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O&G Nuclear Combined Deployment Model and Stage-Gate Framework

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Maritime Nuclear Applications Group
National Reactor Innovation Center

MPR Associates, Inc.

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REVISION LOG

Revision No.	Date	Affected Pages	Description
DRAFT A	March 2, 2026	All	For NRIC Review
DRAFT B	April 17, 2026	All	NRIC and MNAG Feedback Incorporated
DRAFT C	May 21, 2026	Section 3.3	Removed Figures
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ABSTRACT

As the oil and gas industry explores possibilities to improve energy security and operational efficiency in offshore environments, stakeholders have begun exploring nuclear power as a potential solution for powering oil and gas platforms. Conventional offshore oil and gas facilities rely on extracted hydrocarbons or diesel fuel to generate electricity. The maturation of advanced nuclear reactor technologies, combined with decades of naval nuclear propulsion experience with pressurized water reactors, has prompted questions about whether commercially operated marine based (i.e., floating) nuclear power plants could provide secure, reliable baseload power for offshore operations. These questions have sparked technical and regulatory discussions about the technical feasibility, safety requirements, and economic viability of deploying floating nuclear power plants to support offshore oil and gas production in U.S. waters. This report draws from these discussions and explores what a sample stage-gate deployment framework might look like for future Nth-of-a-kind combined offshore oil and gas and nuclear projects. The stage-gate framework highlights critical financial decision gates to help industry partners understand timelines and financial expectations associated with a combined project. This framework provides stakeholders interested in exploring potential benefits of nuclear power with information required to make decisions related to maritime nuclear applications.

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ACRONYMS

ABS	American Bureau of Shipping
BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement
BWR	Boiling Water Reactor
CAPEX	Capital Expenditure
COL	Combined Operating License
COLA	Combined Operating License Application
CZMA	Coastal Zone Management Act
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
DPP	Development and Production Plan
EIS	Environmental Impact Statement
EP	Exploration Plan
EPA	Environmental Protection Agency
EPC	Engineering, Procurement, and Construction
FEED	Front-End Engineering Design
FID	Final Investment Decision
FNPP	Floating Nuclear Power Plant
FNTP	Final Notice to Proceed
FOAK	First of a Kind
FPSO	Floating Production Storage and Offloading
FSO	Floating Storage and Offloading
IACS	International Association of Classification Societies
INL	Idaho National Laboratory
ITAAC	Inspections, Tests, Analyses, and Acceptance Criteria
LLE	Long Lead Equipment
LLWR	Large Light Water Reactor
LNTP	Limited Notice to Proceed
LR	Lloyd’s Register
MNAG	Maritime Nuclear Application Group
NOAK	Nth of a Kind
NRC	U.S. Nuclear Regulatory Commission
NRIC	National Reactor Innovation Center

O&G	Oil and Gas
OPEX	Operating Expenditure
OPS	Offshore Power System
PSV	Platform Supply Vessel
PWR	Pressurized Water Reactor
SAR	Safety Analysis Report
SMR	Small Modular Reactor
SURF	Subsea, Umbilical, Riser, and Flowline
SPAR	Single Point Floating Reservoir
ROV	Remote Operated Vehicle
T&I	Transportation and Installation
USCG	United States Coast Guard

1. INTRODUCTION

1.1 Purpose

The purpose of this report is to describe a potential deployment model and stage-gate framework for an offshore project that incorporates the parallel execution of a floating nuclear power plant (FNPP) and a traditional offshore oil and gas (O&G) platform (i.e., the Project). The stage-gate framework described herein highlights critical financial decision gates to help industry partners understand timelines and financial expectations associated with a combined project. This report helps to set the stage for broader commercial nuclear maritime conversations and strategic exploration by summarizing the current state of the industry, highlighting regulatory and technical roadblocks, and considering how a potential commercial nuclear maritime project may be executed. The stage-gate framework can be leveraged to manage interfaces between the O&G platform and the FNPP and inform risk management strategies through the incorporation of offramps. Understanding how an O&G project deployment model could be superimposed with a nuclear project deployment model will help establish nuclear as a next-generation power source for the offshore O&G industry.

The stage-gate framework and deployment model described herein were developed by the National Reactor Innovation Center (NRIC) in collaboration with experts who regularly participate in Maritime Nuclear Applications Group (MNAG) activities. NRIC is a U.S. Department of Energy (DOE) led program established to accelerate the demonstration and deployment of advanced nuclear reactor technologies. NRIC provides developers with access to national laboratory infrastructure, regulatory support, and operational expertise to help move novel reactor concepts from design through construction and operation. NRIC plays a key role in enabling advanced reactors to reach commercial readiness and supporting novel/emerging applications such as maritime power. MNAG is an industry-led collaborative group designed to convene stakeholders from nuclear, maritime, offshore energy, and regulatory communities to assess technical feasibility, regulatory pathways, and business models for deploying nuclear power in marine environments. MNAG's activities typically center on identifying barriers to deployment, sharing better practices and lessons learned from prior maritime nuclear programs, and developing frameworks to support future applications.

1.2 Primary Use Case

The application of nuclear technology to power offshore O&G platforms presents several potential use cases, each with distinct technical, regulatory, and commercial considerations. These configurations range from centralized FNPPs serving several O&G facilities to fully integrated platforms in which a nuclear reactor is collocated with O&G operations. Understanding the challenges and opportunities associated with various configurations is key to identifying a desired concept and developing the associated deployment pathway.

A large number of deployment options and configurations are possible, and it is not feasible to account for them all in this report. While each configuration has its own set of advantages and challenges, one was found to be more pragmatic in the near term. The candidate configuration that consists of a single floating O&G platform, powered by a dedicated FNPP connected via subsea cabling, was selected as the primary use case for the deployment model and stage-gate framework presented in this report. Consistent with most offshore O&G development in the United States, this project would be located on the Outer Continental Shelf (OCS) in the Gulf of America.

FNPPs offer several advantages in this scenario, most notably ease of transportation for service, lack of need for onsite-construction, and minimal infrastructure at the operating site, allowing for easier logistics during deployment. This report is agnostic to the specific O&G platform type (see Section 7.2 for discussion of alternative O&G use cases). Electrification of different types of production/drilling platforms comes with different sets of benefits and challenges that are outside of the scope of this report. The selected use case reflects a practical deployment scenario, leveraging the Gulf's mature offshore infrastructure, experienced O&G regulatory environment, and well-established supply chain for production systems.

The deployment model and stage-gate framework presented in this report was developed based on the primary use case, depicted in Figure 1, and may not be representative of all use cases. If alternative use cases are selected in the future, the deployment model and stage-gate framework may need to be re-evaluated.

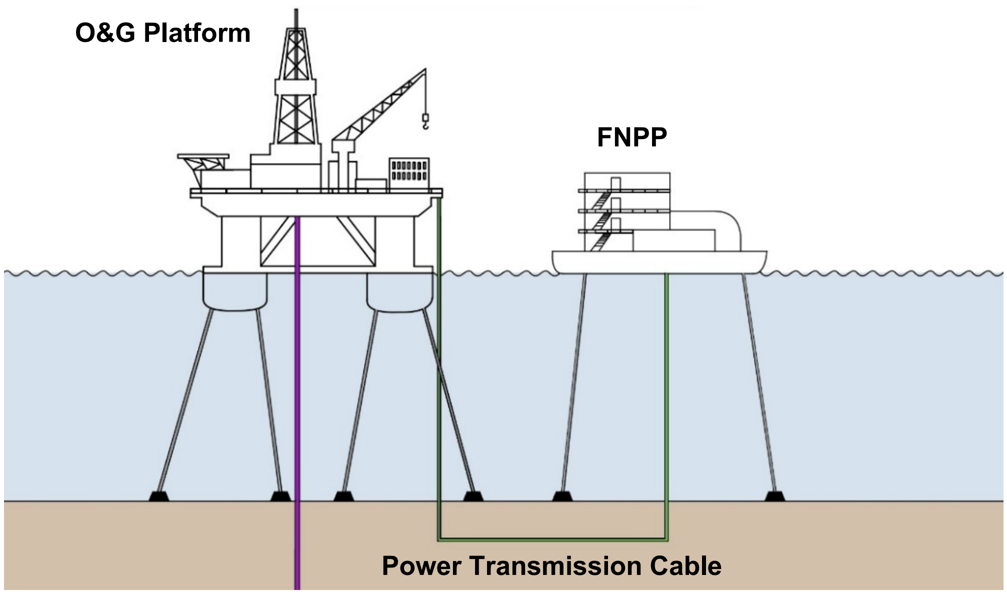


Figure 1. Primary Use Case.

Other configurations were considered during the development of this framework but were ultimately not selected as the primary use case due to potential technical and regulatory complexities. Configurations such as a fully integrated platform in which the nuclear reactor is located on the same floating structure as the O&G platform could minimize subsea power transmission requirements and simplify electrical integration. However, a fully integrated platform is a complex technical and regulatory configuration. This configuration would introduce significant safety challenges related to nuclear–hydrocarbon collocation leading to the need for compounded hazard analyses and safeguards as well as heightened regulatory scrutiny.

The primary use case has the advantage of setting the stage for future examination of a centralized FNPP providing power to multiple offshore O&G platforms via subsea transmission cables. This potential future configuration could offer economies of scale by spreading reactor capital and operations costs across multiple facilities and reducing the number of power generation assets required per field. This approach is not addressed in this report because it would increase dependence on shared infrastructure, elevate exposure to subsea transmission outages, and requires careful coordination of power demand, maintenance, and lifecycle planning across multiple platforms

2. SUMMARY OF RESULTS AND CONCLUSIONS

This report proposes a deployment model and stage-gate framework that can be used to deploy an offshore O&G platform powered by an FNPP. The proposed stage-gate framework and deployment model, described in Sections 5 and 6, show that while technical and regulatory challenges exist, it is possible to align the parallel execution of these projects from two historically separate industries. This report does not explicitly explore the financial feasibility of deploying the projects in parallel (see Section 4.1 for the scope of this report). This report also does not explore O&G platform or FNPP operations, potential operating models, technology feasibility, or required design adaptations.

Key observations on the deployment model are provided below.

- **Project deployment phases and decision points between typical O&G and nuclear projects can be aligned to present a harmonized deployment model**. Traditional O&G deployment frameworks and advanced nuclear deployment frameworks share similarities in their key financial investment decision points (i.e., decision gates). This alignment enables decision gates to be synchronized for efficient parallel development of both the O&G platform and the FNPP in future combined projects. The specific timing between decision gates will vary by project based on the selected nuclear technology and the O&G platform's purpose and configuration (e.g., drilling, production, storage, etc.). Timeline alignment between decision gates is expected to be more achievable in Nth-of-a-Kind (NOAK) deployments where nuclear maritime technologies have reached commercial maturity than in First-of-a-Kind (FOAK) demonstration projects where nuclear maritime technologies are still maturing and regulatory pathways are still being established.
- **Integrating the existing regulatory frameworks for offshore O&G facilities and nuclear facilities creates a complicated regulatory model with overlapping jurisdictions. Potential new pathways remain in a state of evolution as regulatory agencies gain experience with advanced nuclear technologies in marine environments**. A combined nuclear maritime and O&G project will require coordination efforts to align the various regulators in an efficient and effective manner. Anticipated activities include coordinating traditional United States Nuclear Regulatory Commission (NRC) licensing milestones with Bureau of Ocean Energy Management (BOEM) lease approvals and development plan reviews, all while integrating Bureau of Safety and Environmental Enforcement (BSEE) safety reviews, United States Coast Guard (USCG) engagement, and Environmental Protection Agency (EPA) permitting into the overall project schedule. For at least the first few combined projects, the complexity of managing separate regulatory processes will be challenging and represents one of the most significant schedule risks. Overlapping jurisdictions will need to be evaluated further as, for example, the NRC is responsible for licensing all reactors (including maritime projects) and BOEM has not yet established a process for collocation of offshore energy projects. This report recognizes that existing, established regulatory pathways could be applied in novel contexts and/or new regulatory pathways could emerge based on lessons learned from early deployments, potentially streamlining the licensing and deployment process (e.g., coordinated multi-agency review processes, development of specific regulatory frameworks for commercial FNPPs).

- **NOAK deployments of O&G and nuclear maritime facilities likely remain many years into the future**. The timeline to NOAK deployment is driven by the fact that smaller scale advanced nuclear reactors must first be successfully deployed, licensed, and operated as demonstration projects on land or in simpler marine applications before they can be confidently deployed in parallel to an offshore O&G environment.
- **A real-world pilot project is needed to further advance this concept**. Regulators require concrete project specifics to effectively integrate and develop new regulatory pathways. Similarly, a wide range of execution topics are best resolved within actual project contexts (e.g., contracting mechanisms, responsibility allocation, quality requirements, and construction methods).

Prerequisites for initiating a pilot project include identifying O&G and nuclear sponsors with investment appetite, identifying an opportunity with a viable business case, achieving needed technical maturity in the nuclear technology vendor's scope, and potentially government support (that could be in the form of commercial or policy levers).

