PATHWAYS TO A LOW CARBON FUTURE

FLOATING NUCLEAR POWER PLANT

IN PARTNERSHIP WITH

Herbert Engineering Corp.

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FORWARD

The American Bureau of Shipping (ABS) and Herbert Engineering Corporation often collaborate to investigate the application of new technologies for commercial vessels. The partnership leverages Herbert Engineering's naval architecture expert ability to incorporate novel arrangements or equipment into conventional vessel types. With specialist insights from ABS on classification and regulatory perspectives, the concept designs produced are effective first looks at novel arrangements.

The goal of creating concept vessel designs, even those without substantial technical detail, is to begin the iterative design process at a high level, conceptualize the potential hazards of the new technology, and prepare to implement engineering solutions to address potential risks. As a part of the regulatory aspects of this concept design, it is recommended that a goal based standards approach be used that will incorporate several risk analyses. This forward-looking concept investigating floating nuclear technologies is intended to be aligned with the release of the ABS *Requirements for Nuclear Power Systems for Marine and Offshore Applications*. As with all introductions of new technology, close collaborations with flag Administrations and port States will be necessary as the design continues to evolve.

With advancements in nuclear engineering and the development of many types of advanced nuclear reactors, there are opportunities to implement the technology for commercial floating nuclear power plant (FNPP) applications.

In contrast to previous studies investigating a nuclear-powered containership, suezmax tanker, and LNG Carrier, an additional arrangement of interest is to investigate an FNPP facility. Considering the demand of ports to supply low-carbon power to cold-iron vessels, especially visiting containerships and cruise ships, the FNPP *Nuclear Navigator* was designed with supply to the shore grid in mind to increase the available energy to support maritime decarbonization in port. This study reviewed existing ports fitted with onshore power supply (OPS) in the United States (U.S.), and the typical energy consumption from large ships such as cruise vessels. With these parameters in mind, an FNPP supplying a maximum of 70 MWe to the port electric grid was considered sufficient to meet the need of up to six visiting cruise ships at once. The ability to deliver the FNPP to its site location and connect to the local grid from the pier can ease many portside challenges of increasing available power for port operations.

Technical specifications of advanced nuclear reactors under development today, often referred to as small modular reactors (SMRs) for their scaled-down designs, are not widely available, or are not specifically designed for floating applications.

To conceptualize the possible design, the design team invited a reputable small reactor designer to provide information regarding the use of their reactor design for the FNPP. This reactor design has been supported by the U.S. Department of Energy's Advanced Reactor Demonstration Program (DOE ARDP) to demonstrate the commercial viability of SMRs.

With these design arrangements in mind, ABS and Herbert Engineering are pleased to present a first look at a conceptual future FNPP.

We welcome your feedback through comments or suggestions.

Mike K

Michael Kei
ABS Vice President, Technology, Americas

INTRODUCTION

The scope of this report is to describe the design of a floating nuclear power plant (FNPP) that is intended as an auxiliary electrical power source for ports that provide cold-ironing capabilities. Additional electrical power in ports is intended as a way to enhance decarbonization of port infrastructure and equipment. Ports like Los Angeles/ Long Beach are starting to see issues with expansion and reliability of the electrical power supply to meet aggressive decarbonization targets.

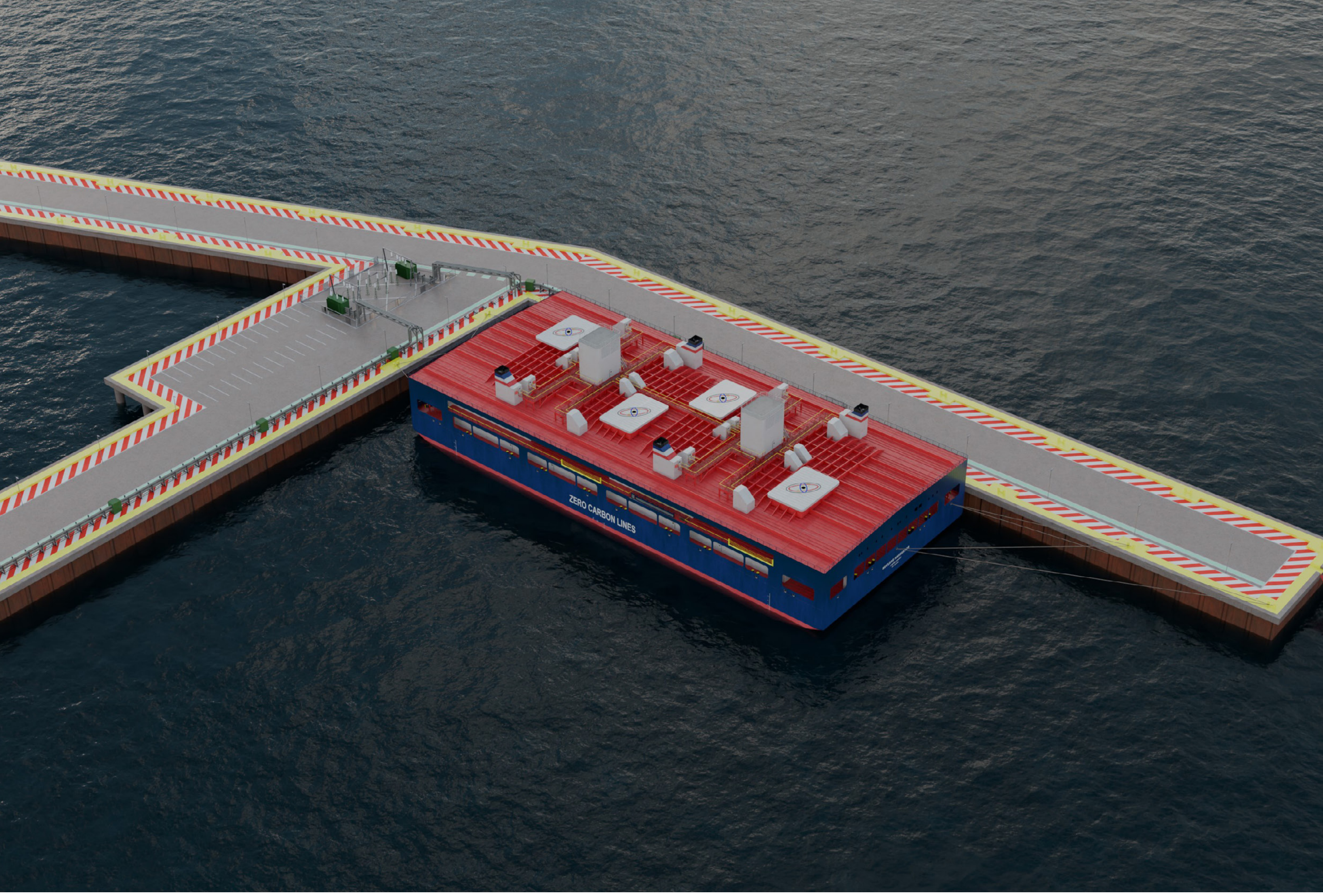
References provided at the end of this report are assumed to form the basis of the regulatory requirements for classification and nuclear license, where the nuclear systems are to have a license from an approved nuclear regulator such as the NRC, and the barge structure and marine systems receive ABS classification. It is also assumed that the FNPP, arranged on a barge, would have to be designed to accommodate a number of different installation locations and commercial needs, thus necessitating reasonable flexibility both in terms of power output and restricted water access.

