near NIT terminal and could produce challenges with adopting alternative technologies like small nuclear reactors.

Appendix B – Future Port Partners

The following ports have met the screening criteria indicating potential suitability for small nuclear reactor deployment (Section 3.1.1) and therefore warrant further feasibility analysis. These ports represent the next candidates for expanded research within this scope of work, with a few points highlighted about each.

- **Port of Newark, New Jersey**
  - NERC study highlighted an elevated risk status for the regional grid (America's Power 2024).
  - Opportunities for resource development to support possible electrification efforts and supporting other large energy users (nearby airport).
- **Port of Philadelphia, Pennsylvania**
  - NERC study highlighted an elevated risk status for the regional grid (America's Power 2024).
  - Existing large, energy-intensive neighbors include refineries and shore power (EPA 2022).
  - Relevance to regional resiliency since it is designated as an NPRN Port (Maritime Administration 2024).
- **Port of Wilmington, North Carolina**
  - NERC study highlighted an elevated risk status for the regional grid (America's Power 2024).
  - Existing large, energy-intensive neighbors include refineries.
  - Relevance to regional resiliency since it is designated as an NPRN Port (Maritime Administration 2024).
- **Port of Houston, Texas**
  - NERC study highlighted an elevated risk status for the regional grid (America's Power 2024).
  - Existing large, energy-intensive neighbors include refineries and other industrial companies.
- **Port of Galveston, Texas**
  - NERC study highlighted an elevated risk status for the regional grid (America's Power 2024).
  - Existing large, energy-intensive neighbors include refineries and shore power (Galveston Wharves n.d.).
- **Port of Charleston, South Carolina**
  - NERC study highlighted an elevated risk status for the regional grid (America's Power 2024).
  - Relevance to regional resiliency since it is designated as an NPRN Port (Maritime Administration 2025).
- **Port of Boston, Massachusetts**

  - NERC study highlighted an elevated risk status for the regional grid (America's Power 2024).
  - SMRs could be potential resource to support future shore power implementation (Burrell 2024).
- **Port of San Juan, Puerto Rico**
  - Opportunities for resource development to support highly vulnerable grid.
  - SMRs could be potential resource to support future shore power implementation, should the port's cruise industry adopt shoreside electrification.
- **Port of New Orleans, Louisiana**
  - NERC study highlighted an elevated risk status for the regional grid (America's Power 2024).
  - Existing large, energy-intensive neighbors include refineries.
  - SMRs could be potential resource to support future shore power implementation, should the port's cruise industry adopt shoreside electrification.
- **Military Ocean Terminal Concord (MOTCO)**
  - Relevance to regional and national resiliency.
- **Military Ocean Terminal Sunny Point (MOTSU)**
  - Relevance to regional and national resiliency.

Appendix C – Regional Electricity Prices for U.S. Ports

This report is meant to be a high-level approximation of large amounts of data, so future research would require more granularity into the costs of electrical demand, which can change during the peak hours of use or the magnitude of energy demand. As a general approximation, ports can use the electricity prices per state for the industrial sector provided by the U.S. Energy Information Administration (EIA n.d.[b]) for October 2025. Generally, the range of cost in 2025 USD per kWh is 0.0696 to 0.359.

Table C.1. Electricity price for the industrial sector for ports in their respective states, provided by the U.S. EIA.

Maritime Port Name	State	Industrial Electricity Rate (USD 2025/kWh) (data from April. 2026, EIA n.d.[b], except where marked with *)
West Coast		
Port of Juneau	AK	0.2066
Port of Long Beach	CA	0.1931
Port of Oakland	CA	0.1931
Port of Honolulu	HI	0.3247
Port(s) of Seattle/Tacoma	WA	0.0574
Port of Anacortes	WA	0.0674
Port of Everett	WA	0.0674
East Coast		
Port of Baltimore	MD	0.1159
Port of Boston	MA	0.1978
Port of Newark	NJ	0.1368
Port of Philadelphia/Camden	PA	0.0906
Port of Detroit	MI	0.0852
Gulf		
Port of Corpus Christi	TX	0.0663
Port of Houston	TX	0.0663
Port of Galveston	TX	0.0663
Port Arthur/Port of Beaumont	TX	0.0663
Port of New Orleans	LA	0.0511
South		
Port of Miami	FL	0.0854
Port of Everglades	FL	0.0854
Port of Savannah	GA	0.0888
Port of Wilmington	NC	0.0818
Port of Charleston	SC	0.0762
Port of Norfolk	VA	0.0919
U.S. Operated		
Port of Apra Harbor	GU	0.0902*
Port of San Juan	PR	0.2458**