3. BACKGROUND

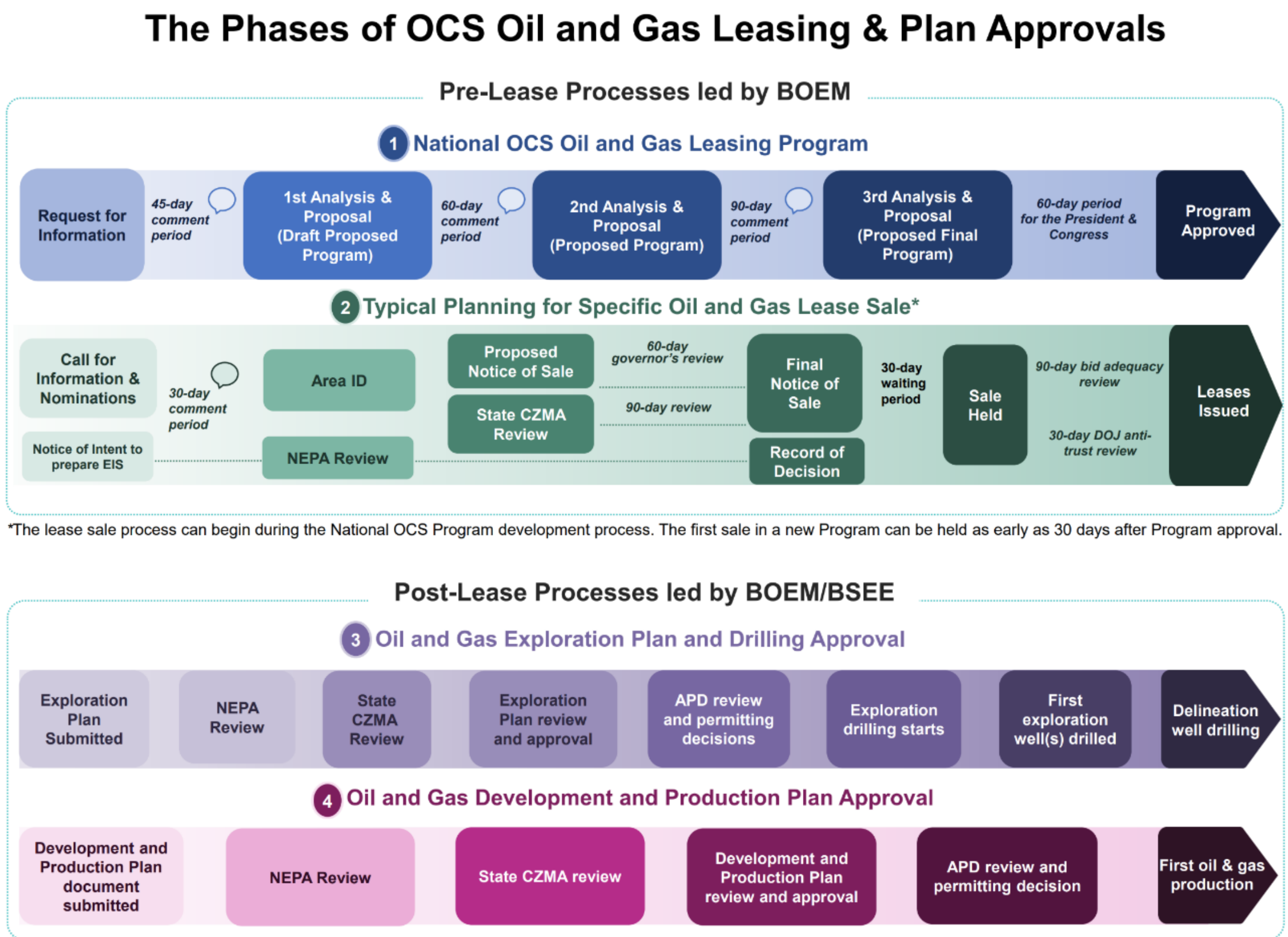
This section provides the historical and technical context needed to frame the subsequent sections of the report. This section describes the background of offshore O&G development and modern nuclear energy systems and provides examples of current commercial maritime nuclear concepts.

3.1 Offshore O&G Background

The majority of offshore O&G platforms in the United States are located on the OCS in the Gulf of America, most particularly off the coasts of Louisiana and Texas. The Gulf of America OCS includes the submerged lands, seabed, and subsoil that lie seaward of state coastal waters and extends 200 nautical miles offshore (Reference 1). The thousands of offshore O&G facilities range from shallow water fixed platforms to deepwater floating platforms. Fixed jacket platforms remain the most common type at depths up to 2,000 feet, consisting of steel jacket structures anchored to the seabed with facilities for drilling, production, and processing of resources (Reference 2).

In recent years, industry focus for new offshore platforms deployed in the Gulf of America has shifted towards floating platforms and away from fixed platforms. As accessible shallow-water reserves have been largely depleted, the industry has progressively moved into deepwater and ultra-deepwater environments (water depths exceeding 1,000 feet and 5,000 feet, respectively) (Reference 2). At these depths, fixed platforms become technically impractical. Examples of floating platforms include tension-leg platforms, single point floating reservoirs (SPARs), and floating production, storing, and offloading (FPSO) platforms. Floating platforms have mooring systems that tie them to the sea floor as opposed to the anchored jacket structures used for fixed platforms. Most offshore platforms are powered by gas turbines or diesel generators located on the platform, with typical power requirements ranging around 40-150 MW for deepwater floating O&G platforms (References 3 and 4). For production platforms, most of the power comes from gas turbine generators powered by off-gasses associated with oil production. The remainder of the power, for cold start and backup power, comes from generators powered by diesel fuel that is shipped to the platform via specialized platform supply vessels (PSVs). Drilling platforms do not have the same access to off-gasses for power generation; the primary source of power for these platforms comes from fuel that is delivered to the platform by PSVs.

BOEM, as part of the U.S. Department of the Interior (DOI), oversees all O&G licensing and construction on the Gulf of America OCS. BOEM performs regional assessments of the Gulf of America OCS and provides initial data, grants leases for blocks, and approves exploration, development, and production plans to entities interested in O&G platform deployments. Figure 2, provided by BOEM, explains the lease processes, led by BOEM and BSEE, through which O&G deployment occurs.



Note: Government-to-Government consultations are conducted throughout all leasing phases.
Key: OCS= Outer Continental Shelf; APD = Application for Permit to Drill; CZMA = Coastal Zone Management Act; DOJ = Department of Justice; EIS = Environmental Impact Statement; NEPA = National Environmental Policy Act

Figure 2. BOEM/BSEE O&G Lease Process (Reference 5).

Several other permits must be obtained from entities such as BSEE, USCG, and the EPA.

BSEE is primarily responsible for reviewing and approving detailed engineering designs and safety systems, conducting inspections throughout fabrication, installation, and operations, enforcing operational safety requirements, and overseeing incident investigation and enforcement actions for safety violations.

The USGC is primarily responsible for reviewing and approving platform design for maritime safety and stability, ensuring compliance with vessel traffic and navigation safety requirements, conducting inspections of emergency evacuation systems, and enforcing maritime security regulations.

The EPA is primarily responsible for regulating air emissions from O&G platforms, enforcing water discharge standards, and ensuring compliance with hazardous waste management regulations for onboard waste handling and disposal.

The O&G developer is responsible for securing offshore leases through BOEM lease sales, preparing development and production plans (DPPs) with environmental impact assessments (EIAs), designing and constructing the floating platform to meet all regulatory requirements from BSEE, USCG, EPA, and others, obtaining all necessary permits and approvals before installation and operations, maintaining operational safety and environmental compliance throughout the platform lifecycle, and ultimately funding and executing decommissioning and site restoration when production ceases.

3.2 Nuclear Background

The deployment of commercial nuclear reactors in the United States is governed by the NRC. Traditional large light water reactors (LLWRs), including pressurized water reactors (PWRs) and boiling water reactors (BWRs), make up the existing commercial fleet in the United States. While the vast majority of regulatory experience comes from large reactors in land-based facilities, it is recognized that the NRC is ramping up capabilities and experience for projects using smaller reactor designs in non-traditional applications. Small reactor designs (i.e., small modular reactors (SMRs) and microreactors) are being explored heavily in the nuclear industry due to anticipated lower costs, shorter deployment timelines, and smaller footprints. Where current commercial nuclear fleet LLWRs have an electrical power output of roughly 1000 MW per unit, microreactors are intended to produce up to 20 MW per unit, and SMRs upwards of 300 MW (Reference 6). Although SMRs and microreactors are becoming more attractive deployment options in the nuclear industry, many are still going through regulatory processes with the NRC and planning for construction of first deployments in the near future.

The NRC has established various pathways for reactor licensing and standard design approvals:

A. A well understood two-step process under 10 CFR Part 50

B. A streamlined combined license approach under 10 CFR Part 52.

C. A newly established 10 CFR Part 53, risk-informed and technology inclusive, framework. This option offers a voluntary, performance-based alternative for licensing future commercial nuclear plants (Note - This pathway was not considered in this report as it was in draft state at the time this framework was developed).

10 CFR Part 50 represents the traditional licensing approach, requiring a two-step process. First, a construction permit is obtained, followed by preliminary design review and subsequently obtaining an operating license after construction completion and demonstration that the as-built facility conforms to the approved design and can operate safely. This sequential approach allows for design evolution during construction but creates regulatory uncertainty regarding final approval (Reference 7).

10 CFR Part 52 (one-step process) offers the ability to obtain a combined operating license (COL) that authorizes both construction and conditional operation in a single proceeding. The COL approach resolves major safety and environmental issues before construction begins, reducing the risk of delays, though it requires more complete design information upfront. Following COL approval under 10 CFR Part 52, the licensee may commence construction of safety-related structures, systems, and components, with construction durations around 7-10 years for LLWRs and an estimated 2-4 years for factory-fabricated SMRs (Reference 6). Throughout construction, the NRC conducts regular inspections to verify conformance with the COL, while the licensee completes inspection, test, analysis, and acceptance criteria (ITAAC) to demonstrate that the as-built facility conforms to the certified design. Upon ITAAC completion and NRC verification, the NRC authorizes nuclear fuel loading under 10 CFR 52.103(g), enabling the licensee to load nuclear fuel and begin low-power testing (see Section 6.5.1 for further details). Commissioning then proceeds through progressive power testing and full-power demonstration, resulting in the NRC's final finding under 10 CFR 52.103(g) that all ITAAC have been successfully completed, and the plant may commence commercial operation (Reference 8). 10 CFR Part 52 was chosen as the pathway for this deployment model due to the enhanced regulatory stability and reduction in risk associated with the design pre-approval process in addition to the efficiencies associated with the streamlined combined license.

Existing regulatory processes described in this subsection were developed for conventional, land-based nuclear deployments. Application of the existing regulatory processes to an FNPP may require adaptation in sequencing and integration due to fabrication, transportation, and offshore commissioning considerations. Regulatory processes are subject to updates and improvements, however changes to existing rules or the development of new ones follows a thorough review process.

Among other things, licensing and standard design approval pathways require demonstration of systematic safety analysis results, environmental impact reviews, and demonstration of financial and technical qualifications. The licensing process involves multiple stages of assessment by NRC staff and public participation at hearings. Since current SMR and microreactor deployment projects are FOAK, the deployment timeline is understandably longer in order to address novel technologies and methodologies proposed by the applicant and its supply chain. Once SMR and microreactor deployments become NOAK, the deployment timelines are expected to see time and cost efficiencies as a result of industry experience gained during fabrication and construction of first deployments.

An applicant for a nuclear project is expected to develop a working understanding of the regulatory processes in order to select and justify which framework best fits the project(s) being proposed. NRC offers a variety of pre-licensing tools to obtain feedback on proposed technologies and methodologies including feedback on which licensing process may best fit a specific use case. The NRC’s pre-licensing support options range across facilitating drop-in meetings, offering feedback on white papers, and issuing evaluation reports on submitted topical reports.

Licensing is normally carried out in stages commensurate with typical project stages and the nature of the safety issues associated with each stage. Construction is focused on the quality of the as-built facility design and assurances that no flaws are emerging that could pose safety/security issues in the operating phase. A decision to operate the facility gets the greatest amount of attention given the prevention and mitigation of risks associated with the presence and use of nuclear substances during operation. The NRC is responsible for conducting safety and environmental reviews at each licensing stage, ensuring compliance with all applicable regulations, conducting inspections throughout construction and operation. Additionally the NRC maintains oversight authority to modify licenses or otherwise impose conditions or take action to compel corrective action to comply with requirements if safety concerns arise during the reactor's operational lifetime.

As part of the reactor procurement process, nuclear technology developers are typically expected to demonstrate that the technologies being developed and the processes being used meet all NRC safety requirements. This includes preparing design documentation for use in any design approval or certification processes and/or, by the project applicant in their licensing submissions. These vendors are typically expected to provide continuous technical and engineering support to the project licensee including responding to NRC inquiries, supporting closure of regulatory matters, providing operational fleet support, and maintaining long-term parts availability and design updates for the design life of their reactors.

3.3 Commercial Nuclear Maritime

At present in the United States, naval nuclear applications are regulated under separate defense regulatory provisions and are therefore not subject to civilian regulations. This limits the ability of the commercial sector to leverage elements of technologies used for military purposes such as (1) access to technical information in the naval nuclear sector is not available due to national security reasons, and (2) defense regulatory frameworks differ from civilian frameworks. This is typical for most countries with nuclear naval capabilities[a].

While the commercial maritime nuclear environment is largely uncharted, there have been a few projects that have explored its potential feasibility. In the 1960s and 1970s, Westinghouse Electric Corporation developed conceptual designs for FNPPs based on their PWR technology, most notably proposing barge-mounted nuclear plants that could be constructed in shipyards and towed to coastal sites to provide electricity to areas without suitable land locations for nuclear reactor deployments. The most advanced concept was the Offshore Power Systems (OPS) project, a joint venture between Westinghouse and Tenneco that received significant attention in the mid-1970s, proposing standardized 1,150 MWe FNPPs to be fabricated at a dedicated manufacturing facility and moored in coastal waters a few miles offshore. Despite receiving preliminary design approval and constructing the manufacturing facility, the OPS project was ultimately cancelled in 1982 due to a combination of factors, including declining electricity demand growth following the 1970s energy crisis, increased capital costs and regulatory uncertainty following the Three Mile Island accident in 1979, public opposition to nuclear facilities, and the inability to secure firm orders from utilities (Reference 9). In present day, public opinion has improved, and electricity demand has increased significantly. Ceasing

a The only exception to this is found in the Russian Federation, where a multiple decade effort was carried out to establish a civil framework for nuclear ships. This was first established to accelerate the development and deployment of their nuclear icebreaker fleet and then adapted to accommodate their proposed barge-mounted floating nuclear power platform concept. These facilities are all commercially operated but were also heavily supported under a national security umbrella. (Reference 10) on this demand and widespread acceptance of nuclear technology, several companies are pursuing plans to develop their own FNPPs.

Outside of the United States, Russia successfully deployed the Akademik Lomonosov, which began operation in May 2020 in Pevek, Chukotka. This unit provides roughly 70 MW of electrical power to the remote Arctic community using two modified KLT-40S naval propulsion reactors. Russia's state nuclear corporation Rosatom is actively marketing this technology internationally and developing next-generation designs including the RITM-200 based floating power plants with enhanced power output (up to 50 MWe per reactor) and optimized construction timelines (Reference 11).

China has similarly pursued floating nuclear technology with the development of the ACPR50S, a small modular PWR specifically designed for offshore deployment to power remote island installations and offshore O&G platforms, with the first demonstration unit under construction and planned deployment in the South China Sea to support energy security for disputed island territories and offshore resource development (Reference 12).

4. METHODOLOGY

This section includes discussion on the methodology NRIC leveraged to develop the deployment model and stage-gate framework that follows.

4.1 Scope

The purpose of this study is to develop a stage-gate framework and propose a deployment model that can be used to deploy an offshore O&G platform powered by an FNPP. The deployment model includes steps needed for site specific project scoping, design, procurement, construction, and regulatory pathways. The model starts at project initiation, ends with reactor startup, and does not include operations of either facility. The report explores how to merge the requirements and practices associated with nuclear and O&G deployment models, including regulatory practices in addition to construction, design, finance, and project management. A robust evaluation of the feasibility of this concept should consider all of the above topics in detail, many of which are being evaluated by NRIC in concert with this study. The merged deployment model has features that are not present in either of the two separate sets of practices from the two industries.