A cluster of advanced reactors currently under development was therefore chosen to provide a power output of 35–70 MWe (which can be reduced to a minimum of 5.25 MWe), corresponding to the highest electrical power demand of four to six large cruise liners in port. This conservatively high power may also be used for onshore power supply or battery charging services to containerships or other vessels in port.

1. SCOPE OF STUDY

1.1. STUDY GOALS

The scope of this study is to develop a high-level design of a FNPP intended as an auxiliary power source for ports adopting onshore power supply (OPS), or cold-ironing, for visiting vessels. It is assumed that the installation would not need to change location often, so a non-propelled tow barge was chosen as a design basis. Furthermore, the design assumes a sheltered, pier-moored installation which is flexible enough to adapt to a variety of typical port locations. For this reason, no anchoring facilities are currently part of the design, and no environmental impact analysis was carried out. While the addition of anchoring facilities is generally easy to achieve, environmental impact, local seakeeping, and power offtake arrangements (as agreed by the power purchase agreement) would have to be considered in detail once a specific location is chosen.



2. DESIGN BASIS

2.1. DESIGN SPECIFICATIONS

The specific technical requirements of this FNPP concept are as follows:

1. The power plant needs to be able to provide up to 70 MWe and to be flexible enough to adapt to the variable load profiles, with oscillations reflecting the alternating presence in port of large consumers. However, since the FNPP is to be connected to the grid, its capabilities do not need to consider the ability to load follow in a dynamic manner.
2. The design, beam and length of the FNPP should be such that it may be transported widely across the U.S. during sequential construction and outfitting and brought to its final location. The dimensions should allow mooring to be possible in a reasonably large number of locations.
3. The plant cannot represent an increased threat to nuclear weapon proliferation, for security and safeguard concerns.
4. The plant needs to maintain an acceptable level of safety in all accident scenarios and cannot force the port to adopt special evacuation arrangements.
5. The design needs to be cost-competitive and should be designed with economy as a critical factor.
6. The reactor design minimizes the need for refueling, which is carried out off site. For this reason, no on-site refueling arrangements are included in the design.
7. Plant personnel would need day accommodation since it is expected that crew would alternate on board and otherwise live on shore. For this reason, minimal onboard transition accommodation for crew during barge relocation is included in the design.

The above requirements impose a certain number of basic choices for the concept design. First, the nuclear power plant needs to be designed so that the associated emergency planning zone (EPZ) is as small as possible, or ideally contained within the vessel boundaries, to showcase safety and allow access to commercial trade ports. This limits the choice of reactor types. Second, the choice of fuel type and handling arrangements are to address nuclear weapon proliferation and security concerns.

Other design considerations stemming from basic naval architecture and nuclear technology requirements can be summarized as follows:

1. A modular design would satisfy the need for ease of construction, redundancy, segregation and, ultimately, safety.
2. The location of the nuclear reactors is affected by the following:
    a. Radiation shielding characteristics, with particular emphasis on weight and volume in relation to the barge's trim, stability and structural strength.
    b. The need to protect the structures from reactor residual heat allowing for its removal through passive convection.
    c. Structural or mechanical protection from collision, grounding and malicious attacks.
    d. Security arrangements for the protection from unauthorized access.
    e. Barge accelerations experienced during tow, assuming pre-activation open ocean tow, and post-activation coastwise tow for relocation or refueling.
    f. Considerations of auxiliary power-generating machinery and explosion hazards.
    g. Consideration of ease of off-site refueling operations, reactor maintenance and ease of installation/removal.
3. The choice of the turbomachinery and electrical generation plant is mostly a consequence of the reactor's functional characteristics and operating temperatures, as the two need to be designed together. However, the type of electrical power generation plant will affect the surrounding arrangements.