Maritime Port Name	State	Industrial Electricity Rate (USD 2025/kWh) (data from April. 2026, EIA n.d.[b], except where marked with *)
MOTCO (Military Ocean Terminal Concord)	CA	0.1931
MOTSU (Military Ocean Terminal Sunny Point)	NC	0.0818

* Data are from Dec. 2025, EIA n.d.(c).
** Data are from Dec. 2025, EIA n.d.(d).

Appendix D – Calculations for Industrial Neighbor Energy Use

D.1 Industrial & Manufacturing

D.1.1 Steel Manufacturing Plant

Steel manufacturing is an industry commonly located near maritime ports. While there are other metals that can be produced in facilities near ports, steel is very common and was found at some of the ports used in this analysis.

Steel can be produced in a few ways, most commonly via coal-based methods such as a blast furnace, basic oxygen furnace (BOF), or open-hearth furnace (Global Energy Monitor n.d.). Additionally, steel can be created using electricity-based approaches via an electric arc furnace (EAF). The furnaces used in steel production usually require the largest quantity of energy among all the processing steps (ABB 2022)—around 80 percent of the final energy has been estimated to be used from the furnaces for both iron and steel production.

The annual energy consumption for steel manufacturing plants was estimated based on the furnace type and size of plant. The results can be seen in Table D.1. Relative sizes are based on the processing capacity of real plants. It is worth noting that the values used for energy consumed per furnace type were taken from a paper published in 1997 to 1998. The final energy per plant could therefore be an overestimation since there have probably been strides in process efficiencies and reduction in energy needs. However, these values are intended to serve as general estimates; therefore, a slightly conservative (higher) estimate is acceptable to help ensure the small nuclear reactor is appropriately sized.

Table D.1. Energy used for furnace types—blast furnace, hot metal production (HMP), and EAF—and general sizes for a steel manufacturing plant. An annual energy consumption estimate was calculated for the different furnace types and production capacities.

Energy for Different Production Methods					
Type of Production	**Energy Requirement (million BTU/ton steel tapped)**	**Energy Requirement (million BTU/net tons hot metal)**	**Energy Requirement (million BTU/tons cast product)**	***Processes & Inputs Used in Energy Estimate***	***Notes***
EAF	5.65			Electricity, Coal, Oxygen, Natural Gas, Lime	Table 6
HMP		15.48		Sintering, Pelletizing, Coke Plant, Tuyere Injectants, Blast Furnace	Table 2
BOF			14.07	Hot metal, Oxygen, Electricity, Caster, Other	Table 5

Production Plant Sizes		
Plant Size	**Annual Tons**	***Notes***
Small	300,000	Based on size of minimill (Stubbles 2000, p. 11)
Large	14,000,000	Based on average of top steel companies in USA (SteelOrbis n.d.): Nucor (2023); Steel Dynamics (2022); US Steel (2022)

Estimating Annual Plant Energy				
Plant Type & Size	**Small**	**Large**	**Small**	**Large**
EAF	1.7E+12 BTU	7.9E+13 BTU	5.0E+08 kWh	2.3E+10 kWh
HMP	4.6E+12 BTU	2.2E+14 BTU	1.4E+09 kWh	6.4E+10 kWh
BOF	4.2E+12 BTU	2.0E+14 BTU	1.2E+09 kWh	5.8E+10 kWh

D.1.2 Chemical and Petrochemical Manufacturing Plant

Petrochemical industries are important to the network of other industries that depend on the output products and raw materials that are utilized to create fertilizers, plastics (AFPM Communications 2017), textiles, and pharmaceuticals (Popoola et al. 2026).