For effective focus, and to reduce complexity, this report focuses on the deployment model and stage-gate framework and does not evaluate or discuss many other topics that are associated with nuclear deployment on an offshore platform, including:

- Financial Evaluations - Assessing the financial feasibility of deployment of nuclear facilities on an absolute basis and relative to other optimization pathways (e.g., renewables).
- Design Adaptations - Adapting the design of a nuclear technology to an offshore environment.
- Operating Model - Development of the operating model and concept of operations.
- Risk Assessment - Producing a risk matrix and mitigation plan for a combined O&G and maritime nuclear project, assessing insurance and liability considerations.
- Deeper Technical and Regulatory Studies – Consideration of high-voltage dynamic power cable design, alignment of less critical regulatory permits, etc.

4.2 Assumptions and Ground Rules

There are many potential configurations that a combined nuclear maritime and O&G project could leverage. To enable development of a deployment model and stage-gate framework, the following assumptions are made:

- The O&G company and FNPP owner/operator are separate entities.
- The O&G company is a United States-based company with Gulf of America operating experience, and the FNPP owner/operator would similarly be a United States entity due to domestic nuclear regulatory requirements and national security considerations.
- The O&G platform will be deployed at a site with little detailed site characterization prior to project initiation and no previous development/construction.
- The O&G facility and the nuclear reactor will be on separate floating platforms.
- The FNPP will solely provide power to the offshore floating O&G platform and will have no cabling or piping connections to shore.
- The FNPP will be powered by one or multiple microreactor(s) or a single SMR.
- The combined deployment schedule is presented as an aspirational NOAK project rather than a FOAK project with the assumption that FOAK specific challenges (e.g., novelties of technology/processes and their impacts on decision making) have already been resolved to the degree practicable.
- The nuclear portion of the Project will follow the 10 CFR Part 52 (one-step) process instead of the 10 CFR Part 50 (two-step) process.
- The primary product that would be delivered from the FNPP to the O&G platform is electric power. Heat is a potential second order consideration that could have a number of interesting technical value case considerations but is not discussed in this study.
- The integrated O&G and nuclear maritime project is deployed in federal territorial waters of the United States on the Outer Continental Shelf (OCS) of the Gulf of America (in deepwater).
- Fuel loading takes place at the deployment site (in alignment with current regulatory frameworks, see Section 6.5.1 for details)

4.3 Approach

NRIC leveraged a phased approach to develop a stage-gate process for the integrated O&G and nuclear maritime project. The stage-gate process discussed herein is informed by research, interviews with industry experts, broader MNAG contributor reviews, and domain expertise within NRIC.

NRIC conducted research to gain insight into FNPP technology and O&G platform deployment via review of existing concepts and literature. NRIC leveraged domain expertise and insights from the initial literature review to develop a preliminary stage-gate framework.

NRIC led exploratory discussions with stakeholders including nuclear technology vendors, offshore O&G platform operators, regulators, classification societies, and other industry experts. The purpose of the stakeholder interviews was to solicit feedback on the preliminary stage-gate framework, identify topics that required additional investigation, and further inform the report.

Insights from interviews and subsequent research informed updates to the stage-gate framework and the report. The draft report was reviewed by interviewees as well as MNAG working groups to ensure insights from interviews were appropriately captured and the report contents met expectations.

5. PROPOSED STAGE GATE FRAME WORK

This section presents a proposed stage gate framework for a combined offshore O&G and nuclear maritime project. Figure 3 depicts a Gantt chart of the proposed deployment model and stage gate framework. Detailed discussion of key deployment model activities and milestones identified in the Gantt chart is included in Section 6.

In Figure 3, the project phases are shown at the top of the chart, and the major workstreams are noted along the left side. The Gantt chart includes key activities, milestones, and class estimates that occur throughout the Project. Class estimates are a classification system used to define the accuracy and maturity of project schedules and budgets (i.e., Class 5 are the most high-level estimates and Class 1 are the most detailed, accurate estimates). Each bar in the Gantt chart is high-level and can represent a series of detailed steps, but for visualization purposes is represented as a single bar. Activity durations are not included in the Gantt chart since it is a notional deployment framework. The Gantt chart is intended to illustrate the sequence of events for major tasks.

O&G Nuclear Combined Deployment Model and Stage-Gate Framework

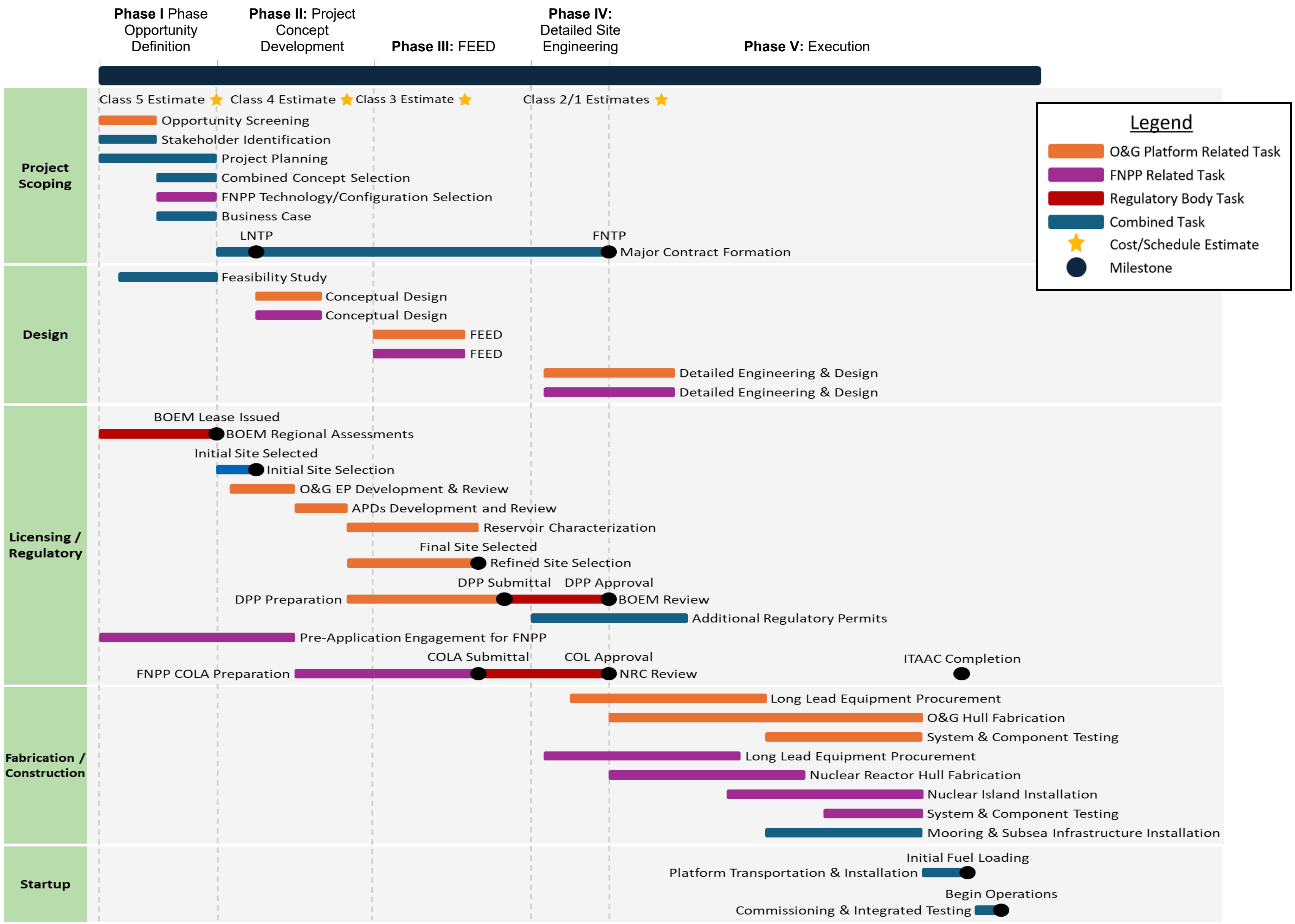


Figure 3. Proposed Deployment Model and Stage-Gate Framework for Combined Offshore O&G and Nuclear Maritime Project.

The proposed deployment model and stage-gate framework shown in Figure 3 includes five phases that progressively mature the Project and decision gates to ensure the Project remains aligned with its goals and objectives (e.g., financially viable). The phases of the Project are outlined in Section 5.1 through 5.5. Each phase includes a set of key tasks that are completed in series or parallel. Decision gates (i.e., key financial investment decisions) follow each Project phase. At each decision gate, the project leadership team (likely formed from executive leadership of the O&G company and FNPP owner/operator) would be responsible for:

1. Making a go/no-go decision for further investment based on stakeholder insights, perspectives on risk, and the likelihood of the Project being able to deliver on the commercial requirements.
2. Adjusting areas of emphasis for the follow-on phase based on the outcomes of the prior phase.
3. Refining budgets and schedules for the next phase and the full delivery model.

Each decision gate offers an off-ramp through which the Project can be paused or terminated. Figure 4 illustrates the proposed phases and decision gates offered in this report.

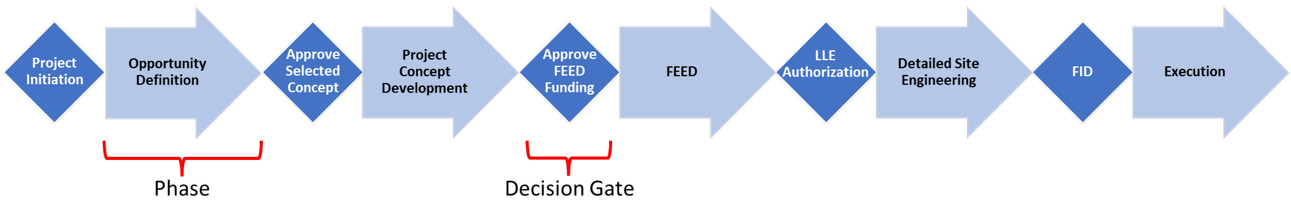


Figure 4. Proposed Phases and Decision Gates for Project Deployment.

The phases and decision gates proposed in this report and discussed throughout this section may differ from those eventually used by stakeholders interested in deploying a project of this nature. It is likely that future deployment frameworks would closely resemble that proposed in this report, but additional phases/gates could be added and/or existing or additional scope could be shifted to an earlier or later phase.

5.1 Phase I – Opportunity Definition

Phase I, Opportunity Definition, initiates when a O&G company decides to commit resources to a decision-making process for an O&G project. This report, which focuses on NOAK projects, assumes that the O&G facility will be powered by an FNPP.

Most key tasks during Opportunity Definition are project scoping and planning based tasks (See Table 1). The goal of Phase I is to define the Project and determine if the Project can credibly deliver the desired revenue/benefits within the Project owners' business case. Activities like concept selection and the feasibility study will be crucial once the project scope is optimized for the purposes of proceeding efficiently through the various regulatory decision-making paths. If an economically viable opportunity for potential deployment is identified, the decision gate to move on to Phase II is approving the selected concept. Additional details informing the approval of the selected concept include whether the identified opportunity, selected concept, and project plan, budget, and schedule align with the project objectives. If the selected concept is approved, the O&G company can submit a competitive bid to BOEM for a block to deploy the Project. Once a lease is obtained from BOEM, Phase II begins, and the FNPP owner/operator will have clarity on the region in which the FNPP site will be located (informing early characterization, design, and safety analysis work).

The Opportunity Definition phase concludes with a Class 5 estimate for Project cost and schedule, which will be developed by the O&G company and FNPP owner/operator. The Class 5 estimate is a high-level, rough order of magnitude estimate used for initial feasibility. Table 1 provides a summary of key tasks of the Opportunity Definition phase.

Table 1. Phase I – Opportunity Definition Summary.

Key Tasks	Decision Gate
Opportunity Screening Stakeholder Identification Project Planning Combined Concept Selection FNPP Tech./Config. Selection Business Case Feasibility Study BOEM Regional Assessments	Approve Selected Concept

5.2 Phase II – Project Concept Development

Phase II (Project Concept Development) and Phase III Front-End Engineering Design (FEED) are similar in that they both focus on maturing the project concept and preparing for regulatory decision-making processes. Phase II includes collecting the design information necessary to carry out early engagement with regulators to identify Project-specific regulatory challenges. This information is used by the Project planners and decision makers to plan if/how to prevent and mitigate Project risk. For the FNPP portion, information from Project Concept Development is used to conduct early combined license application (COLA) development, exploration plan (EP) development and review, and early DPP development. The decision gate to move onto Phase III is approving FEED funding. Key aspects that will inform this decision include if early regulatory application development is progressing on schedule and Project-specific design maturity is progressing such that information needed for future decision-making processes will be ready and sufficient to prevent delays.

Refined Class 4 estimates for Project cost and schedule will be formed near the end of the Project Concept Development phase based on insights from Phase II. Table 2 provides a summary of key tasks of the Project Concept Development phase.

Table 2. Phase II – Project Concept Development Summary.

Key Tasks	Decision Gate
Major Contract Formation Combined Conceptual Design Initial Site Selection O&G EP Development & Review APDs Development & Review Reservoir Characterization Refined Site Selection DPP Preparation FNPP COLA Preparation	Approve FEED Funding

5.3 Phase III – FEED

Phase III, FEED, is a continuation of Phase II, and its primary objective is to advance the design and licensing maturity of the Project. During the FEED phase, key regulatory applications need to be submitted to their respective regulators (i.e., DPP to BOEM and COLA to NRC). Early regulatory reviews will be supported by the appropriate applicants for the activities proposed (e.g., O&G company for O&G activities, FNPP owner/operator for FNPP activities, etc.). In each case, the applicant is supported by their supply chain (e.g., FNPP vendor). A proposed decision gate to proceed to Phase IV is Long-lead Equipment (LLE) procurement authorization. LLE procurement authorization occurs before the Final Investment Decision (FID), allowing some capital to be put at risk before all permits are obtained to keep the Project on schedule. However, for both O&G and FNPP LLE procurement, authorization of LLE is highly dependent on several factors, including:

- Sufficient technical information to support an LLE approval given the commercial risk of the long-lead process
- Status of regulatory reviews (i.e., regulatory review process is progressing on schedule)
- Project owners' risk appetite

The Project team can proceed to Phase IV with higher confidence after Project owners confirm the above criteria are met. The decision to authorize LLE procurements will be project specific. Owners of NOAK projects will determine If the proposed decision gate aligns with their risk tolerance and execution approach.

Insights from Phase III will be used to produce Class 3 estimates for Project cost and schedule. Table 3 provides a summary of key tasks of the FEED phase.

Table 3. Phase III – FEED Summary.