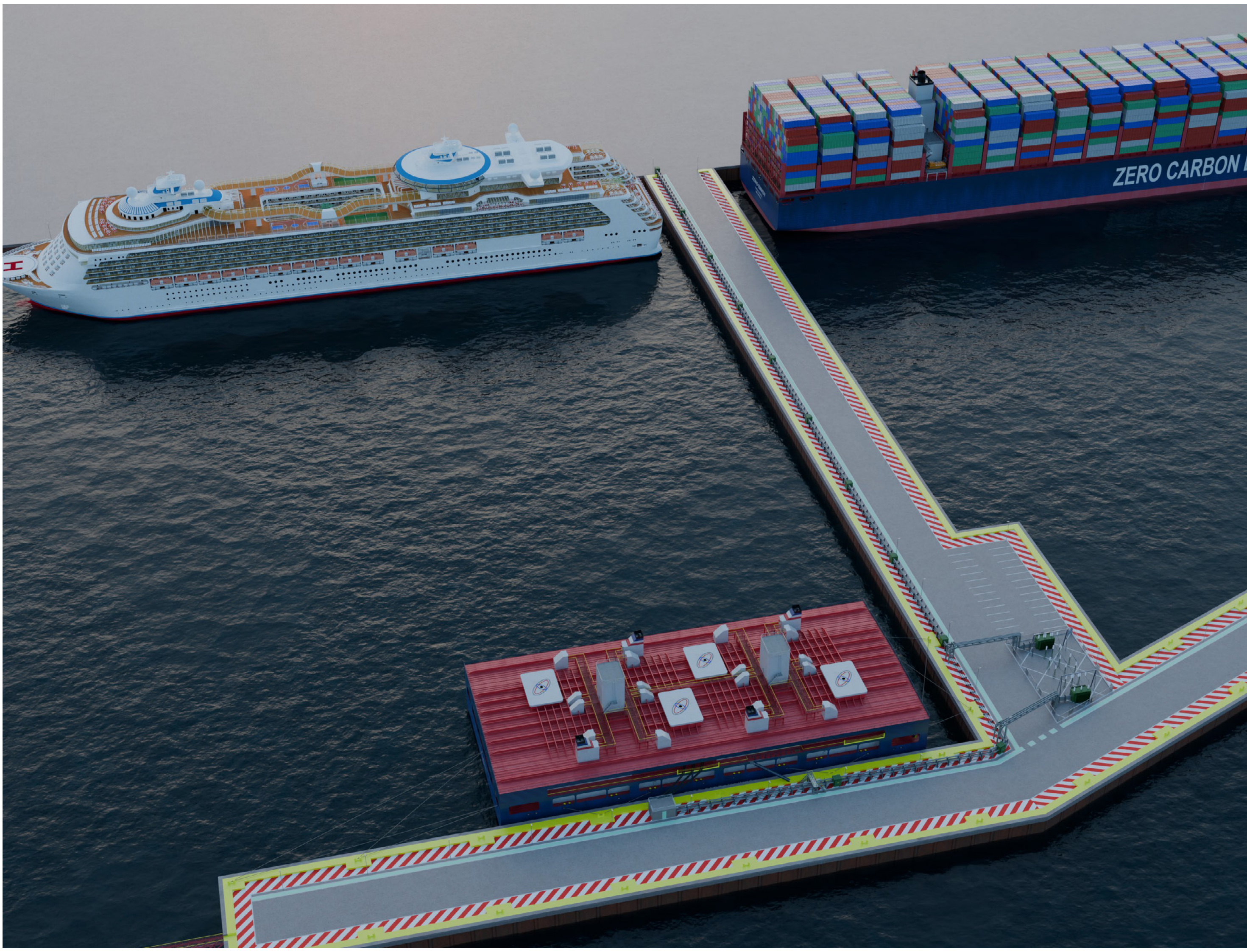
It is important to appreciate that the level of detail attainable at concept design is limited by the data available. For instance, nuclear waste generation, handling, storage and discharge arrangements cannot be addressed in detail at this stage. Similarly, other nuclear plant characteristics cannot be defined in detail, such as shutdown and startup process, capacities and performance of insulation and shielding materials, reactor room ventilation requirements, etc.

2.2. DESIGN ASSUMPTIONS

The design of this FNPP required several assumptions based on the perceived level of technical readiness and some operational parameters of the reactors that at this time are not defined. The reactors used in this concept study have been designed for land-based applications and have not considered special provisions for marine operations. The primary design assumptions are:

- Three modular reactor types of various sizes were considered: 5 MWe, 17.5 MWe and 30 MWe. Ultimately, the 17.5 MWe reactor was chosen, as it offers the best compromise between output flexibility, design complexity and capital expense (capex).

- The 17.5 MWe high temperature gas cooled reactor (HTGR) used in this concept study is an advanced reactor with enhanced performance properties including inherent safety and security features. Relatively high operational temperatures facilitate higher-efficiency energy conversion, while lower operating pressures and the use of advanced fuel should permit smaller EPZs [1].
- The design tried to extend the modular reactor philosophy to the entire FNPP, with four identical modules and two barge ends. This is intended to reduce building costs and provide improved levels of redundancy, independence and segregation, thus enhancing plant reliability and safety.
- Although the connection to land power could be used in an emergency, each module is designed to be able to provide independent, continuous emergency electrical power sufficient for two modules for 30 days to support reactor safety features and shutdown, as required by Ref. [2].
- The reactors are protected from collision and grounding locating the reactor compartments above the B/15 bottom damage line and within the B/5 transverse damage penetration extents [2]. Furthermore, the barge bow and stern sections (which include mooring decks and day accommodation for the plant personnel) protect the modules at each extremity.
- It is assumed that the nuclear reactors will be refueled off-site every five years. In this sense, arrangements are in place to allow the deck immediately above the reactors to be free from equipment, facilitating the extraction of the core (i.e., the pressure vessel and everything in it) during special dry docking for replacement with newly refueled equipment. However, the refueling process itself is not something that can be done on site because it requires extensive radiological protection arrangements even when the reactors are designed to be refueled on board, instead of extracted and replaced as these are. The issue is therefore not how long it would take to refuel these reactors, but rather the availability of shipyards which have appropriate radiological protection arrangements and know-how to carry out such specialized activities.



2.3. REACTOR TECHNOLOGY

The advanced nuclear reactor technology of interest for commercial marine applications is limited to small modular reactors (SMR) – designed to generate between 10 and 300 MWe and microreactors – designed to generate up to 10 MWe. Both are envisioned to be factory-built according to a standard design to benefit from economies of scale and reduced licensing costs.

HTGRs, such as BWXT's advanced nuclear reactor (BANR) are advanced reactors with lower thermal power rating. HTGRs are one of several types of advanced reactor designs, designated by the coolants, fuel types, and moderators used. HTGR designs are typically helium-cooled graphite-moderated nuclear reactors using fully ceramic TRi-structural ISOtropc (TRISO) coated particle-based fuels. These reactors are characterized by inherent safety features, fission product retention in the fuel, and high-temperature operation suitable for the delivery of industrial process heat.