For the purpose of this study, an ethylene production facility is used as a proxy for the general estimate of a petrochemical manufacturing plant. Since ethylene is used so universally, it would most likely be relevant to the most number of ports assessed in this study. A database of current ethylene production facilities in Europe and North America was used to create relative sizes of plants based on the distribution processing capacity (Kampmann et al. 2024). About 2.47×10^6 kJ or approximately 686 kWh of energy is used to produce one metric ton of product (Popoola et al. 2026). Annual energy consumption per plant, per year, can be found in Table D.2.

Table D.2. Sizes of current ethylene manufacturing plants in the United States, used as a proxy to estimate the energy needs for a petrochemical plant. Energy consumption was estimated for different plant processing capacities.

Petrochemical Plants in U.S. (Kampmann et al. 2024)				
Plant Name	**City**	**State**	**Capacity (metric tons ethylene per year)**	**Status in 2024**
Morris Complex	Channahon	IL	358,000	Operating
Ingleside Facility	Ingleside	TX	544,000	Operating
Point Comfort Complex	Point Comfort	TX	816,000	Operating
Port Arthur (BASF)	Port Arthur	TX	1,040,000	Operating

Shell Polymers Monaca	Industry	PA	1,500,000	Operating
Unknown	Port Arthur	TX	1,900,000	Announced
Formosa Sunshine Project	White Hall	LA	2,400,000	Under construction

Estimating Petrochemical Plant Energy

Treatment Plant Size	**Approx. Capacity (metric tons of Ethylene per year)**	**kWh for Production/yr**	***Notes***
S	500,000	3.4E+08	~686 kWh/metric ton of product produced (Popoola et al. 2026)
M	1,000,000	6.9E+08	
L	1,500,000	1.0E+09	
XL	2,000,000	1.4E+09	

D.1.3 Petroleum Refinery

Common petroleum processes include distillation, cracking, reforming, and hydrotreating (desulfurization) (MASAFEE n.d.; Planete Energies 2025). To develop a representative range of refinery sizes (AFPM 2024), researchers used a 2024 report from the American Fuel and Petrochemical Manufacturers to identify states with a single refinery and its associated capacity. In addition, a 2025 list of the 10 largest petroleum refineries in the United States (Abraham Watkins 2025) was used to define the upper bound of refinery size.

Annual electrical energy consumption data for refineries were obtained from an EIA (2024[b]) EIA analysis and converted to kWh. Using these sources, approximate refinery energy consumption was estimated by averaging values across states within each size category. This analysis is not intended to be comprehensive, but rather to provide an order-of-magnitude estimate of refinery energy use. A more detailed assessment would be required for higher fidelity estimates, as refinery energy consumption depends on numerous operational and site-specific factors. Table D.3 summarizes the states included in each refinery size category and the associated estimated energy use.

Table D.3. Sizes of petroleum refineries and estimated energy consumption for the different refinery capacities. Relative refinery sizes were created and based on existing U.S. refineries.

Approximating Refinery Sizes

States with Refineries	***Reported Capacity per Day (barrels/day)***	***Reported Capacity per Year (barrels/yr)***	***EIA Annual Refinery Electricity Consumption, 2024 (kWh)***	***Notes***
Nevada	2,000	730,000	1.02E+13	These states were chosen for evaluation since they only had one refinery operating
West Virginia	22,300	8,139,500	5.02E+14	
Wisconsin	38,000	13,870,000	1.49E+15	

North Dakota	71,000	25,915,000	2.64E+15	
Hawaii	93,500	34,127,500	6.18E+14	
New Mexico	110,000	40,150,000	3.24E+15	
Michigan	140,000	51,100,000	4.78E+15	
Delaware	171,000	62,415,000	3.87E+15	
Tennessee	180,000	65,700,000	6.72E+15	
Kentucky	300,000	109,500,000	1.12E+16	
Texas	268,000–654,000	97,820,000–238,710,000	–	Range for the Texas refineries came from list of top 10 largest refineries in USA (2025), Port Arthur and Houston

Estimating Energy Consumption

Relative Refinery Size	***States***	***Approx. Capacity Range (barrels/yr)***	***Approx. Annual Energy Consumption (kWh)***	***Notes***
S	NV, WV, WI, ND, HI	1M–30M	1E+15	Average was taken from all the sized refineries' energy consumption
M	NM, MI, DE, TN	40M–70M	5E+15	
L	KY, TX	1B+	1E+16	

D.1.4 Cement Manufacturing Plant

The energy consumed at a cement manufacturing facility will depend on the production capacity and the processes involved in production. This level of analysis is outside the scope of this report; however, a high-level estimate of energy use was found in a research paper by Mossie et al. (2025, Table 4) that estimated the average total daily energy required for a cement plant, based on three case study plants with capacity of around 6 million metric tons per year. Over a year, the estimated energy for maximum production levels, with some fluctuation provided daily ebbs and flows demand, was 5.4E+08 kWh ± 1.8E+08 kWh.