Key Tasks	Decision Gate
Major Contract Formation FEED Reservoir Characterization Refined Site Selection DPP Preparation BOEM Review of DPP FNPP COLA Preparation NRC Review of COLA	Authorize LLE Procurement

5.4 Phase IV – Detailed Site Engineering

Phase IV, Detailed Site Engineering, includes supporting regulatory reviews and receiving approval on key regulatory applications. The project team will advance detailed site engineering while regulatory reviews are in progress.

The decision gate at the end of Phase IV, the FID, is a critical point where the rest of the capital can be put forth to complete the Project because the Project-specific design is sufficiently advanced and there is confidence in regulatory approvals. The FID decision gate typically represents a “point of no return,” where all remaining capital from Project owners is committed, enabling the remainder of equipment procurement and fabrication to occur. There are no more off-ramps once this decision has been made. Well-defined Class 2 and 1 estimates for Project schedule and budget (i.e., roughly 50+ percent defined with higher levels of accuracy) will be in the late stages of refinement around the time of FID to better inform the decision.

Several criteria are used by Project owner(s) to evaluate the Project’s status and determine if the FID should be approved. FID criteria for a combined nuclear maritime and O&G project would likely include:

- Detailed class estimates indicating that the lifecycle economic results of the Project clear financial hurdles and requirements.
- Engagement with regulators is progressing according to plan. A conservative developer would require all major regulatory approvals to be in hand prior to FID. A more risk tolerant developer might require a clear line of sight to all major regulatory approvals.
- Major contracts are executed (e.g., engineering, procurement, and construction (EPC)) companies, supply chain, operations and maintenance staff).
- The remaining risks involved in the final stage of execution and delivery are within the Project owners’ risk appetite.
- Sufficient design configuration readiness.

Table 4 provides a summary of key tasks of the Detailed Site Engineering phase. Completion of activities in the Detailed Engineering Phase will provide information required to inform the FID decision.

Table 4. Phase IV – Detailed Site Engineering Summary.

Key Tasks	Decision Gate
Major Contract Formation Detailed Engineering & Design BOEM Review of DPP NRC Review of COLA Additional O&G Regulatory Permits Long Lead Equipment Procurement	FID

5.5 Phase V – Execution

Phase V, Execution, includes fabrication, installation, and commissioning. The Execution phase will have the longest duration of all the phases and ends with the approval to start commercial operations.

The FID made at the end of Phase IV releases the rest of funds required for the remaining procurement and major fabrication activities. There are several moving parts to the Execution phase, especially considering various portions of the Project would likely be manufactured in different locations around the globe. The order of events in the proposed deployment framework described in this report will likely change for a true NOAK scenario.

Class 2 and 1 estimates will be finalized early in the Execution phase once detailed engineering is nearing completion. For the FNPP, final supply vendor qualification is completed in order to proceed with determining final estimates for goods and services. There is no decision gate that concludes the Execution phase. Instead, the Execution phase concludes once both the O&G platform and the FNPP are in operation and integrated to achieve the Project objectives (i.e., end of the deployment framework in this report). Future work will need to address forward-looking phases, such as operations, outage management, waste management, and decommissioning. Table 5 provides a summary of key tasks of the Execution phase.

Table 5. Phase V – Execution Summary.

Key Tasks	Decision Gate
Detailed Engineering & Design Additional O&G Regulatory Permits Equipment Procurement O&G Hull Fabrication Nuclear Reactor Hull Fabrication Nuclear Island Installation System & Component Testing Mooring & Subsea Infrastructure Installation Platform Transportation & Installation Commissioning & Integrated Testing	N/A

6. PROPOSED DEPLOYMENT MODEL ACTIVITIES

This section discusses the proposed deployment model activities and milestones from Figure 3 in greater depth. The deployment model activities are grouped into five major workstreams: project scoping, design, licensing/regulatory, fabrication/construction, and startup/commissioning.

6.1 Project Scoping

The project scoping phase establishes the foundation for the Project. This section discusses the key elements of the project scoping process.

6.1.1 Opportunity Screening

Opportunity screening begins when an O&G company starts to actively consider deploying a new O&G platform. For the purposes of this report, a specific opportunity (i.e., the Project) must be identified in which an O&G platform is suited to be powered by an FNPP. The O&G company establishes scoping estimates for the power requirements of the new O&G platform based on its primary purpose and completes early technical and economic analyses to demonstrate the viability of powering the O&G platform with an FNPP over other methods, including conventional gas turbines commonly used in the O&G industry. As the lead stakeholder for the Project, the O&G company (i.e., owner of the future O&G platform) must engage and work with the FNPP owner/operator (the proposed deployment model assumes that the FNPP owner and O&G owner are different entities) to explore viable commercial arrangements of an O&G platform with an FNPP and understand applicable regulatory pathways. Stakeholder identification and project planning will be conducted in parallel with opportunity screening, which will then lead into more detailed project scoping activities.

6.1.2 Stakeholder Identification

Stakeholder identification is the process of identifying entities that will influence, be impacted by, or have regulatory authority over the Project. Stakeholder identification is a critical activity due to the complexity of the Project and its intersection of nuclear regulation, maritime law, offshore energy production regulation, and environmental protection law. The purpose of stakeholder identification is to create a list of stakeholders, identify each of their interests, understand levels of authority and influence, and create engagement plans. Early engagement plans for each stakeholder are established once a complete list of stakeholders is assembled.

The O&G company evaluating opportunities to power a new O&G platform with an FNPP will be responsible for coordinating stakeholder identification with the FNPP owner/operator. Major regulators common to the O&G industry include BOEM, BSEE, USCG, and EPA. Additional regulators, such as the NRC, will also be major stakeholders for the Project. The eventually selected nuclear technology vendor and FNPP owner/operator will lead NRC interactions.

Table 6 provides brief descriptions of several stakeholders that would likely be involved in a project of this nature.

Table 6. Typical Stakeholder Descriptions.

Stakeholder	Description
O&G Company (O&G Platform Owner/Operator)	The O&G company is the lead stakeholder for the Project and is responsible for determining the financial viability of powering the O&G platform with an FNPP. They are the lessee for offshore hydrocarbon production and purchase electrical power from the FNPP under a power purchase agreement. They are also responsible for the safe production, storage, and offloading of hydrocarbons.
FNPP Owner/Operator	The FNPP owner/operator is responsible for addressing all aspects of the FNPP deployment lifecycle and determining the FNPP’s viability of being deployed in arrangement with an offshore O&G platform. Owns the FNPP and holds the licenses issued by the NRC (and other applicable permits for the FNPP), is responsible for all nuclear operations and maintenance activities, sells electrical power to the O&G platform operator, and is ultimately liable for nuclear safety and regulatory compliance.

Table 6. Typical Stakeholder Descriptions.

Stakeholder	Description
Engineering, Procurement, and Construction (EPC) Contractor[1]	Organization responsible for the detailed design, procurement of equipment and materials, fabrication and construction of the nuclear platform hull and/or the O&G platform, quality assurance and testing, and delivery of the completed facility ready for commissioning.
Nuclear Technology Vendor (and their Supply Chain)	The nuclear technology vendor will supply the SMR or microreactor technology, assist the FNPP owner/operator with NRC licensing process and subsequent permitting, and support the FNPP owner/operator in the procurement of nuclear related structures, systems, and components. The supply chain of the nuclear technology vendor is subject to FNPP licensee scrutiny. Manufactures or oversees manufacturing of nuclear components. The nuclear technology vendor may also provide initial fuel loading services.
BOEM	BOEM manages the development of U.S. offshore O&G resources on the Gulf of America OCS by planning lease sales, conducting environmental reviews, and issuing leases to companies. Develops offshore leasing programs and oversees the early stages of exploration and development planning. This includes issuing a lease for the O&G platform location, reviewing and approving the DPP, and ensuring compliance with environmental and resource management requirements (Reference 13).
NRC	Nuclear safety regulator responsible for assessing the license application and other technical documents associated with the FNPP, carrying out activities to verify the licensee is in compliance with nuclear safety and security regulations, and issuing the COL (Reference 14).
BSEE	BSEE verifies the safety and environmental compliance of offshore O&G operations, including conducting inspections of the O&G platform facility, reviewing the Safety and Environmental Management System (SEMS), and enforcing regulations to prevent accidents and environmental damage (Reference 15).
EPA	EPA regulates environmental discharges and air emissions from both platforms, ensures compliance with Clean Water Act and Clean Air Act requirements, and assesses the environmental impact of the combined facility operations (Reference 16).
USCG	Maritime Safety authority responsible for certifying floating platforms, enforcing security zones around the facilities, and ensuring compliance with international maritime conventions and domestic vessel safety regulations (Reference 17).
Classification Societies	Maritime industry institutions that possess the authority to assess and certify ships for compliance with safety, environmental, and construction standards. They also ensure safety and reliability compliance of all vessels Applicable classification societies for this Project include the American Bureau of Shipping (ABS), Lloyd's Register (LR), etc. (Reference 18).
Community Stakeholders	Encompasses federally recognized tribes, fishing communities, coastal communities, etc. These stakeholders participate in public comment periods during environmental reviews and advocate for the protection of cultural resources, fishing grounds, and coastal economies.

[1]The quantity and roles of EPCs will likely vary from project to project. For FOAK deployments, the likely model would include one EPC responsible for the fabrication of the O&G platform and one EPC responsible for the fabrication of the FNPP. For NOAK deployments, it is possible that an EPC that supports the combined project could be leveraged if it benefitted the overall deployment. This report generally refers to the EPC as the collection of potential contractors hired to support execution of the Project.

6.1.3 Project Planning

Project planning lasts for the duration of all project scoping tasks. Project planning is used to establish the framework for developing and deploying an O&G platform powered by an FNPP. For efficiency, this activity involves creating and managing an integrated schedule, establishing the Project's governance structure, and developing an execution strategy. An initial risk register will be created along with a risk management plan due to the various complexities stemming from an interdisciplinary project, including parallel regulatory pathways and extended licensing timelines. Additionally, separate decommissioning plans and funding need to be established during the project planning process for the end of life of the O&G platform and the FNPP. The bulk of project planning concludes once the overall project concept selection is finalized.

The O&G company and FNPP owner/operator are the main stakeholders that are responsible for project planning, but all stakeholders should be involved in either a supporting role or as a reviewer (e.g., regulators can inform regulatory pathways).

Project planning must account for stage-gates aligned to milestones within both the O&G platform and FNPP development. The framework discussed in this report is intended to support this process. Refer to Section 5 for discussion of the proposed Project phases.

6.1.4 Combined Concept Selection

Once the initial project scoping activities (i.e., opportunity screening, stakeholder identification) are essentially complete, combined concept selection can begin. Combined concept selection encompasses the process of matching O&G project requirements with a commercially available FNPP design. The matching process involves the O&G company and FNPP owner/operator evaluating and agreeing on a combined O&G platform and FNPP model that is best suited to capture the identified opportunity. This report speculates that for NOAK scenarios, multiple established FNPP configurations will be commercially available. The FNPP configuration best-suited for the O&G platform will be selected.

Key features of concept selection include establishing the O&G platform use-case (i.e., drilling, production, storage, combination), O&G and FNPP platform configuration, and power delivery method. Selection criteria, established by the O&G company, will be used to score various combined arrangement concepts and come to a final decision. Selection criteria may include factors such as capital cost, technical practicality, and economic feasibility. Nuclear technology selection (i.e., FNPP configuration selection) is a parallel activity to combined concept selection and is further discussed in the technology selection section.

Certain O&G platform design details will directly inform the FNPP matching process. For example, once the O&G platform use-case (i.e., drilling, production, storage, combined) is determined, the O&G platform power requirements will be better defined. The estimated power requirements will be used to match the O&G platform with an appropriate FNPP configuration capable of being deployed within the O&G deployment timeline. The selected and approved combined concept becomes the basis for all subsequent activities for the Project. The O&G company and selected FNPP owner/operator must engage with applicable regulators to understand the regulatory feasibility of various potential concepts.

6.1.5 FNPP Technology/Configuration Selection

In a NOAK scenario, the potential FNPP owner/operators will enter discussions with the O&G company with pre-evaluated FNPP configurations. The FNPP owner/operators will have already undergone a significant amount of engineering, safety analysis and security/safeguards efforts to demonstrate the FNPP configuration meets requirements and is ready to deploy.

During FNPP selection, the O&G company should evaluate how commercially available reactor designs and FNPP configurations match with the overall project requirements. Requirements of the FNPP for the overall Project may include:

- Power output is sufficient and provides operational flexibility to match the O&G platform electrical demand, which can be anywhere around 40-150 MWe (References 3 and 4)
- Reactor and FNPP designs are mature, have proven performance in marine environments, and have the readiness to continue the licensing process
- Fuel cycle length and refueling requirements align with the O&G production schedule flexibility
- Supply chain is capable of supporting fuel delivery to meet FNPP outage schedule
- FNPP supply chain has demonstrated to be sufficiently reliable over the lifecycle of the facility to reduce the potential for extended unplanned service interruptions for the O&G platform
- Clarity on how security of the FNPP will be provided (design provisions and use of security forces)
- Vendor financial stability and project delivery capability
- Lifecycle costs (e.g., fuel, maintenance, decommissioning) are acceptable

Once the O&G company has executed an agreement with an owner/operator of the FNPP, the FNPP owner/operator will be the primary stakeholder responsible for demonstrating both that the FNPP meets the O&G company needs and that the FNPP can be complete Project phases on a schedule that is aligned with the desired O&G platform deployment.

6.1.6 Business Case

Business case development includes conducting economic analyses that justify the investment required to deploy the O&G platform and FNPP. This task involves building financial models that compare the FNPP-powered O&G platform concept against conventional gas turbine-powered O&G platform concepts over the full lifecycle of the O&G platform. Key economic inputs include O&G production profiles and pricing forecasts, capital expenditure (CAPEX) estimates, and operating expenditure (OPEX) estimates. The business case should also address non-economic factors like energy security and business goals. Non-economic factors will likely be key details supporting nuclear power over other conventional methods considering nuclear power is expected to have higher capital costs. The FNPP owner/operator will need to forecast the price of power required to make it financially advantageous to enter a partnership with the O&G company to deploy the Project. Business case development initiates after the bulk of opportunity screening and stakeholder identification are complete, but before major contracts are executed, and continues through concept selection and approval. The O&G company and FNPP owner/operator financial groups are responsible for developing their own business cases to determining the viability of taking on the Project.