Although they may have limitations for onboard use due to the high temperature (for instance, the reactor heat dispersed through ventilation during hot shutdown can result in temperatures up to 800° C of the area immediately adjacent to the reactor itself, and thus imply the need for a refractory barrier to protect steel structures and radiological shielding), they imply a smaller EPZ than some other advanced reactor designs. However, the reprocessing of TRISO spent fuel is not fully developed and may need to be addressed to fully realize the benefits of the fuel.

2.4. NUCLEAR PLANT

In the following, an overview is presented of the HTGR concept used for the design. This reactor is characterized as a modular, factory-fabricated system that is small and light enough to be transported via rail, ship, or truck. It is helium-cooled and uses HALEU (19.75 percent enriched) uranium oxycarbide (UCO) TRISO fuel and graphite matrix as a moderator to produce 50 MWt. This reactor operates in the thermal neutron energy range. A nominal steam Rankine cycle of 35 percent efficiency is prospected to generate net 17.5 MWe. However, it should be noted that higher core outlet temperature may enable direct Brayton cycle or combined cycle to increase efficiency from 35 percent to closer to 50 percent.

Used with permission of BWXT

Figure 1: Example HTGR microreactor deployment application.

Advanced sensors enable semiautonomous control, and a five-year nominal lifetime before core skid replacement would allow refueling at each ship's special drydocking. Coarse and fine reactivity control are provided though mechanical means. Passive decay heat removal is achieved by the large heat capacity of UCO TRISO graphite matrix and a moderator block absorbing heat into the solids until reactor temperatures increase. Radiated decay heat is dispersed to the ultimate heat sink (the atmosphere), while keeping the fuel and material temperatures below their design limits. This system feature is coupled with a negative reactivity temperature coefficient [3], providing inherent, engineered safety without the need for active safety features. TRISO fuel also contributes significantly to safety and security, as it is designed to be an accident-tolerant and proliferation-resistant fuel form.

3. FLOATING NUCLEAR POWER PLANT DESIGN

3.1. GENERAL ARRANGEMENT

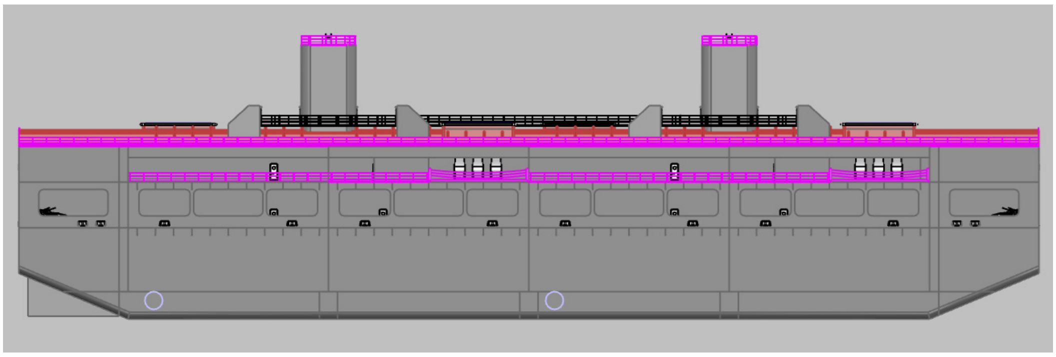


Figure 2: FNPP, HTGR Outboard Profile.

The proposed layout of the FNPP results from the combination of four identical modules (see Figure 3), each capable of providing 17.5 MWe independently of the others. Each module has a reactor compartment arranged within the B/5 collision limit and above the 3 m double bottom. The reactor room is radiologically shielded and contains the helium processing skid, steam generator, reactor and active and passive heat removal arrangements (Figure 4). The reactor is also surrounded by a refractory barrier outside the passive heat removal arrangement to protect the structural steel. Hatches above the reactors allow their off-site installation, removal and refueling.

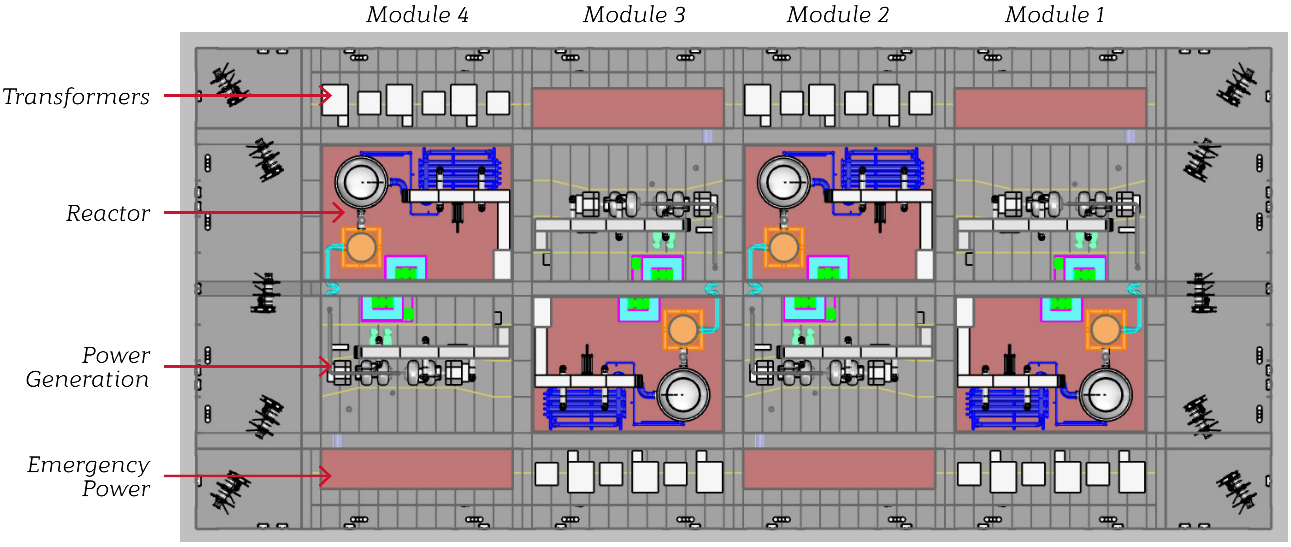


Figure 3: FNPP, HTGR Plan.