An alternative study published by The Portland Cement Association (Boyd and Zhang 2011) investigated a survey of U.S. and Canadian cement industry's labor and energy usage. The data collected was used to produce an average energy estimate for the annual operation of a single plant. The result was around 1.4E+09 kWh for a plant with a capacity of around 1.0 to 1.6 million metric tons.

Based on these two estimates, this report will use 5.4E+08-1.4E+09 kWh as a representative range for the annual energy demands for a cement production facility, respectively.

D.1.5 Natural Gas Liquefaction Plant (LNG Production)

A common liquefaction process for natural gas is the cascade cycle. This process takes around 13.5 kW/Ton (Emmitt and Songhurst 2008). Assuming a production facility operates 24 hours a day for 365 days a year, and there are 1,000 kg in a ton, this would amount to 0.324 kWh/kg of LNG. Annual energy consumption for different LNG plant classes—micro, small-scale, mini, mid-scale, and large-scale—was done by multiplying the energy per unit of LNG by the plant capacities listed in Table D.4.

Table D.4. Sizes of natural gas liquefaction plants and their estimated respective energy consumption based on the assumed liquefaction process of a cascade cycle.

Sizes of LNG plants				
LNG Plant Class (Sandoval 2025; SASPG n.d.; Tractebel Engineering S.A. 2015)	**Typical Use**	**Approx. Capacity (Nm^3/day)**	**Approx. Capacity (kg/day)**	***Notes***
Micro	Remote sites, fueling stations	10K–50K	7.2K–36K	Assuming 100% Methane, 1 atm, 0 deg C. 1 NM^3 of CH4 ~0.72 kg (ISO 6976)
Small-Scale	Industrial, local grids	50K–200K	36K–144K	
Mini	Regional supply	200K–500K	144K–360K	
Mid-Scale	Regional export, clusters	500K–2M	360K–1.44M	
Large-Scale	Global export terminals	2M–20M+	1.44M–14M	
Approximate Energy Use				
Liquefaction Process		***Avg Specific Power per Day (kW/Ton)***	***Avg Energy Use per Day (kWh/kg)***	***Notes***
Cascade Cycle (Emmit and Songhurst 2008)		13.5	0.324	1 Ton = 1,000 kg, 1 day assumed 24 hrs
Estimating LNG Plant Energy Use				
LNG Plant Class	**Average Capacity per Day (kg/day)**	**Average Energy Use per Day (kWh)**	**Average Energy Use per Year (kWh)**	
Micro	21,600	7.0E+03	2.6E+06	
Small-Scale	90,000	2.9E+04	1.1E+07	
Mini	252,000	8.2E+04	3.0E+07	
Mid-Scale	900,000	2.9E+05	1.1E+08	
Large-Scale	7,920,000	2.6E+06	9.4E+08	

D.2 Other Co-Located Industries

D.2.1 Desalination Plants

Desalination is the process of purifying source waters—brackish groundwater, seawater, or wastewater from industrial plants—that have concentrations of ions and precipitated salts. Modern desalination technologies fall into two main categories: membrane-based and thermally driven processes (IAEA 2022, p. 28). Reverse osmosis (RO) is the most widely deployed membrane technology, using electrically driven high-pressure pumps (~5.5 to 8.5 megapascals) to force saline water through semipermeable membranes that reject dissolved salts; RO plants range from small systems to very large facilities and account for roughly half of global desalination capacity. Multistage flash (MSF) and multi-effect distillation (MED) are the dominant thermal technologies, both requiring heat and electricity. MSF heats saline water near boiling and passes it through a series of progressively lower-pressure stages, where water flashes to vapor and is condensed as freshwater, typically operating with 4 to 40 stages and capacities of approximately 4,000 to 30,000 m^3/day. MED operates at lower temperatures but uses steam and a series of evaporators to recover fresh water at decreasing pressures, with typical capacities of 2,000 to 10,000 m^3/day. Hybrid desalination systems are also possible (Aquatech 2021), which combine multiple technologies to improve efficiency and reliability, as demonstrated by large-scale facilities such as Ras Al Khair Desalination Plant in Saudi Arabia and Fujairah 2 Desalination Plant in United Arab Emirates.