6.1.7 Major Contract Formation

Major contract formation begins once a project concept is selected and continues until the FID. Major contract formation involves structuring, negotiating, and executing agreements that will govern and fund the development, fabrication, construction, and operation of the floating O&G platform as well as support timely deployment and operation of the FNPP. An agreement between the O&G company and FNPP owner/operator will be officially established, dividing responsibilities and defining liability agreement details. The exact configuration of contracts between stakeholders will vary from project to project. For the deployment model outlined in this report, in addition to traditional O&G contracts for the deployment of the O&G platform (e.g., EPC for construction and deployment), contractual work will need to address the scope of the FNPP. Contracts may include:

- FNPP supply agreement with the vendor covering design, licensing support, equipment supply, and potentially long-term service
- EPC contracts and licensee oversight of FNPP construction
- Facility commissioning and long-term maintenance including fuel supply and services agreement
- Nuclear security measures
- Waste management logistics/disposal agreement

Once initial steps are taken in major contract formation, the O&G company and FNPP owner/operator issue a limited notice to proceed (LNTP) to necessary stakeholders. The LNTP releases funding to proceed with conceptual design and project deployment planning. Once all major contracts are signed, the O&G company and FNPP owner/operator issue a full notice to proceed (FNTP). The FNTP allows for final detailed design and fabrication activities to begin.

A typical deployment model includes the following stakeholders during major contract formation:

- **O&G Company:** Executes agreements with necessary stakeholders regarding the O&G Project. Issues the LNTP and FNTP concerning the O&G deployment to other stakeholders.
- **FNPP Owner/Operator:** Executes agreement with the O&G company to deploy an FNPP that will solely provide electrical power to the O&G platform. Issues the LNTP and FNTP for the FNPP deployment and other stakeholders.
- **Nuclear Technology Vendor:** Executes agreement with the FNPP owner/operator to supply the FNPP and its associated support services.
- **EPC Contractor(s):** Executes agreements with the O&G company and/or FNPP owner/operator for EPC services related to deploying the O&G platform and FNPP.

6.2 Design

Carrying out parallel design activities for an offshore O&G project powered by an FNPP introduces a set of significant engineering and regulatory challenges that extend beyond the boundaries of traditional offshore O&G and nuclear design practices. Because this project integrates technologies and practices from two historically separate industries, the design workstream must address a set of new coupled requirements related to safety and regulatory compliance. The use of an FNPP brings forward a range of novel design considerations that shape many aspects of the integrated design effort and define the scope of the feasibility analysis, conceptual development, FEED, and detailed engineering.

The use of a NOAK deployment model implies that a significant amount of these major design challenges will have been solved by the time a project of this nature kicks off, leaving primarily site/concept-specific challenges for engineers to evaluate.

Specific activities that make up the design workstream are described in more detail below.

6.2.1 Feasibility Study

The feasibility study assesses the Project's technical, regulatory, and economic viability. This begins with a preliminary analysis identifying the goals of the Project along with any potential roadblocks and unknowns associated with those goals.

Evaluation of the environmental and oceanographic conditions at the proposed deployment site(s) will be used to inform and validate stability and global structural requirements for the FNPP and the O&G platform, as well as their associated mooring systems. Technical challenges and roadblocks that are unique to the selected site/concept will be assessed to identify potential solutions. These proposed solutions will be evaluated and scrutinized to determine technical viability.

This study occurs in parallel with project scoping activities (e.g., combined concept selection, FNPP technology/configuration selection, and business case development, see Section 6.1). Project scoping activities and the feasibility study feed into each other by refining the specifics of the Project's configuration, which in turn is used to assess technical viability. If the selected concept is found to be infeasible, modifications can be made to the concept to improve outcomes. A similar relationship exists between the feasibility study, the FNPP technology/configuration selection, and business case development activities. The parallel execution of these activities allows engineers to use the findings from the feasibility study to identify roadblocks associated with specific configurations and adjust them in real time.

Parallel to the feasibility study, early cost estimates for the energy generated by the FNPP will be compared to industry information about energy costs associated with traditional methods of power generation such as natural gas and diesel generators. These costs will be used to assess the economic feasibility of the Project and inform the business case for moving forward. Similarly, pre-application engagement with regulators such as the NRC and BOEM will be used to assess the Project's regulatory feasibility.

The end of the feasibility phase coincides with the end of project planning, concept selection, technology selection, and the business case. These activities conclude with a Class 5 cost estimate (i.e., roughly 1 percent defined with very low accuracy) and a finalized feasibility report used to make the decision to go into concept development. If the results of the feasibility study are acceptable and all stakeholders agree to continue with the selected concept for the Project, then a competitive bid is submitted to BOEM for a block.

6.2.2 Conceptual Design

The conceptual design begins after the Project owner(s) issues an LNTP to the EPC(s)[b]. Conceptual design activities build upon the feasibility study findings and begin to formalize the technical configuration of the FNPP and its integration with the O&G platform. Additionally, results from the feasibility study are used to define a set of interface requirements that provide a basis for more detailed cost estimates.

A good conceptual design of this nature is risk informed from the outset. Arrangement and layout of systems examine a range of scenarios addressed through a portfolio of studies that consider strength, motions, fire, allisions, and other hazards. Under the oversight of the FNPP owner/operator (who is ultimately responsible for the design), EPC contractors verify the layout of the FNPP, including details such as placement of the reactor module and safety zoning procedures. The early configuration of the FNPP will be subject to preliminary safety assessments to confirm that all Defense in Depth levels are addressed by appropriate design and control measures. Early hydrostatic and hydrodynamic analyses are included as part of conceptual design to ensure that the FNPP remains stable within performance requirements under all plant states[c]. Results from this analysis are used to refine design and control measures (e.g., informing proper motion compensation measures to ensure the reactor is isolated from waves and other environmental factors). Safety assessments for both facilities along with a common facilities security assessment will be used to justify a safe separation distance between the two platforms. These safety and security assessments can also be used to inform any other design and control measures to mitigate events or threats both facilities may face. The separation distance between the O&G platform and the FNPP will be informed by a range of inputs including, but not limited to, motions and excursion of both units, mooring type (catenary vs. tension leg), umbilical/riser motions and exposures, and water depth. High level performance requirements and interface features for both platforms will inform overall sizing of the platforms and selection of supporting equipment.

Conceptual design concludes with the preparation of a Class 4 cost estimate (i.e., roughly 10 percent defined with low accuracy) and a combined conceptual design package that outlines the proposed systems' architectures and integration approach for both facilities. This package can include documentation such as reports that highlight how project needs are met by the concept and supporting documents such as preliminary calculations and block/process diagrams to illustrate workflow.

6.2.3 FEED

FEED activities refine the conceptual designs of both facilities and provide the technical depth needed to support completion of documentation such as the DPP, the Combined Operating License Application (COLA) for the FNPP and the Environmental Impact Statement (EIS) along with procurement planning. The EPCs, overseen by their respective owner/operator

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[b] Recognition is given to the fact that the EPC for the O&G infrastructure may be different and operate under different rules than those that apply to the FNPP infrastructure. The FNPP is a nuclear installation subject to the oversight of the FNPP owner/operator as a licensee. Many aspects of construction of the FNPP will be subject to regulations and requirements applicable to a nuclear facility. Any EPC carrying out work in this area will need to adapt their processes and workflow to comply.

[c] Under the IAEA safety and security framework, plant states are "configurations of a nuclear power plant, categorized by frequency of occurrence for safety assessment. They include normal operation, anticipated operational occurrences, design basis accidents, and design extension conditions, which range from routine function to severe accidents."

organizations, refine the designs of the FNPP and the O&G platform and the interfaces between the two, specifying mechanical connections, electrical architectures, etc. To support this effort, owner/operators may need to engage with regulators concerning interpretation of requirements and guidance.

For the O&G platform, FEED includes defining general layout of equipment and infrastructure necessary to support drilling and/or production (depending on the desired use case). Structural and marine analyses are performed to lay out the hull design, mooring system, and dynamic positioning capabilities. Analyses help define the performance of the platform under extreme conditions to increase confidence that safety can be maintained throughout operations and to support licensing. (Note - This report assumes that traditional pre-FEED work (i.e., earlier engineering progress) is conducted during the duration of the O&G FEED task shown in Figure 3.)

For the FNPP, FEED produces pre-detailed design information such as engineering specifications for all nuclear facilities, systems, and components. This includes verification of adequacy of defense in depth at this point in the design, preliminary safety assessment results and plans for spent fuel management. The FEED phase prioritizes completion of the Safety Analysis Report (SAR) to support the level of bounding information and evidence needed for a "to-be-built" configuration to be used in an NRC license application submittal which occurs at the end of FEED. To support this effort, engineers will need design inputs from the nuclear technology vendor to inform key mechanical/electrical interfaces and demonstrate safety of the system for all plant states.

The FEED effort culminates with updated design documentation, a Class 3 estimate (i.e., roughly 25 percent defined with increased accuracy from Class 4 and 5), and a complete SAR for the FNPP.

A typical deployment model includes the following stakeholders for FEED:

- **Regulators (NRC, BOEM, etc.)**: Provides feedback, or direction (as appropriate to their mandate) to submissions including assumptions and proposed safety procedures.
- **Nuclear Technology Vendors**: Provides sufficient information and evidence to the FNPP owner/operator and the EPCs to support their design verification and safety assessment.
- **EPC Contractor(s)**: Performs front end engineering design and analysis work.
- **FNPP Owner/Operator**: Prepares SAR for submittal to NRC.

6.2.4 Detailed Engineering & Design

Detailed engineering translates FEED outcomes into fabrication and construction-ready deliverables including the build plan which will include certain commissioning and deployment activities. Designers produce full 3D models, detailed piping and cable diagrams, fabrication drawings, etc. They also produce the specifications necessary to procure all of the components for each facility along with the processes and services needed to manufacture and integrate them into the facility. The final design resolves remaining uncertainties and establishes exact dimensions, materials, and assembly sequences for both the FNPP and the O&G platform. This phase prioritizes the detailed engineering efforts associated with the hulls of both platforms so that hull fabrication can begin while other (non-hull-related) detailed engineering efforts are taking place. Engagement with vendors should begin early in this phase to ensure design inputs are provided in time for the completion of the detailed design phase. (Note - The process for the design and production of offshore systems is highly mature and is not discussed here further).

The sequence of manufacturing and construction of the FNPP hull must be aligned to the delivery and installation of key reactors components taking into account matters such as maintaining security as the facility is built and commissioned. The FNPP EPC will need to ensure the overall FNPP meets both marine and nuclear regulatory requirements and integrate inputs from offshore marine qualified contractors and the nuclear technology vendor. For example, all FNPP structures, systems and components will be subject to the nuclear facility safety classification process which identifies their relative safety importance to the facility as a whole and informs justification of the engineering standards used to verify they meet objectives. Standard design approvals and commercial grade dedication can be leveraged to take advantage of commercially available systems.

The detailed design of the FNPP will require finalized design documentation and fabrication/construction plans for all components. The interface provisions between the FNPP and the O&G platform should be mature and reflected in the safety analysis results. The early engagement with nuclear technology vendors from the FEED phase can be built upon and utilized to obtain more detailed design data and ensure that interfacing component designs are adequate, and simulation/calculation data is accurate. Additional items such as instrumentation and control systems, including reactor protection logic, security features, and emergency shutdown protocols, are fully defined during this phase.

Detailed engineering and design activities are supported by parallel verification and validation processes to ensure compliance with project requirements, regulatory standards, and safety criteria. Final design verification and validation activities for marine specific aspects are independently assured by International Association of Classification Societies (IACS) class societies (e.g., ABS, LR) to confirm platform designs meet marine and offshore certification requirements. At the end of detailed engineering, the Project issues construction-ready documentation, an integrated construction schedule, and quality assurance packages, enabling remaining fabrication and integration to proceed for both facilities following the FNTP.

A typical deployment model includes the following stakeholders for detailed engineering and design:

- **Nuclear Technology Vendors**: Provides detailed reactor design data, system requirements, and performance specifications to support completion of the detailed design phase.
- **O&G Vendors**: Provides detailed design data for off the shelf components such as pumps and motors.
- **EPC Contractor(s)**: Performs detailed engineering design and analysis work including pre-procurement qualification of equipment suppliers, fabricators etc. Prepares construction ready design package and project schedule.
- **Classification societies**: Verifies that both platforms meet certification requirements.

6.3 Licensing & Regulatory

This section outlines the licensing and regulatory framework required for the evaluation and parallel deployment of the Project. The scope of this section covers activities that must be completed from Project initiation to the start of operations. The regulatory framework described below is based on existing regulatory pathways for offshore O&G on the Gulf of America OCS and land-based nuclear power projects.

It is important to note that the siting process for an FNPP will be closely tied to the location of the O&G platform. As a result, certain Project Planning activities are led by the O&G company with the FNPP owner/operator carrying out site suitability investigations as part of the early O&G project planning.

The offshore O&G regulatory landscape is mature and projects follow a standard regulatory procedure. The regulatory process initiates with BOEM awarding a lease to an O&G company for a block. The major regulatory documents that enable the O&G company to further explore and develop the block before production include an EP and a DPP. These steps will be discussed in more detail in the subsequent sections.

Additionally, the nuclear regulatory landscape for land-based deployments is mature, and projects follow a standard regulatory procedure. However, the commercial regulatory landscape for offshore nuclear projects is not yet established. Therefore, this report recognizes that existing, established regulatory pathways for land-based nuclear projects could be applied in novel contexts (i.e., offshore nuclear projects) and/or new regulatory pathways could emerge.

6.3.1 BOEM Regional Assessments

BOEM conducts publicly available regional assessments across the Gulf of America OCS to identify areas with hydrocarbon potential and inform leasing decisions (Reference 19). These assessments involve estimating undiscovered, technically recoverable resources by interpreting geological data and studying existing well data from surrounding areas. BOEM also performs environmental baseline studies characterizing marine ecosystems for various regions. The regional assessments result in the publication of resource reports and lease sale announcements that identify specific blocks available for competitive bidding, along with any stipulations or environmental restrictions that will apply to future operations.

These publicly available assessments provide the starting point for O&G companies to evaluate potential exploration opportunities. Once an O&G company has identified areas of interest and completed preliminary planning, the O&G company may submit a bid on specific blocks offered by BOEM through a competitive lease sale. If the O&G company is the highest qualified bidder, BOEM awards the lease, granting the right to explore for resources within that block. Following lease issuance, the company must submit an EP to BOEM for review and approval before conducting site-specific studies, surveys, or drilling activities.

6.3.2 Initial Site Selection

After lease acquisition, the O&G company refines its understanding of the block to identify and prioritize potential exploration targets. This includes developing geological models, assessing drilling risks, and screening locations based on resource potential and operational factors such as water depth and seafloor conditions. These analyses support the EP submitted to BOEM for environmental and technical review prior to any surveys or drilling. Preliminary environmental screening conducted during initial site selection should identify protected habitats that might limit certain drilling locations.