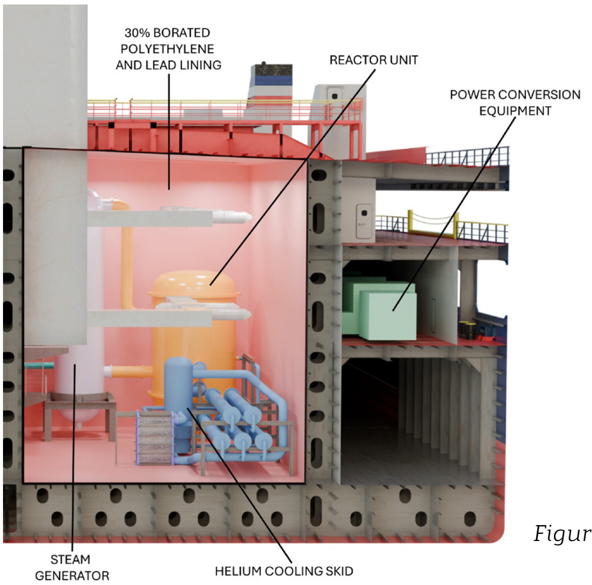


Figure 4: Reactor Compartment.

Symmetrically across the centerline (CL) there is a separate power generation compartment on three decks, which includes the turbogenerators, steam condensers, associated condensate and circulating water pumps, and the reactors and power plants control room (Figure 5). The power generation compartment is also within B/5 and above the double bottom. Each control room can monitor and control all of the four modules and is located at the top of the power generation compartment, just under the main deck and isolated on all sides by A60 fire barriers. The power generation compartment does not need radiation shielding but it is segregated from the rest of the plant to offer improved fire and explosion safety.

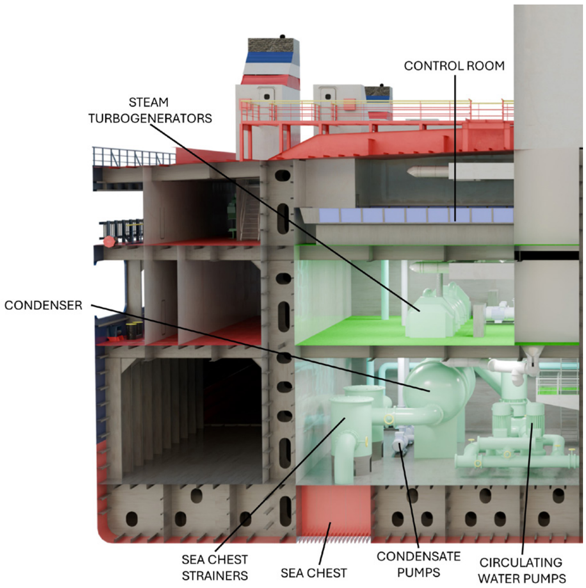


Figure 5: Power Generation Compartment.

Between the B/5 cofferdam and the barge side shell, on the reactor side, arrangements are made for electrical power transformers and offtake cable reels (Figure 6). Symmetrically, on the power generator room side, there is an emergency diesel generator (DG) sitting above its dedicated fuel tank. Each emergency DG set is capable of 1 MWe and sufficient to supply power to all four modules should the barge be disconnected from shore power. The checkerboard arrangement guarantees that at least two such emergency sets would be available even if extensive damage occurs to the other side.

The HTGR electrical power capacity matches reasonably well the overall installed power requirements of the plant which is estimated to be approximately 70 MWe. This power requirement can be satisfied by four standard nuclear power plants using two steam turbines per reactor, each turbine having an assumed 35 percent power conversion efficiency. For this design, two steam turbines per reactor provide power management flexibility to the plant. Assuming this limit to be 60 percent of maximum power output, having four reactors and eight turbines allows the plant's output power to range from a minimum of 5,250 kWe to 70,000 kWe [4]. This setup also provides redundancy and, therefore, improved resilience to turbine breakdowns. The design modularity offsets increased capex.

Excess reactor heat would be rejected through reactor cooling vent stacks. The original land-based designs envision these reactors as air-cooled, so substantial fan rooms, air supply ducting, and exhaust piping have been fitted to the main deck above the reactor compartment to provide the necessary airflow. The excess heat venting arrangements must be capable of managing and distributing the entire maximum reactor thermal load. However, the heat supplied to the Rankine steam cycle would be partly utilized by the turbogenerators, and partly rejected through standard, seawater-cooled steam condensers, effectively using the adjacent body of water as the main heat sink.

