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MIT Science Policy Review

Floating nuclear power plants for desalination: Governance, geopolitics, and the future of water security

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HIGHLIGHTS

- Floating nuclear power plants coupled with desalination systems may provide integrated low-carbon electricity and freshwater production for water-stressed coastal and remote regions.
- The deployment of floating nuclear desalination systems introduces governance challenges spanning nuclear safety, maritime law, environmental regulation, safeguards, and cross-border liability frameworks.
- Floating nuclear-based desalination is not a universal technical solution but a context-dependent infrastructure option shaped by institutional capacity, geopolitical considerations, environmental constraints, and long-term energy–water security priorities.

Escalating freshwater scarcity driven by climate change, population growth, and unsustainable water management is increasing global reliance on desalination. While desalination provides reliable potable water in arid regions, it is energy-intensive and often fossil-fuel dependent, raising concerns about emissions, energy security, and sustainability. Floating nuclear power plants (FNPPs) have been proposed as dual-purpose infrastructure supplying low-carbon electricity and large-scale desalinated water to coastal and remote areas. This paper examines FNPP-based desalination through a multidisciplinary policy framework. It outlines the integration of small modular reactors (SMRs) with desalination technologies, analyzes governance and regulatory challenges spanning nuclear safety, maritime jurisdiction, environmental regulation, and safeguards, and explores geopolitical and strategic deployment considerations. The findings highlight both opportunities and constraints: while FNPPs may offer siting flexibility and integrated energy–water production, they also introduce governance complexity, vendor dependence, environmental responsibilities, and geopolitical sensitivities. Rather than a universal solution, floating nuclear desalination is a conditional policy option dependent on institutional capacity, regulatory coordination, and regional energy–water security needs.

Freshwater scarcity is increasingly recognized as a structural global challenge rather than a localized environmental issue. Climate change is altering precipitation patterns, intensifying droughts, accelerating glacier retreat, and increasing evaporation rates, placing additional stress on freshwater systems. At the same time, population growth, urbanization, and industrial expansion are increasing water demand, particularly in coastal regions where groundwater depletion and saltwater intrusion constrain supply. Global assessments project continued growth in water demand, with many regions already experiencing high or extreme water stress [1].

Desalination has therefore become an important component of water supply strategies in arid and semi-arid regions. Countries in the Middle East and North Africa, parts of South Asia, and small island states increasingly rely on large-scale seawater desalination to secure potable water. However, desalination remains highly energy-intensive and is often powered by fossil fuels, linking water security to energy price volatility and carbon emissions [2]. As demand for desalinated water grows and nuclear energy emerges as a viable solution, nuclear–desalination coupling raises policy questions regarding the radiological integrity of produced water, particularly how potential contamination pathways are prevented, monitored, and regulated.

Floating nuclear power plants (FNPPs) have been proposed as a potential response to this water–energy nexus [3]. By integrating small modular reactors (SMRs) on offshore platforms, FNPPs could supply both electricity and thermal energy for desalination systems, while reducing reliance on fossil fuels [4]. However, offshore nuclear infrastructure introduces regulatory, legal, and geopolitical complexities [5]. FNPP deployment intersects with nuclear safety regulation, maritime law, environmental oversight, and international safeguards regimes, bringing issues pertaining to jurisdiction, liability, security, and the export of mobile nuclear assets [6].

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The author declares no conflict of interest.

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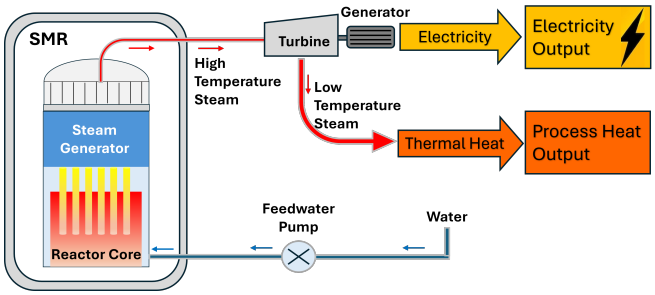

Figure 1: Block diagram of an SMR system for the cogeneration of electricity and heat.