It is important to note that the siting process for an FNPP will be closely tied to the location of the O&G platform's ability to economically access the resources it is extracting. The FNPP owner/operation must carry out site suitability investigations as part of the initial O&G site selection. Siting factors that could impact FNPP operations could include proximity to shipping lanes, distance from shore, metocean conditions, and environmental considerations (e.g., nearby fishing stocks, protected areas, etc.). The output of initial site selection is a prioritized list of exploration well locations with supporting geological data that will form the basis of the EP submission to BOEM. Once the initial site is selected and the EP is approved, reservoir characterization can begin.

A typical deployment model includes the following stakeholders for initial site selection:

- **O&G Company**: Assesses potential drilling locations and creates a prioritized list of exploration well locations.
- **FNPP Owner/Operator**: Communicate with the O&G company to gather preliminary site investigation information in the O&G platform region. Discussions should cover requirements for the FNPP that will come once a specific site is selected for the O&G platform.

6.3.3 O&G Exploration Plan Development and Review

Once the initial site selection process has begun, the O&G company can start to prepare an EP that describes all proposed exploration activities within the lease block, including specific well locations and drilling procedures (Reference 5). As the initial site selection process matures, the information gathered from it will be used to finalize the EP. The EP includes:

- Detailed geological data on the potential exploration areas
- Well design specifications
- Drilling methods and equipment to be used
- Reserve estimates
- Plans for well testing or abandonment
- Environmental assessment analyzing potential impacts to water quality, marine life, and air quality, along with proposed mitigation measures and monitoring programs
- Oil Spill Response Plan (OSRP) addressing potential spill scenarios and response capabilities
- Emergency Response Plan addressing procedures taken during nuclear incidents

The EP should also identify the intent to use nuclear power to support O&G platform operations, though detailed FNPP design is likely not required in the EP. Discussion of using an FNPP to power the O&G platform should be backed by preliminary information demonstrating FNPP defense-in-depth features. This includes initial nuclear emergency preparedness planning. Further details on nuclear emergency preparedness planning should be included throughout the licensing process.

BOEM reviews the EP for consistency with lease terms and regulations. Once approved, the EP allows the O&G company to submit Applications for Permits to Drill (APDs) to BSEE and begin reservoir characterization. Once BSEE approves the APDs, the O&G company can begin spudding each well.

A typical deployment model includes the following stakeholders for EP development and review:

- **O&G Company**: Develop and submit an EP to BOEM that includes the required information previously listed.
- **FNPP Owner/Operator**: Provide high level information to support the O&G company's intent to procure energy from an FNPP.
- **BOEM**: Review and approve the EP for the site of interest.

6.3.4 Applications for Permits to Drill Development and Review

Following approval of the EP, the O&G company must obtain individual APDs from BSEE before drilling each well (Reference 20). One APD is required for each well regardless of similarities between wells. Each APD includes detailed well-specific information including precise location coordinates and complete well design. Exploration wells require more conservative designs due to reservoir uncertainties, while development wells can leverage exploration data and follow more standardized designs. BSEE conducts a technical safety review to evaluate well design adequacy. For exploration and appraisal wells, APDs are typically prepared sequentially based on results from previous wells. Development and production well APDs are not prepared and reviewed until after the DPP submittal.

The development of APDs can commence in parallel to EP review, but they cannot be submitted to BSEE until the EP has been approved by BOEM. Once the EP is approved by BOEM, the APDs can be submitted to BSEE, and initial reservoir characterization activities can begin. Further reservoir characterization can begin after BSEE approves the APDs as drilling for exploratory and appraisal wells is permitted.

A typical deployment model includes the following stakeholders for APD submittal:

- **O&G Company**: Develop and submit APDs that include drilling locations and plans for exploratory and appraisal wells for the initial site selected. Assist BSEE in the review of the APDs.
- **BSEE**: Review all APDs submitted by the O&G company. If sufficient drilling plans are detailed, approve the APDs.

6.3.5 Reservoir Characterization

Initial reservoir characterization begins once BOEM approves the EP. The O&G company will perform field activities to determine whether commercial quantities of hydrocarbons exist and to gather data for development planning. Once BSEE approves the APDs, exploration wells are drilled. Well testing may be conducted to measure flow rates and confirm producibility, while core samples are taken for detailed analysis. All data is integrated into reservoir models to estimate reserves and evaluate commercial viability. Most exploration wells do not result in commercial discoveries, causing them to be plugged and abandoned, while the wells that do present commercially viable discoveries are further developed.

Reservoir characterization must provide sufficient confidence in reserve estimates and production profiles to justify the substantial capital investment in powering the O&G platform with an FNPP. If the discovery appears commercial (i.e., hydrocarbon discovery that is economically viable to develop), the O&G company proceeds to appraisal activities and includes the well in their DPP submittal to BOEM. Refined site selection begins in parallel with reservoir characterization, and the information gathered during reservoir characterization is directly used for refined site selection and DPP development. The majority of reservoir characterization is complete once a refined final site is selected; however, reservoir characterization continues throughout the life of the O&G platform as updated data and production performance is collected to maximize the field production.

A typical deployment model includes the following stakeholders for reservoir characterization:

- **O&G Company**: Conducts the bulk of reservoir characterization and uses it to support refined site selection and DPP development.
- **BSEE**: The spudding of exploration and appraisal wells cannot begin until BSEE approves APDs.
- **BOEM**: Reservoir characterization cannot begin until EP approval from BOEM.

6.3.6 Refined Site Selection

Following commercial discovery, the O&G company will conduct refined site selection to optimize locations for production facilities and development wells. Refined site selection must address requirements of the O&G platform and the FNPP, including water depth suitable for both platforms and adequate separation distance between the O&G platform and FNPP (for safety and security).

Because of the long lead nature of integrating siting information into a site-specific FNPP matching process and subsequent design, the FNPP owner/operator will need to coordinate with the O&G company to gather sufficient site data to support safety analyses as part of final facility design. This process must verify, at an early stage, whether the FNPP can safely and securely operate in all plant states under the site conditions or if the site is deemed unsuitable for an FNPP.

Information gathered during reservoir characterization directly feeds into the O&G portion of refined site selection. Once the refined final site selection process is complete and a drilling location has been chosen, the data that was obtained for it as well as the exact coordinates are used to help prepare the DPP, which can be initiated in parallel to reservoir characterization and refined site selection.

A typical deployment model includes the following stakeholders for refined site selection:

- **O&G Company**: Evaluate data and information obtained from reservoir characterization to select the final, refined site for drilling development. Communicate potential site details with the nuclear technology vendor to determine which sites are suitable for the FNPP.
- **FNPP Owner/Operator & Nuclear Technology Vendor**: Verify that the proposed FNPP configuration can be designed to operate over its full lifecycle within the conditions presented by the site (includes bounding accidents and malfunctions from the O&G facility operations (normal and emergency)).

6.3.7 Development and Production Plan Development and Review

In parallel to refined site selection and reservoir characterization, the O&G company prepares a DPP that serves as the main planning document for field development and production life (References 5 and 21). The DPP must describe the overall development concept including the FNPP configuration and its role in providing power to the O&G platform, physical arrangement and separation between the FNPP and O&G platform, and emergency response coordination and security measures for O&G operations. Security for nuclear operations will be addressed by the owner/operator of the FNPP, including proposed coordination with security of the O&G facility.

Coordination between BOEM and the NRC should be established and reflected in the overall project plan given the specific mandates of the two organizations. Likewise, the NRC will, as part of their processes, rely on specific expertise of agencies such as the USCG, EPA, BSEE, and others.

Following submission, BOEM will review the submitted DPP and begin the process of coordinating an environmental assessment or EIS under the National Environmental Policy Act (NEPA). Although the primary reason for the Project is driven by the O&G mission, the nature of the mission as well as the introduction of a nuclear facility into the Project will require other federal agencies to be coordinated with (e.g., NRC, EPA, USCG) on the environmental review process (e.g., BOEM taking the lead on O&G environmental review and NRC taking the lead on FNPP environmental review). The reviews will include public comment periods and typically multiple rounds of additional information requests. BOEM may impose specific conditions for DPP approval. DPP approval represents a major project milestone authorizing the O&G company to proceed with field development, though numerous additional permits from BSEE and other agencies are still required before site construction and drilling can begin. Additional permit applications can be prepared in parallel to DPP approval, but several cannot be submitted until after the DPP has been approved by BOEM.

A typical deployment model includes the following stakeholders for DPP development and review:

- **O&G Company**: Prepare the DPP for the Project and submit it to BOEM for review. Support BOEM throughout the review process. Prepare additional required regulatory permits during DPP review.
- **FNPP Owner/Operator**: Coordinate with the O&G company to ensure that relevant information on the FNPP design is included in the DPP.
- **BOEM**: Review the DPP and prepare an EA or EIS for the Project. Coordinate with other relevant federal agencies as part of the environmental review process.
- **Additional Regulators (e.g., NRC, EPA, USCG)**: Support the environmental review for the Project that is led by BOEM.

6.3.8 Pre-Application Engagement for FNPP

The deployment model in this report assumes that the 10 CFR Part 52 regulatory pathway for licensing the nuclear reactor will be utilized (See Assumptions, Section 4.2). Therefore, a COLA must be submitted and approved before construction and sequential commissioning of the integrated FNPP systems begins. Confidence in the timing of the COLA licensing will also impact the procurement of long lead equipment (e.g., structures, systems and components, license FNPP staff, etc.). Before submitting the COLA, the FNPP operator should engage in pre-application activities with the NRC to establish the licensing plan, identify and resolve any potential licensing impediments, and assure the Project receives appropriate priority to support the timelines of the O&G deployment. Pre-application engagement begins well before COLA submission and includes pre-application meetings with NRC staff to discuss the project scope and regulatory approach, topical report submissions (if needed) on any refinements to the floating platform design, differences in site design and/or characteristics, and any matters concerning the legal jurisdiction of the site. Where there are substantive differences in the design from past practice, the NRC may ask or be asked to provide feedback on application of requirements and the level of information expected to substantiate the design and/or how those differences will be assessed when submitted in the license application. With exception to standard design approvals or certain topical reports producing a binding safety evaluation report, pre-application feedback is generally non-binding and subject to change during formal COLA review.

A typical deployment model includes the following stakeholders during pre-application engagement:

- **FNPP Owner/Operator**: Lead early discussions with the NRC, providing FNPP deployment project details and plan. Outputs of these discussions should be discussed with the O&G company to support the ongoing O&G engagement with BOEM.
- **NRC**: Respond to pre-application requests in a timely manner in areas such as clarifying the licensing plan, providing feedback on technical/regulatory questions, or rendering decisions as a result of formal processes such as standard design review applications.
- **Nuclear Technology Vendor**: Contribute to early discussions with the NRC with the FNPP licensing lead regarding the FNPP specific deployment. Separate engagement may be completed in parallel by the vendor concerning any changes to reactor technology specific information that has changed since it was last referenced in a license application.

6.3.9 FNPP COLA Preparation & Review

In parallel to the development and review of the DPP, the FNPP owner/operator must prepare a COLA for submission to the NRC under 10 CFR Part 52. The COLA combines the construction permit and operating license into a single application that references a certified reactor design and provides detailed site-specific information demonstrating safe deployment at the proposed offshore location. The COLA must address unique aspects to the FNPP such as certain safety analyses and scenarios unique to the selected site environment. The COLA must demonstrate compliance with NRC's general design criteria. It also must include an Environmental Report evaluating impacts to marine ecosystems. COLA preparation also requires coordination with BOEM regarding the integrated O&G facility.

Following submission, the NRC conducts its review, with multiple technical branches evaluating different components of the reactor design. The NRC evaluations will include how the application and supporting evidence has demonstrated the adequacy of reactor design with regard to marine motions and other offshore effects. The NRC may issue Requests for Additional Information (RAIs) and will conduct mandatory hearings, hold public comment periods, and prepare an EIS as lead federal agency under NEPA for nuclear aspects. The NRC would also coordinate with BOEM's separate EIS for the O&G facility. The Combined Operating License (COL), once issued, authorizes both construction and eventual operation of the FNPP, subject to completion of ITAAC before fuel loading. As combined projects of this nature become more common, it is possible that a joint EIS could be prepared for the O&G platform and FNPP.

A typical deployment model includes the following stakeholders for COLA preparation and review:

- **FNPP Owner/Operator**: Prepare the COLA and submit it to the NRC for review. Assist the NRC during the review process.
- **Nuclear Technology Vendor**: Support COLA preparation by providing up-to-date detailed design and safety analysis information and helping define ITAAC.
- **NRC**: Per the licensing process, assess the COLA and make conclusions for use in licensing decisions. Prepare a separate EIS in addition to the EIS prepared by BOEM.

6.3.10 Additional Regulatory Permits

Following BOEM approval of the DPP, the O&G company and FNPP operator must obtain numerous additional permits from other agencies (e.g., BSEE, EPA, etc.) before site construction and operation can commence. Table 7 identifies additional permits that are expected to be required. This report assumes that permits in Table 7 that are not specifically discussed in previous sections can be obtained in parallel and will not impact the critical path of the Project if acquired before operational startup (e.g., the Facility Design Report (FDR) and initial APDs are often on the critical path to beginning installation and drilling operations). Table 7 identifies which portion of the project (i.e., O&G or FNPP) each permit is applicable to. For permits that would apply to both, it is likely that each entity would obtain its own permit through a separate approval process.

The list in Table 7 is not comprehensive, and Table 8 identifies additional regulatory permits that may be required (likely Project-specific).

Table 7. Additional Expected Required Permits.

Permit	Approval Authority	Applicant	Description
Facility Design Report (FDR)	BSEE	O&G Platform	Includes complete structural design and analysis of the floating O&G platform, mooring system design, and certification by a licensed professional engineer and classification society (Reference 22).
Applications for Permit to Modify (APM)	BSEE	O&G Platform	Required before installing the platform and subsea equipment. The APM describes installation procedures, equipment specifications, and safety systems (Reference 23).
Oil Spill Response Plan (OSRP)	BSEE	O&G Platform	Addresses worst-case discharge scenarios and response equipment and procedures, taking into account the added complexity of oil spill response in proximity to nuclear infrastructure and coordination with nuclear emergency procedures (Reference 24).
Safety and Environmental Management System (SEMS)	BSEE	O&G Platform	Demonstrates compliance with BSEE's SEMS regulations (Reference 25).

Table 7. Additional Expected Required Permits.