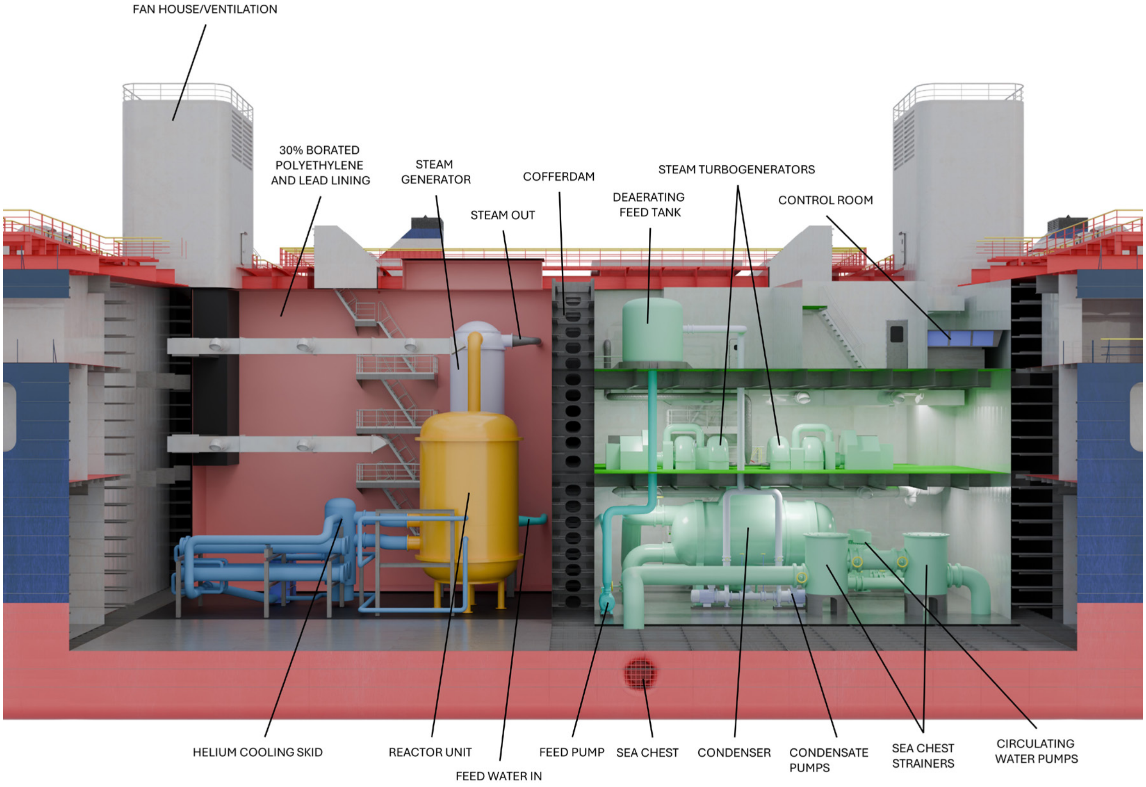


Figure 6: Typical Module Transverse Section.

At this concept stage of design, providing detailed information about the size of reactor room fans, air supply ducting, and exhaust stacks is not possible. However, the size of the steam condensers and associated circulating pumps will likely require approximately the bottom one-third of the power generation rooms. It should be noted that, in an emergency, the reactors can be brought to a reduced power state or shut down, where the thermal energy produced is substantially reduced. In this event, it should be possible to remove excess heat passively through convection. However, shore power and emergency diesel generators would also be available to power the ventilation systems.

Reactor cooling and ventilation exhaust stacks are placed at the end of each module to form two separate islands. This frees a significant portion of the main deck that may be arranged to host emergency helicopter landing facilities, if required. Two day-accommodation blocks are arranged at each end above the main mooring decks. These also host the plant labs. Saltwater ballast capacity is provided by 16 J-tanks arranged in the double bottom, which span the entire length of the barge parallel mid body, under the four power modules.

Each reactor compartment is 20 m long, 15 m wide and 17 m high. All boundary surfaces are covered with 120 mm thick 30 percent borated polyethylene for neutron shielding and 100 mm thick lead for gamma ray shielding. It is assumed that the HTGR is designed with increased shielding directly around the reactor itself, reducing the overall compartment shielding needs. This primary shielding adds approximately 400 MT to the reactor weight but helps reduce the neutron and gamma ray shielding materials for the enclosing bulkheads and decks. This results in a total weight of shielding equal to 11,200 MT which is additional to the 4,600 MT of the reactors and associated power plants. Note that each reactor is located in a separate compartment with dedicated primary and secondary shielding. This allows each reactor to operate even when access to other reactor compartments is needed. The power generation compartments are similarly sized and protected by cofferdam bulkheads and decks lined with 500 mm thermal insulation.

3.2. STRUCTURAL LAYOUT

The barge structural arrangement centers around the key consideration of having to keep all steel structure on the exterior of the reactor compartments to not interrupt internal insulation and radiological shielding. Consequently, a layout was adopted that employs box transversal bulkheads situated at the end of each room, offering a two-meter-wide cofferdam that allows for the necessary structure to be situated on the external wall of each reactor room, while also creating space for insulation, inspection, instruments and radiological shielding (Figure 7). Similarly, three cofferdams extend the length of the ship, one at CL, and two at 15 m port and starboard. These cofferdams are two stiffener spaces wide (approximately 1.5 m) and connected with diaphragm plates with manhole cutouts at every frame to allow access.

In addition to the double bottom and main deck, two partial decks at 10 and 15 m above baseline (BL) extend continuously along the length of the barge throughout the wing sections, outward of the B/5 limit. These decks provide support for mooring arrangements, emergency generators and associated fuel, as well as a ring walkway around the entire barge. These decks also provide support for two flats in the power generation rooms where the control rooms and turbomachinery are located. Neither of these flats are present in the reactor rooms. Thus, they are not longitudinally continuous and not considered as providing longitudinal strength.

A longitudinal frame spacing of 0.75 m was chosen, with a non-tight web frame located at every frame and watertight subdivision by a pair of transverse bulkheads forming a cofferdam where appropriate. A vertical stiffener spacing of 800 mm is implemented from above the inner bottom to the main deck for stiffeners on the side shell and on the longitudinal bulkheads. Deck longitudinal stiffeners are spaced 750 mm from CL to the 15 m off-centerline longitudinal bulkheads. Outboard of these longitudinal bulkheads, the deck longitudinal spacing transitions to 833 mm, which is continued to the side shell.

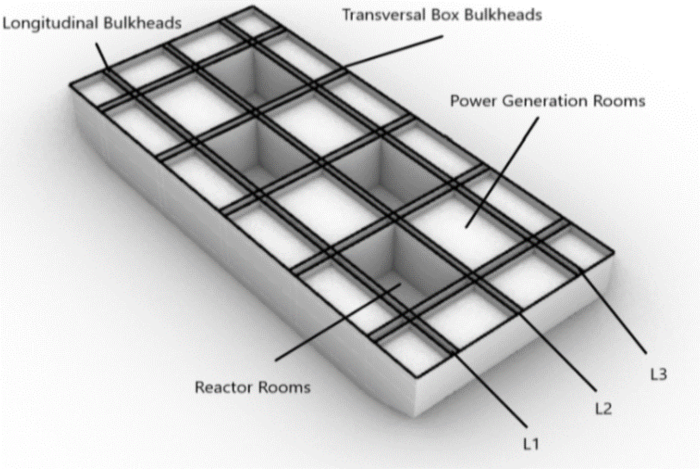


Figure 7: 12m ABL Cut View Depicting the Layout and Location of Rooms and Cofferdams.