To estimate the magnitudes of electrical energy required for different types of desalination plants co-located with maritime ports, researchers analyzed the most common desalination technologies and their approximate energy requirements. From real desalination plants, relative sizes for the plants were generated to produce approximate annual energy consumption (Eke et al. 2020) (Table D.5).

Table D.5. Sizes of desalination plants and respective energy consumption estimates for different desalination processes—RO, MSF distillation, and MED—using different feed water types: salt water (SW) and brackish water (BW).

Energy and Forms of Desalination				
Ranking of Deployed Technologies (most major/common)	**Water Input**	**Total Energy Requirement (kWh/ m^3)**	**Average of Energy Range (kWh/ m^3)**	***Notes***
RO	SW	3.0–4.0	3.5	(Eke et al. 2020, Sec 3.2.2)
RO	BW	0.5–2.5	1.5	
MSF Distillation	SW	10.0–16.0	13.0	
MED=	SW	5.5–9.0	7.3	
Desalination Sizes				
Size	**Technology + Water Type**	**Capacity (m^3/day)**	***Desalination Plant Location***	***Notes***
S	RO + BW	940	Romania	(Eke et al. 2020, Table 2)

S	RO + SW	600	Bahamas		
M	RO + BW	1,850	Qatar		
M	RO + SW	4,315	Colombia		
L	RO + BW	22,500	Iran		
L	RO + SW	30,000	Cyprus		
XL	MSF + SW	880,000	Saudi Arabia		
XL	MED + SW	454,200	UAE		
Estimating Desalination Plant Energy					
Size	**Technology + Water Type**	**Approx. Capacity (m^3/day)**	**Approx. Energy for Technology + Water Type (kWh/ m^3)**	**Total Energy per Day (kWh)**	**Total Energy per Year (kWh)**
S	RO + BW	1,000	1.5	1.5E+03	5.5E+05
S	RO + SW	500	3.5	1.8E+03	6.4E+05
M	RO + BW	2,000	1.5	3.0E+03	1.1E+06
M	RO + SW	4,500	3.5	1.6E+04	5.7E+06
L	RO + BW	230,000	1.5	3.5E+05	1.3E+08
L	RO + SW	300,000	3.5	1.1E+06	3.8E+08
XL	MSF + SW	1,000,000	13.0	1.3E+07	4.7E+09
XL	MED + SW	450,000	7.3	3.3E+06	1.2E+09

D.2.2 Wastewater Treatment Plants

Within total urban electrical energy consumption (Masłoń et al. 2020), around 40 percent can be simply from water and sewage processing. These plants can often be located near maritime ports and the industrial spaces surrounding it. Because of the high level of continuous energy use, this potential port neighbor was included in the analysis.

Energy consumed at a wastewater treatment plant can majorly depend on the technology used, how it is operated, the quality/level of purification needed of the treated water, and the total processing capacity. While the energy can vary, a report found that a wastewater treatment plant can consume approximately 0.5 to 2.0 kWh per cubic meter of treated water (Hamawand 2023).

The throughout/capacity of the treatment plant can depend on the port location, which is why real wastewater treatment plant capacities are used in this analysis to provide a range for the approximation. The general capacities of the treatment plants are listed in Table D.6. Additionally, values for treatment capacity can vary depending on dry or wet conditions of operation. The values listed for different plants are estimates of the average of capacity for dry and wet conditions.

Based on the capacities of real wastewater treatment plants, researchers create relative sizes for the plants based on their capacity per year. Annual energy use was estimated using the energy per cubic meter of water treated included above. The results can be seen in Table D.6.