Permit	Approval Authority	Applicant	Description
Air Quality Permits	EPA	O&G Platform and FNPP	Required from EPA (or state agencies if within 25 miles of shore) for combustion equipment, flaring, and process heaters; however, a nuclear-powered O&G facility may have significantly reduced air emissions compared to conventional gas turbine power generation, potentially simplifying air permitting (Reference 26).
National Pollutant Discharge Elimination System (NPDES) Permit	EPA	O&G Platform and FNPP	NPDES permits for discharges and potential Marine Mammal Protection Act authorizations if high-noise activities are involved (Reference 27).
Private Aids to Navigation (PATON) Permit	USCG	O&G Platform and FNPP	Authorizes the O&G and FNPP owners/operators to install and maintain navigation aids (e.g., lights, buoys) on the offshore platforms to warn vessels of the structure's presence and ensure maritime safety (Reference 28).
Nuclear Fuel Transportation Approval	DOE	FNPP	Authorizes the transportation of spent nuclear fuel to interim storage or reprocessing facilities (Reference 29).
Spent Fuel Storage Plan	NRC	FNPP	Certifies the FNPP owner/operator's plan for managing spent nuclear fuel after it is removed from the reactor (i.e., on-site temporary storage or dry cask storage systems on a nuclear barge) and demonstration of adequate cooling, shielding, and safeguards for the spent fuel throughout the storage period until final disposition (Reference 30).
Hazardous Materials Transportation Permit	DOT	FNPP	Authorizes the shipment of nuclear fuel and other radioactive materials as hazardous materials (Reference 31).

Additional permits that may be required depending on the Project specifics are discussed in Table 8. This report assumes that the following permits can be obtained in parallel and will not impact the critical path of the Project. The list in Table 8 is not comprehensive but serves to provide examples of additional permits.

Table 8. Additional Potentially Required Permits.

Permit	Approval Authority	Applicant	Description
Pipeline Right-of-Way (ROW) Grant	BOEM	O&G Platform	If new export pipelines are required, a pipeline ROW grant must be obtained, requiring pipeline route surveys, environmental assessment, and anchoring hazard analysis (Reference 32).

Table 8. Additional Potentially Required Permits.

Permit	Approval Authority	Applicant	Description
Marine Mammal Protection Act (MMPA) Authorization	National Marine Fisheries Service (NMFS)	O&G Platform and FNPP	Allows the operator to conduct activities that may incidentally harass (but not injure or kill) marine mammals through underwater noise from construction or seismic activities (Reference 33).
Coastal Zone Management Act (CZMA) Consistency Determination Update	State Coastal Management Agency	O&G Platform and FNPP	Certifies that proposed offshore activities are consistent with the state's federally-approved coastal zone management program. This ensures that federal actions affecting coastal resources align with state policies for protecting coastal environments and communities (Reference 34).
Safety/Security Zone Approval	USCG	O&G Platform and FNPP	Establishes a designated area around the offshore facility where vessel traffic is restricted or prohibited to protect the platforms from collision and ensure safety during critical operations or outside threats (Reference 35).

As more projects of this nature are deployed, the required and optional regulatory permits may change. However, it is anticipated that these permits can be processed in parallel to the required permits requested.

6.4 Fabrication & Construction

The fabrication and construction workstream includes activities required to assemble and deliver physical assets ready for commissioning and operations to the offshore site. This workstream involves the coordinated procurement of long-lead equipment, parallel fabrication of the O&G platform hull and FNPP hull, integration of the nuclear island, extensive component-level and system-level testing, and installation of the mooring and subsea infrastructure that will secure both floating assets at the offshore deployment site. Because this project integrates nuclear and maritime aspects, the construction workflow must adhere to best practices of both industries.

6.4.1 Long Lead Equipment Procurement

LLE procurement begins once LLE authorization is given by the Project owner and continues into construction. LLE authorization is given before an FID to reduce the risk that components with extensive lead times will delay overall project execution. It should be noted that any procurement taking place prior to the FID carries inherent risk associated with potential shifts in scope or changes to the overall design and/or project direction. The timing of LLE procurements will ultimately be driven by the owner(s)'s risk tolerance and confidence that the Project will be successfully deployed. Amongst other topics, confidence in project deployment will be informed by progress on key regulatory application reviews (i.e., DPP and COLA). In conservative scenarios, LLE procurement would be authorized once all required permits are obtained; however, conservative LLE procurement authorization could lead to delayed schedules later in the Project.

Both the nuclear and O&G supply chains require early engagement with vendors to account for procurement timelines, secure production slots, and process orders. LLE procurement concludes with delivery of major components to the construction yard(s) for integration during hull fabrication and outfitting.

LLE associated with the FNPP could include items such as the reactor module, shielding structure components, and specialty equipment for the hull. These components often require certification, material traceability, and quality surveillance under ASME NQA-1, with fabrication taking place at approved nuclear suppliers.

LLE associated with the O&G platform could include major topside process equipment such as hoisting systems, cranes, and large compressors.

A typical deployment model includes the following stakeholders for LLE procurement:

- **FNPP Owner/Operator**: Approve LLE procurement for FNPP.
- **O&G Company**: Approve LLE procurement for O&G platform.
- **EPC Contractor(s)**: Place orders for LLE. Engage vendors to ensure needs can be met.
- **O&G Vendors**: Assess manufacturing capabilities to ensure design needs can be met.
- **Nuclear Technology Vendors**: Process the long lead procurement request in line with the procurement specifications and accommodate the oversight required by the licensee and its representatives.

6.4.2 O&G Hull Fabrication

Fabrication of the O&G hull begins after approval of required construction licenses and the owner makes the FID. O&G hulls are typically fabricated by large shipyards with the capacity for high steel throughput and heavy-lift integration. O&G hull fabricators operate worldwide, with modules or entire hulls often fabricated in one region and transported to another for completion or ultimate deployment. Current geographic centers include Korea (newbuild hulls including FPSOs and SPARs), Europe (smaller modules, integration work, and high-spec offshore systems), and Southeast Asia (Floating Storage and Offloading (FSO) and FPSO conversions) (References 36 and 37). Yard selection is generally driven by available capacity, heavy-lift infrastructure, and the owner's local-content requirements.

O&G hulls are built using modular fabrication techniques in which large steel sections are constructed in parallel and then welded together at a dry dock. A dry dock is able to be drained of water to allow for the construction of large vessels before being flooded with water at the end of construction to allow the vessel to float and enter nearby bodies of water. This method supports efficient sequencing while enabling installation of major structural members, tank boundaries, and internal compartments to class standards. Once the primary structure is assembled, heavy-lift cranes install topside modules, and outfitting advances through piping, electrical, HVAC, and safety-system integration. The completed hull undergoes hydrostatic testing, coating, weld inspections, and other class surveys prior to tow out and pre-delivery commissioning.

A typical deployment model includes the following stakeholders for O&G hull fabrication:

- **Shipyard**: Performs block fabrication, structural integration, heavy lifting, coating, and most mechanical outfitting.
- **EPC Contractor(s)**: May fabricate production modules in separate module yards and deliver them for integration.

- **Specialty Vendors**: Provide packaged equipment skids for power, water, drilling, and safety systems.
- **Classification Societies**: Conducts rule-based reviews and survey activities throughout construction.

6.4.3 Nuclear Reactor Hull Fabrication

The FNPP will be required, under its nuclear facility license, to demonstrate that safety, security, and environmental protection requirements are met. One aspect of meeting these requirements is the need to demonstrate that the quality of as-built structures, systems and components results in a level of reliability commensurate with their mission and lifecycle. This report recognizes that many elements of an FNPP can be fabricated using many of the same modular offshore construction techniques applied to the O&G platform, but with some supplemental quality, traceability, and configuration-control measures due to nuclear specific requirements.

The FNPP hull will likely be fabricated under a “graded quality” regime that integrates both marine requirements and nuclear-safety requirements. While the overall structure is built to a combination of offshore standards and class rules, portions of the hull that directly support or protect nuclear safety functions (e.g. the reactor compartment boundary, safety-related penetrations, equipment foundations, and shielding supports) must be fabricated under nuclear quality assurance programs (e.g., ASME NQA-1). Other portions of the hull that are not safety-significant can follow conventional offshore quality assurance practices. This blended approach allows the hull to provide the safety functions required by the reactor design while avoiding unnecessary nuclear program requirements across the entire marine structure.

To enable this graded quality approach, the Project will require partnership with a shipyard capable of delivering both offshore fabrication and nuclear-quality work. In the United States, there are a total of six shipyards that build, refuel, and maintain all of the nation’s nuclear vessels (Reference 38). As of writing, there are no commercial shipyards with sufficient O&G hull experience that maintain a nuclear QA program outside of the defense industry (shipyards that deliver for United States defense customers are unlikely to be viable candidates for a host of reasons). International precedent exists, most notably the delivery of Russia’s Akademik Lomonosov, a floating nuclear power station[d].

Delivering a United States floating nuclear hull would likely require development of a nuclear-ready shipyard, by either upgrading an existing shipyard or creating a hybrid facility. This represents a critical supply-chain and regulatory challenge that must be addressed during a FOAK deployment. As this study assumes a NOAK deployment, those challenges are not addressed as part of this report.

The sequence of fabrication, assembly and installation of all structures, systems and components is determined by the build plan (in the nuclear power sector, this is similar to the construction and commissioning plan encompassed in the license for the facility). The plan takes into consideration the use of modular construction and integration practices, where the various modules are fabricated and how they are integrated into the final facility configuration. The build plan and the sequencing of activities will depend on the characteristics and

[d] Russian requirements, originally established for their nuclear icebreaker program, were updated during the 2010’s to include standards for the construction, deployment and operation of domestic FNPPs. The modification of the requirements involved a long program of work between the nuclear marine authorities and authorities that regulate land-based plants. Since then, these practices are being applied into a serial fleet FNPP build which is currently underway (Reference 11).

configuration of the reactor and how best to install the systems needed for facility operation. Examples of systems to be considered are heavy shield structures, locations of tanks to support plant operation, logical planning for piping and cabling runs and systems and components that may have environmental and/or security sensitivities and need to be protected. All activities are executed under strict work-package control. Throughout the process, the shipyard, classification society, and nuclear regulators would likely coordinate inspections to validate compliance with both marine and nuclear design bases. Prior to tow out, the hull undergoes final QA reviews and readiness assessments for nuclear-island installation.

A typical deployment model would likely include the following stakeholders for the nuclear reactor hull fabrication:

- **Shipyard**: Performs block fabrication, structural integration, nuclear outfitting, and maintains NQA-1 or equivalent program controls.
- **Nuclear Technology Vendor**: Supplies containment structures, shielding components, penetrations, and reactor-support systems; provides nuclear QA documentation and oversight.
- **Specialized Fabrication Shops**: Produce high-integrity components such as pressure-boundary penetrations, embedded plates, and heavy shielding assemblies under nuclear QA requirements.
- **Classification Societies**: Applies marine nuclear notations, conducts structural and systems inspections, and ensures compliance with marine nuclear certification.
- **NRC**: Provides oversight of nuclear-scope fabrication, configuration control, material traceability, and readiness for nuclear-island installation.

6.4.4 Nuclear Island Installation

Once the FNPP hull is structurally complete and outfitted to its nuclear-ready state, the nuclear-island installation phase begins. This operation will likely occur in a controlled area of the shipyard or at a specialized integration site that can accommodate heavy-lift operations and regulatory access. The reactor module will be fabricated and tested at the reactor vendor's facility then transported to the shipyard.

Heavy-lift cranes or skidding systems will be used to place the reactor module into the containment compartment or reactor well. Mechanical alignment and attachment are performed under strict configuration control and documented in accordance with nuclear QA procedures. Safety-critical interfaces are completed using detailed installation procedures with multiple hold points and regulatory inspections.

Throughout this phase, nuclear regulators and classification societies conduct inspections and review installation records to verify compliance with the licensing basis, safety-analysis assumptions, and marine/nuclear certification requirements. Once installation is complete, the integrated nuclear island undergoes pre-commissioning tests, configuration audits, and turnover to the commissioning team ahead of site deployment and fuel-loading activities.

A typical deployment model includes the following stakeholders for nuclear island installation:

- **EPC Contractor(s)**: Installs reactor module into designated position on the FNPP.
- **Nuclear Technology Vendors & FNPP Owner/Operator**: Supplies and participates in the installation and early commissioning of reactor systems.

6.4.5 System & Component Testing

After mechanical installation is completed on both the O&G platform and the FNPP, full system-level and component testing begins. For the FNPP, cold (i.e. fuel-out) commissioning is performed prior to fuel loading, verifying that all systems respond as designed without introducing nuclear material. For the O&G platform, tests are performed on topside process modules, power distribution systems, and emergency response equipment. Technicians perform checks and install instrumentation required for reactor monitoring and protection.

6.4.6 Mooring & Subsea Infrastructure Installation

While hull fabrication and testing are underway onshore, marine contractors install the mooring and subsea infrastructure at the offshore deployment site. This includes driving piles or installing suction anchors, laying mooring chains, and preparing subsea manifolds (References 39 and 40). Static mooring systems are designed to maintain the designated safe separation distance between the FNPP and the O&G platform, allowing both units to adjust to environmental loads without interference or violation of the predefined safety distance between the units.

Subsea power cables and fiber-optic communication links are installed using specialized cable-lay vessels. All infrastructure undergoes inspection via remote operated vehicles (ROVs). Subsea cables and mooring lines are prepared for hookup and tension testing. Upon completion, the site is ready to receive the two floating structures for hookup and commissioning.

6.5 Startup & Commissioning

The startup and commissioning workstream includes platform tow out, fuel loading, and commissioning. Commissioning of both facilities will likely be carried out by different commissioning plans, with different technical disciplines. However, the two plans should be coordinated in a manner that ensures that activities at one facility do not interfere with or introduce unanticipated hazards to the other. There will be some interfacing systems between the two facilities that will need to be coordinated, such as electrical connection tests and verification of FNPP response to power demand fluctuation from the O&G facility. This workstream begins as soon as there is evidence the facility operating license will be granted, and after the subsea infrastructure is in place at the offshore deployment site. This workstream ends once the FNPP and O&G platform begin commercial operations.

6.5.1 Platform Transportation & Installation

Once hull fabrication and system/component testing are complete, the O&G platform and the FNPP are transported by transportation and installation (T&I) contractors to the designated offshore lease area by either a wet tow or dry tow. There may be one or more T&I contractors depending on the point of origin for both platforms. Regardless, this activity requires careful marine logistics planning, weather window selection, and adherence to tow and transport procedures approved by the USCG, BOEM, and the NRC (if there is nuclear material onboard). Upon arrival, the facilities are positioned, after which the mooring lines and other subsea, umbilical, riser, and flowline (SURF) connections are installed and tensioned. The platforms undergo motion monitoring to confirm that the physical behavior matches predictions made during design and analysis. Only after completion of all ITAAC activities will regulators authorize progression to nuclear-specific startup activities.