3.2.1. SCANTLINGS

ABS *Rules for Building and Classing Barges* and ABS *Rules for Marine Vessels* were followed for the initial scantling sizing of the FNPP. The vessel was divided into three analysis regions (Figure 8) bounded by the inner bottom, 10 m deck, and main deck for the purposes of sizing scantlings and calculating design pressure heads. Utilizing three regions allowed for a degree of basic tapering in scantlings, while also keeping the analysis simple for this high-level conceptual design.

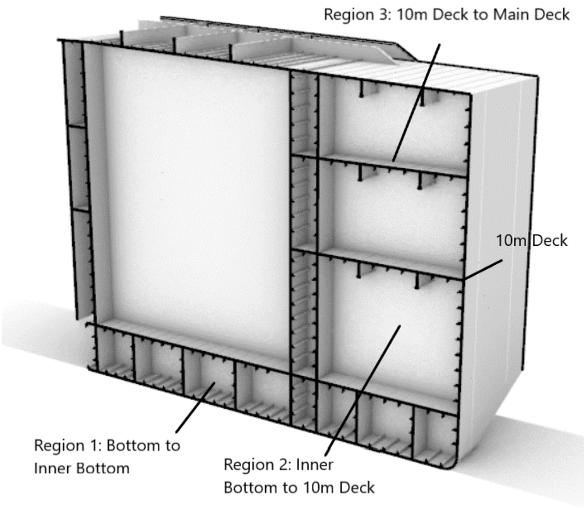


Figure 8: Cross Section Illustrating the Different Regions for Calculations.

3.2.2. STEEL WEIGHT SUMMARY AND HULL GIRDER SECTION MODULUS

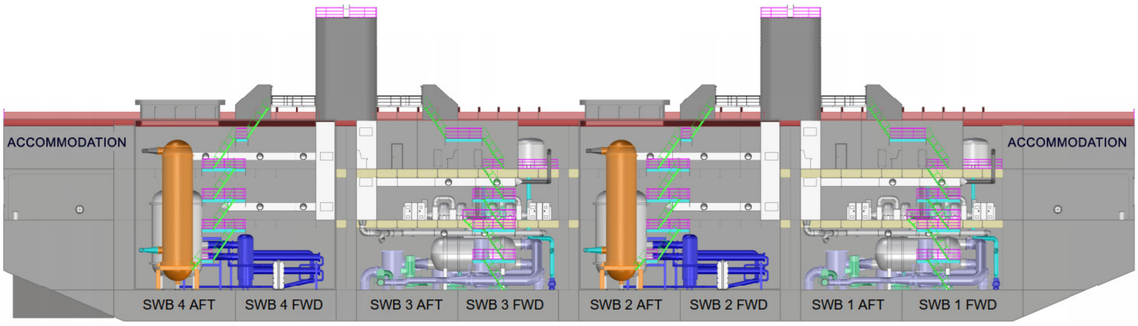
By analyzing a variety of load cases that the barge could commonly operate at, a still-water bending moment envelope was derived and the required hull girder section modulus was obtained from the 2024 ABS *Steel Barge Rules*. Considering the maximum still water bending moment from the different load cases and the design wave bending moment, a hull girder section modulus of 133,668 cm2-m is required. With the prospect of the barge being kept in port and experiencing less wave loading and consequently fatigue wear over its life than would be expected from a non-stationary barge, it can be expected that the required section modulus of the barge would be considerably greater than would be actually required. In fact, local scantling considerations ended up being more significant than hull-girder bending loads when sizing of the structures. In other words, the initial steel scantlings resulted in a section modulus approximately double that required by minimum rule requirements. This corresponds to a steel weight of approximately 10,278 MT.

4. SUMMARY AND CONCLUSIONS

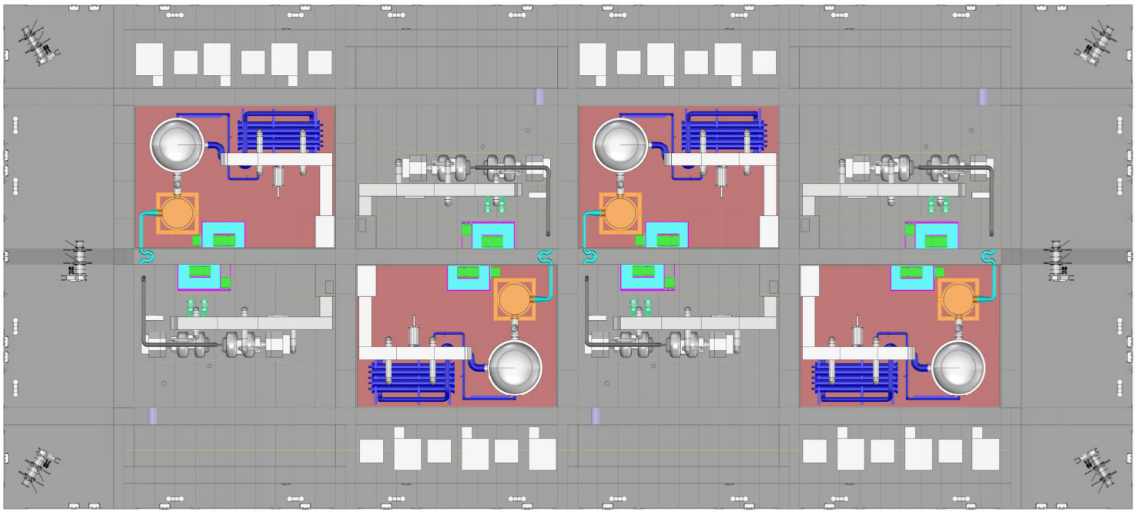
The main conclusions of this study are as follows:

- The maturity of advanced nuclear technologies that may be implemented for a FNPP is currently low. Therefore, the level of detail provided in this study is limited to engineering information available from the design of terrestrial applications for engineering postulation and recommendations for future design optimization.
- The modular reactor philosophy can successfully be carried over to the FNPP design with significant advantages in terms of safety and cost. Furthermore, the modularity concept allows the FNPP output to be reasonably flexible to adapt to the cold-ironing needs of large ports.
- Refueling cycles of approximately five years allow the design to be compact and simpler, with no need for fuel or high radioactive waste to be handled on board.