Table D.6. Sizes of wastewater treatment plants and respective energy consumption estimates based on annual capacity. General sizes for plants are based off real U.S. plants, and the energy per cubic meter of treated water was an average of the energy required for dry and wet operation conditions.

Existing Wastewater/Sewage Treatment Plants (USA)				
Treatment Plant Name	**City (State)**	**Average Capacity (gallons per day)**	**Average Capacity (cubic meters H_2O per day)**	**Citation**
Detroit Wastewater Treatment Plant	Detroit (MI)	6.50E+08	2.46E+06	EGLE n.d.
Passaic Valley Wastewater Treatment Plant	Newark (NJ)	3.30E+08	1.25E+06	Passaic Valley Sewerage Commission n.d.
Deer Island Sewage Treatment Plant	Boston (MA)	1.27E+09	4.81E+06	McFarland and Lewis 2012
McAlpine Creek Wastewater Treatment Plant	Charlotte (NC)	5.00E+07	1.89E+05	Municipal Water Leader n.d.
Stickney Water Reclamation Plant	Chicago (IL)	1.20E+09	4.54E+06	Metropolitan Water Reclamation District of Greater Chicago n.d.
Hyperion Water Reclamation Plant	Los Angeles (CA)	2.75E+08	1.04E+06	Brown and Caldwell n.d.

Estimating Wastewater Treatment Plant Energy					
Treatment Plant Size	**Approx. Capacity (cubic meters H_2O per day)**	**Approx. Capacity (cubic meters H_2O per Yr)**	**Low Energy Range (kWh/Yr)**	**High Energy Range (kWh/Yr)**	***Notes***
S	1E+05	3.7E+07	1.8E+07	7.3E+07	0.5–2 kWh per Cubic Meter of H_2O Treated (Hamawand 2023)
M	5E+05	1.8E+08	9.1E+07	3.7E+08	
L	1E+06	3.7E+08	1.8E+08	7.3E+08	
XL	5E+06	1.8E+09	9.1E+08	3.7E+09	

D.2.3 Data Centers

While data centers are more likely to be located near maritime ports versus operating directly on-site, it is still relevant in this study to estimate the relative scale of energy use. Data centers continue to be constructed all around the nation and are often in industrial areas, where ports might be nearby. The energy needed by data centers can indicate future bottlenecks in grid power and limit the energy available for ports as they expand and electrify their operations.

According to the International Energy Agency (IEA 2025), “A typical AI-focused data center consumes as much electricity as 100,000 households, but the largest ones under construction today will consume 20 times as much.” If this general range is taken to approximate the energy use, in 2015 (EIA 2023), the average individual household consumed around 8,211-13,895[18] kWh. Across 100,000 households this would be approximately 8.2E+08-1.4E+09 kWh, and 20x this (about 20 million houses) would be around 1.6E+10 – 2.8E+10 kWh annually. This energy range (~1E+09 – 2E+10 kWh) for one data center is on the order of the annual energy generated by the Hoover Dam (~4E+09 kWh) (USBR 2018). Additionally, it has been found that a single server in a data center can draw approximately 330 W of electrical load (Shehabi et al. 2016). So, for a large data center (which have about 5,000 servers [Leppert 2025]), assuming 24-hour operations for 365 days a year, this would amount to 1.5E+10 kWh/year, respectively. This aligns with the upper end approximate of our estimations for a data center to be the energy use of about 20 million homes. While this energy estimate is not meant to be rigorous, it does highlight that a data center would be a very large energy consumer and limit the grid capacity available to other users such as maritime ports.

Given the various large industrial energy users located at the port, as well as neighbors (such as possible desalination plants or data centers), ports should be investigating alternative sources of energy to meet their growing operational demands and shrinking energy availability. Small nuclear reactors could be one of these energy sources that could aid maritime ports. Since not every port has similar energy demands and therefore might not require the large energy supply, this report first down-selects a representative list of ports from across the United States and then categorizes them based on their estimated annual energy consumption and other factors to determine whether deploying small nuclear reactor technology could benefit the port and its operations.

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[18] The average annual household energy consumption was regionally influenced, with a household in the North East consuming 8211 kWh per year; in the Midwest, 9,567 kWh; the South, 13,895 kWh; and the West, 8,525 kWh in 2015.

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