This paper examines FNPP-based desalination through an integrated policy framework and presents it as a conditional policy option rather than a universal technological solution. It evaluates technical feasibility, reviews the regulatory and legal landscape governing offshore nuclear deployment, and analyzes the associated geopolitical implications. Rather than advocating for or against the adoption of FNPPs, the analysis clarifies the institutional, regulatory, environmental, and strategic conditions under which floating nuclear desalination may be responsibly considered within energy and water infrastructure planning.

Technical foundations

SMR systems: FNPPs are offshore energy platforms designed to host SMRs on maritime vessels or barge-mounted structures. In this paper, FNPPs refer to floating or offshore platforms using compact nuclear reactors to provide electricity, thermal energy, or both. Most proposed FNPP systems use reactor technologies derived from naval propulsion or land-based SMR designs, typically ranging from 50–300 MWe per unit. This range distinguishes them from both conventional large reactors and much smaller microreactor concepts [7]. These reactors emphasize modular fabrication, passive safety features, and compact containment systems intended to shorten construction timelines and improve manufacturing quality relative to conventional large-scale nuclear plants [8].

Figure 1 illustrates the basic configuration of an SMR energy system. Nuclear fission produces thermal energy that is transferred to a steam generator, where steam is produced for energy conversion. The generated steam can either drive a turbine–generator system to produce electricity or be utilized directly as process heat. The resulting electricity may be supplied to the power grid to power facilities and infrastructure, while the thermal energy can support heat-driven industrial processes [2].

Most floating SMR concepts are based on pressurized water reactor (PWR) technology, although alternatives such as high-temperature gas reactors and molten salt reactors have also been proposed for offshore deployment [9]. Key technical features relevant to policy include integrated primary systems, passive decay heat removal, and strengthened containment resilience, all of which influence licensing requirements, emergency planning, and safety frameworks [8].

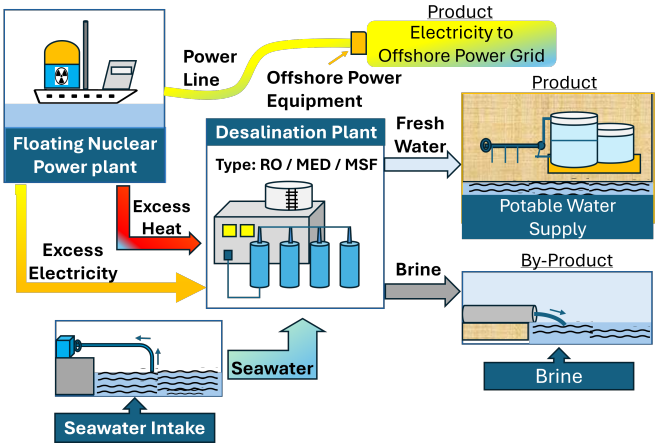

Figure 2: Architecture of a floating nuclear power plant–based desalination cogeneration system illustrating the main outputs—electricity and freshwater—and the resulting by-product, brine.

FNPP–desalination cogeneration system: Coupling an FNPP with a seawater desalination facility creates a cogeneration system capable of producing both electricity and heat [3]. As shown in Figure 2, nuclear heat is converted into electrical energy while recoverable low- or medium-grade heat (i.e., excess heat) can be directed to desalination processes. Unlike conventional nuclear plants that reject excess heat to the environment, this configuration utilizes both electricity and thermal energy for water production, improving overall energy efficiency and lowering the carbon intensity of desalinated water.

FNPP-based cogeneration can support both electricity-driven reverse osmosis (RO) systems and thermally driven desalination processes such as multi-effect distillation (MED) and multi-stage flash (MSF). Although this hybrid capability improves deployment flexibility, the practical integration of thermal desalination with offshore SMRs remains technically challenging [2]. Thermal desalination processes require relatively stable heat delivery, whereas offshore reactors may operate under variable marine conditions, fluctuating electricity demand, and constrained maintenance windows. As a result, the theoretical efficiency gains often cited for nuclear cogeneration may be more difficult to achieve under real offshore operating conditions than under idealized design assumptions.

Desalination facilities connected to FNPPs generate two primary output streams: freshwater suitable for municipal or industrial use, and concentrated brine that must be discharged to the marine environment through controlled systems designed to mitigate environmental impact [10]. Co-location of nuclear energy generation and desalination facilities can reduce transmission losses and improve infrastructure utilization. However, integrated offshore systems also increase operational coupling between critical infrastructure sectors. Disturbances affecting reactor thermal performance, seawater intake systems, or marine environmental conditions may propagate across both electricity generation and freshwater

production systems simultaneously. This interdependence introduces additional reliability and resilience considerations that are often underrepresented in conceptual FNPP deployment studies [3]. However, such integration benefits from coordinated oversight between nuclear regulators, environmental agencies, and water authorities, particularly given the need to ensure radiological integrity across system boundaries.