Throughout this report, “fuel loading” is referred to as a step that takes place at the deployment site as this is in line with existing regulatory frameworks. Many advanced reactors are being designed to be factory-built, factory-fueled, and shipped as a sealed unit. This presents challenges in today’s regulatory environment as shipping of factory-fueled reactors remains an unresolved issue under the current U.S. nuclear licensing framework. According to the NRC, a factory-fabricated reactor module is considered to be “in operation” once nuclear fuel is loaded, regardless of whether the reactor has achieved criticality. Under existing regulations, the NRC does not authorize the transportation of utilization facilities that are deemed to be in operation, which means a fueled reactor could not be shipped from a manufacturing facility to a deployment site without changes to the regulatory framework. If fuel is loaded at the manufacturing facility, the licensee for the deployment site would be unable to comply with the notification requirement in 10 CFR 52.103(a), which obligates the licensee to notify the NRC of the scheduled date for initial fuel loading at the licensed site. In a factory-fueling scenario, fuel loading would occur under the manufacturer’s license rather than under the deployment-site license. This creates a fundamental challenge for factory-fueling concepts. To address this regulatory mismatch, NRC staff have suggested that the licensee could instead provide a schedule for removing design features intended to preclude criticality. These features would be incorporated into the reactor design and installed at the factory to prevent criticality during transportation. In place of notifying the NRC before fuel loading, the owner would instead notify the NRC before removing these features thereby establishing a clear regulatory transition point between manufacturing, transportation, and operational licensing (References 41 and 42). This methodology is actively under consideration by the NRC.

Given this deployment model postulates a site fueling model for the reactors, once all ITAAC activities are complete, the reactor undergoes initial fuel loading operations, in accordance with the reactor’s licensed technical specifications and operating procedures. Fuel loading is performed only after prerequisite operations criteria for the FNPP have been met. For example, construction/installation/cold commissioning are completed and pre-operational system tests verified systems that support safety and security are available for the next phase of commissioning. Once this step is complete, a series of low-power tests confirm the readiness of the reactor for startup. Successful completion results in approval to advance to integrated commissioning.

A typical deployment model includes the following stakeholders for platform transportation and installation:

- **T&I Contractors**: Transport the FNPP and O&G platform from the shipyard to the final site using heavy-lift semisubmersible vessels.
- **Warranty Surveyor**: Specialized service providers that assure the tow out from the yard and onsite installation of the offshore platforms.
- **Marine Contractors**: Complete subsea hookup procedures of mooring lines and cables per the specifications and quality requirements of the FNPP Operator.
- **FNPP Owner/Operator**: Notify the NRC of scheduled date for loading of fuel (or removal of features to preclude criticality) in accordance with 10 CFR 52.103(a). Approve and facilitate transportation of FNPP.

- **O&G Company**: Approve and facilitate transportation of O&G platform.
- **NRC**: Carry out compliance verification activities associated with this phase. Provide approval for fuel loading (or removal of features to preclude criticality) and subsequent commissioning activities per the approved commissioning plan.
- **EPC Contractor(s)**: Load fuel in accordance with reactor specifications and license requirements.

6.5.2 Commissioning and Integrated Testing

The fuel-in or hot commissioning is the last part of the commissioning plan and involves a structured sequence of activities and tests to verify that all platform systems function as part of an integrated facility. As is typical for any nuclear facility, some validation activities may involve verifying trip setpoints and fail-safe functions by simulating adverse conditions even when the reactor is operational. Examples include loss of power supply response, failure of logic in safety systems, etc. Reactor startup begins after the completion of all pre-operational and system integration validations. The process follows a controlled sequence in which control rods are gradually withdrawn to achieve the first sustained nuclear chain reaction. As power increases in steps, thermal-hydraulic parameters are monitored to confirm that cooling performance meets design assumptions. Once the reactor reaches its rated power level, electrical export to the O&G platform begins, first on a test basis and then under commercial loading through a carefully managed load-acceptance procedure. It is standard practice for a plant outage to be carried out shortly after hot commissioning to full power has been completed in order to carry out system inspections in readiness for a long commercial operation run. The deployment plan needs to account for the initial plant outage in the schedule as it may involve additional regulatory compliance validation activities. The facility officially enters commercial operation after demonstrating stable operation under full power and after all final regulatory confirmations are complete.

Simultaneously, the O&G equipment undergoes similar commissioning activities. All O&G equipment is tested to ensure that drilling/processing steps can be carried out under the most extreme design conditions.

Regulatory inspectors from USCG, BOEM, BSEE, and NRC may perform joint site verifications during this period to ensure that the combined facility meets multi-agency requirements for nuclear and offshore industrial operations.

A typical deployment model includes the following stakeholders for commissioning and integrated testing:

- **EPC Contractor(s)**: Performs technical aspects of integrated testing and commissioning procedures
- **Regulators (NRC, BOEM, etc.)**: Provides oversight and authorization for key steps in the commissioning process.
- **FNPP Owner/Operator**: Oversees execution of all commissioning activities related to the FNPP. This includes working with EPC contractors on commissioning procedures and services and ensuring FNPP operators are trained and qualified. The FNPP owner/operator takes a lead role in deciding when it will accept turnover from commissioning contractors and what role it takes in operating the FNPP during commissioning.
- **O&G Company**: Oversees execution of all commissioning activities related to the O&G platform. This includes working with EPC contractors on commissioning procedures and services and ensuring O&G operators are trained and qualified. The O&G company takes a

lead role in deciding when it will accept turnover from commissioning contractors and what role it takes in operating the O&G platform during commissioning.

7. ADITIONAL TOPICS

This section includes additional topics that were considered throughout the course of developing the proposed deployment model and stage-gate framework.

7.1 Project Execution & Stakeholder Considerations

The successful deployment of this combined Project will require enormous coordination among stakeholders distributed across multiple jurisdictions, geographies, skills, contracts, timescales, labor environments, quality programs, etc. Major O&G industry players are experienced managing major multi-contract execution models that span the globe, although the level of challenge of this combined project deployment will likely stretch that experience. The considerations that follow illustrate some of the major features of the diverse stakeholders that will need to be coordinated to execute a combined project in the Unites States.

The O&G company would likely be a United States-based company with Gulf of America operating experience, while the FNPP owner/operator would similarly be a United States entity due to domestic nuclear regulatory requirements and national security considerations. The nuclear technology vendor would most likely be a United States company, though international vendors from allied nations with advanced nuclear programs could participate, subject to technology transfer agreements and regulatory approval.

EPC contractors for the O&G platform, FNPP, and final assembly would predominantly be United States firms with domestic nuclear and offshore construction experience. However, the fabrication of major components, particularly the floating platform hulls for both the O&G facility and the FNPP, as well as potentially reactor pressure vessel components, could occur at international facilities with established heavy marine fabrication capabilities. Hull construction might be executed at shipyards in South Korea (e.g., Hyundai Heavy Industries, Samsung Heavy Industries), Singapore (e.g., Sembcorp Marine, Keppel), or China, which have demonstrated expertise in FPSO and floating platform construction (Reference 43). Reactor module fabrication could occur at specialized facilities in the United States, though certain components such as large forgings for pressure vessels have historically been sourced from countries like Japan (e.g., Japan Steel Works), France (e.g., Framatome), or South Korea (e.g., Doosan) due to limited domestic heavy forging capacity (Reference 44).

This global supply chain would necessitate careful logistics planning for component transportation to a Gulf Coast assembly facility likely located in Louisiana, Texas, or Mississippi with deepwater access and heavy-lift infrastructure. Major hull sections and reactor modules would likely be transported via heavy-lift vessels or barges to an onshore integration facility, where final assembly, systems integration and testing, and regulatory inspections would occur for both the O&G platform and the FNPP. Upon completion, the O&G platform and FNPP would each be towed to the offshore site using tugs and moored to seafloor anchoring systems. This execution model requires robust quality assurance protocols spanning multiple jurisdictions, clear contractual interfaces between international fabricators and United States regulatory authorities, and detailed logistics planning to manage schedule dependencies across the global supply chain. Figure 5 provides a diagram of a stakeholder network for a potential deployment scenario.

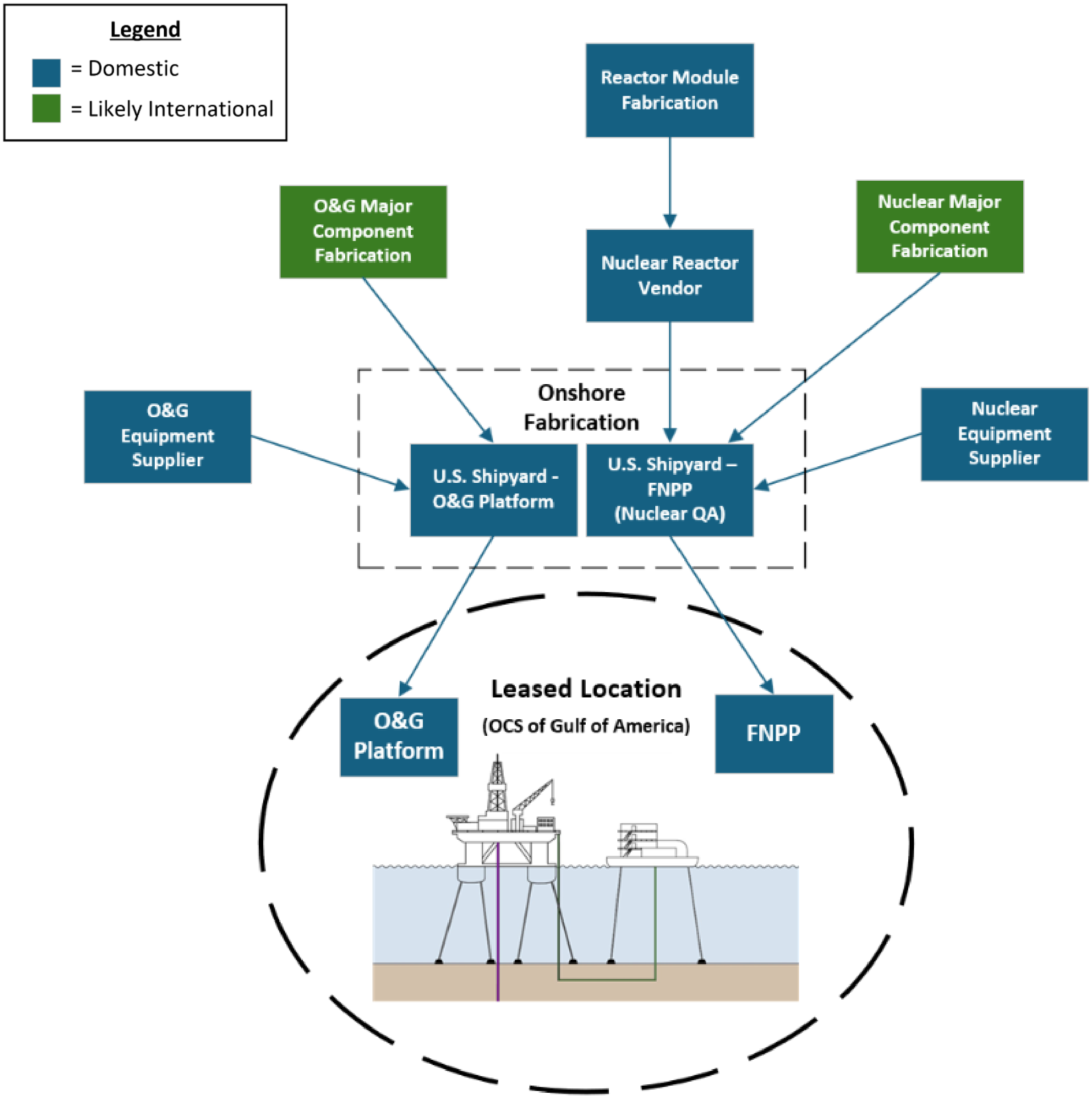

Figure 5. Stakeholder Network for a Potential Deployment Scenario.

7.2 Considerations for Alternative O&G Use Cases

The purpose of this report is to describe a potential deployment model and stage-gate framework for an offshore project that incorporates the parallel execution of an FNPP and a traditional offshore O&G platform. Before selecting a concept and investing significant capital, it is essential to consider the business case. Additional work that was not performed as part of this report is required to assess the business case and the economics of each of the scenarios discussed below in greater detail (see Section 4.1 for scope discussion).

Production Platforms. The business case for nuclear-powered production platforms faces challenges that may limit near-term deployment opportunities. Production facilities typically utilize extracted hydrocarbons as low-cost fuel for conventional gas turbines or diesel generators, creating a substantial economic barrier for nuclear power to overcome. The capital expenditure for an FNPP combined with operational costs such as specialized staffing, maintenance, and regulatory compliance, would need to compete against relatively cheap fuel with established operational practices. This business case may be challenging to justify on purely financial grounds at this point in time, particularly for mature production facilities with stable power demands that are well-served by conventional generation. Given these economic constraints, an O&G company would likely require additional non-economic motives to consider nuclear power as a viable option for production platform applications. Those considerations might include corporate reliability commitments, government mandates associated with energy security, stakeholder expectations, or strategic positioning for future energy dominance markets. At the time of NOAK deployments, energy security may become a higher priority and could favor nuclear options.

Drilling Vessels. Large, non-self-propelled drilling units (e.g., relocated via tows or heavy lift vessels) may present a more viable application for nuclear power due to their inability to access produced hydrocarbons for power generation, which results in a higher fuel cost. However, drilling operations typically consume less power than production platforms, and they are trending towards reducing power requirements on board to cut costs. The exact power requirement depends on factors such as water depth and operational intensity. The transient nature of drilling operations, where units operate at specific locations for limited durations (usually a few weeks or months), before relocating to the next prospect, does introduce many operational considerations that would need to be addressed. The frequent repositioning of an FNPP to follow drilling operations would introduce several challenges, including dynamic mooring systems and power cable management. Additionally, frequent repositioning of the FNPP would likely require EISs for each new operational area under NEPA, and potentially additional environmental reviews, thereby adding regulatory steps that could prolong project timelines. However, if these regulatory pathways can be streamlined through programmatic approaches or regional assessments, and if operational protocols can be standardized, this application could represent a reasonable deployment scenario for operators with sustained drilling programs in defined geographic areas.

Other Applications. Other alternative applications may offer favorable economics and operational profiles. Stationary, long-term installations with substantial baseload power demands (e.g., FPSO vessels in ultra-deepwater fields lacking pipeline infrastructure, or permanent offshore processing hubs) may represent more suitable initial applications for FNPPs. These facilities operate continuously for decades, cannot easily access conventional fuel sources, and would benefit from the operational simplicity of nuclear baseload power without the complications of frequent relocation. Heavy construction vessels have high load requirements and may result in an appropriate application for FNPPs. Ocean mining also requires high loads and are located in isolated locations for extended periods, appearing to be another potential application for FNPPs. Furthermore, emerging applications such as offshore hydrogen production, coastal data centers, and desalination facilities could provide better opportunities for FNPP technologies considering economic requirements.

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