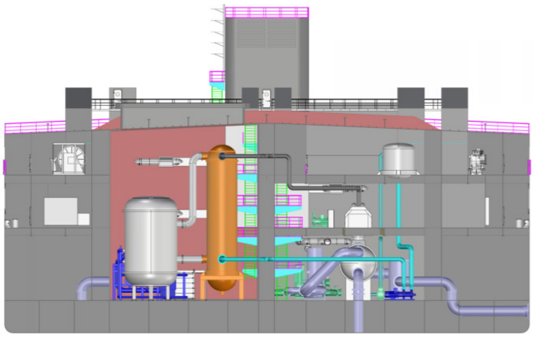
APPENDIX A — DESIGN SKETCH



Inboard Profile



10m ABL Plan



Midships Section
Fr. 28.5 Lkg FWD

FLOATING NUCLEAR POWER PLANT BARGE	GENERAL ARRANGEMENT		
	DATE:	20 - AUG - 2024	
	REV:	-	SHT. 1/1

MAIN PARTICULARS		POWERING	
Length Overall	112 m	Reactor Type	HTGR
Length Between Perpendiculars	112 m	Fuel Type	TRISO
Breadth, Molded	50 m	Number of Reactors	4
Draft, Design	4.5 m	Reactors Thermal Capacity	50 MWt
Lightship	22,000 MT	Reactors Capacity	17.5 MWe
Displacement at Design Draft	22,900 MT	Fuel Life	5 years

HEC Herbert Engineering Corp.
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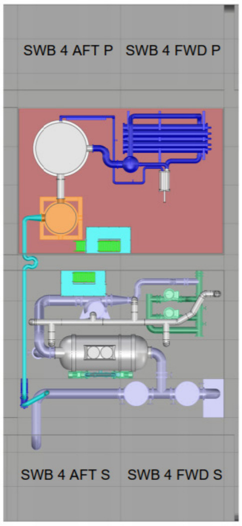
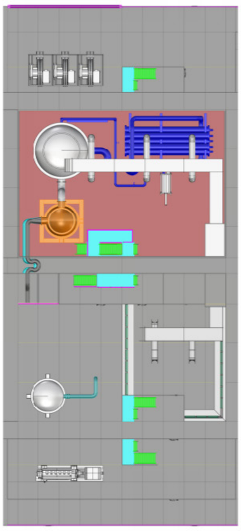


3m ABL Plan
Module 4 Only



15m ABL Plan
Module 4 Only

END NOTES

[1] Ref. [1] reports: “For planning purposes, the NRC defines two emergency planning zones around each nuclear power plant. The exact size and configuration of the zones vary from plant to plant due to local emergency response needs and capabilities, population, land characteristics, access routes and jurisdictional boundaries. The two types of EPZs are:

- The plume exposure pathway EPZ extends about 10 miles in radius around a plant. Its primary concern is the exposure of the public to, and the inhalation of, airborne radioactive contamination.
- The ingestion pathway EPZ extends about 50 miles in radius around a plant. Its primary concern is the ingestion of food and liquid that is contaminated by radioactivity.

More generally, an EPZ is the area around a nuclear plant that would require planning of concerted actions aiming to prevent or relieve the exposure of the public to radiation.

[2] The International Maritime Organization (IMO) has defined through an extensive statistical analysis the maximum damage penetrations due to grounding (B/15 or 1/15th of the breadth above the ship’s bottom line) and collision (B/5 or 1/5th of the breadth transversally, from the ship’s sides).

[3] Nuclear reactors are said to have a negative reactivity temperature coefficient if the chain reaction decreases as the temperature of the core increases. This negative feedback is a design feature intended to provide a passive safety net against meltdowns.

[4] The figure of 5,250 kWe is obtained assuming that only one turbine of one reactor is active (the rest being on hot standby and disconnected from the turbogenerators) running at 60 percent. Therefore, 60 percent of one-half of 17.5 MWe is 5.25 MWe).

REFERENCES

“Backgrounder on Emergency Preparedness at Nuclear Power Plants”, NRC - https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/emerg-plan-prep-nuc-power.html#zones

ABS *Requirements for Nuclear Power Systems for Marine and Offshore Applications* (October 2024).

ABS *Rules for Building and Classing Steel Barges* (January 2024).

ABS *Rules for Building and Classing Marine Vessels* (January 2024).

ACRONYMS AND SYMBOLS

B	Ship's beam; the vessel's width
BL	Baseline; intersection of the longitudinal symmetry plane with the keel
BANR	BWXT Advanced Nuclear Reactor
capex	Capital expense
CL	Ship's center-line; the vessel's plane of symmetry
CO_2e	Carbon dioxide equivalent or CO_2e means the number of metric tons of CO_2 emissions with the same global warming potential as one metric ton of another greenhouse gas
EPZ	Emergency planning zone
FNPP	Floating nuclear power plant
HALEU	High-assay low enriched uranium (up to 20 percent of 235U)
HEU	Highly enriched uranium (235U above 20 percent)
HTGR	High-temperature gas reactor
IAEA	International Atomic Energy Agency
IMO	International Maritime Organization
LEU	Low-enriched uranium (up to 7 percent 235U)
LNG	Liquefied natural gas
MS	Midship location
MW	Megawatt
MWt	Megawatts thermal, a unit of power used for the thermal output of a reactor before conversion to electricity
MWe	Megawatts electrical, a unit of power used for the electrical output of a nuclear plant
NRC	Nuclear Regulatory Commission in the United States (U.S.)
OPS	Onshore power supply
opex	Operating expense
P&I	Protection and Indemnity insurance, as provided by a P&I Club
SMR	Small modular reactor, typically in the 20 to 300 MWe range
TRISO	Fully ceramic TRi-structural ISOtropic coated particle-based fuels
UCO	Uranium oxycarbide

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