In practical terms, the nuclear heat source and the desalinated water stream must remain physically and operationally separated. This separation is maintained through engineered safeguards, including multi-loop heat exchange systems, pressure differentials designed to prevent backflow, and continuous radiological monitoring to detect potential contamination pathways. As a whole, these measures help minimize the risk of radionuclide transfer and ensure the quality of the produced water. Beyond these technical considerations, confidence in the radiological integrity of desalinated water is essential for public acceptance, interstate trust, and the long-term political viability of FNPP-powered desalination projects.

Modern reverse osmosis (RO) typically requires 3–4 kWh/m^3 of electricity, while thermal desalination (MED/MSF) additionally utilizes reactor heat. The electrical output of current FNPP concepts (50–300 MWe) is therefore sufficient, in principle, to support utility-scale desalination alongside electricity generation [11].

Operational and environmental considerations

Safety, environmental and offshore considerations: Although SMRs incorporate passive safety mechanisms such as gravity-driven cooling and natural circulation heat removal, offshore deployment introduces additional operational risks [12]. Marine deployment environments introduce degradation mechanisms that differ substantially from those encountered in conventional land-based nuclear facilities. Long-term exposure to saltwater accelerates corrosion and material fatigue in structural components, piping systems, and offshore support infrastructure. These effects may increase maintenance frequency, shorten component lifetimes, and complicate inspection procedures throughout the reactor deployment cycle, which may include transportation through remote offshore environments even when the reactor ultimately operates at a nearshore site supplying desalination facilities. Risk assessments would also benefit from accounting for tsunamis, storm surge, sea-level rise, and maritime traffic.

Emergency preparedness frameworks for offshore nuclear installations may differ from those applied to land-based reactors. Offshore facilities located within Exclusive Economic Zones (EEZs) introduce jurisdictional complexities related to accident response, evacuation coordination, and cross-border notification under maritime law. Existing international mechanisms, including the Convention on Early Notification of a Nuclear Accident [13] and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency [14], establish frameworks for information sharing and international cooperation during radiological incidents. However, these arrangements were developed primarily with land-based nuclear facilities in mind, and their application to mobile offshore nuclear infrastructure remains less clearly defined. This is particularly relevant in scenarios involving multiple jurisdictions, disputed maritime boundaries, and transboundary emergency response coordination. From a geopolitical perspective, the consequences of a radiological incident may extend beyond emergency response considerations. Disputes regarding responsibility, liability, compensation, and the allocation of environmental remediation costs could become significant sources of tension among neighboring states. In regions where political relations are already strained, such disagreements may further exacerbate existing geopolitical frictions and complicate regional cooperation.

Environmental considerations include thermal discharge effects on marine ecosystems, brine management from desalination operations, radioactive waste storage and transport logistics, and spent fuel handling arrangements. These issues intersect with both nuclear regulatory systems and marine environmental protection frameworks [15]. These environmental stressors are not independent, but they coexist and are likely cumulative in FNPP–desalination systems. Current existing marine regulatory frameworks may not be adequately equipped to address the combined thermal, salinity, and radiological impacts associated with such integrated operations.

Operational experience and pilot projects: The most prominent operational example of an FNPP is the Akademik Lomonosov, operated by Rosatom [16]. The facility hosts two KLT-40S PWRs with a combined electrical capacity of approximately 70 MWe and supplies electricity and district heat to remote Arctic communities. Its operation demonstrates the technical feasibility of sustained offshore nuclear power generation and floating reactor deployment under harsh environmental conditions.

However, the facility does not operate as an integrated nuclear desalination platform, and therefore provides only partial insight into the challenges associated with FNPP-based freshwater production. Offshore desalination introduces additional operational and environmental considerations beyond electricity and district heating applications, as mentioned earlier. Consequently, while the Akademik Lomonosov offers valuable operational experience for floating reactor systems, it does not constitute a full-scale validation of offshore nuclear desalination deployment. Additional floating SMR and nuclear desalination concepts have been explored in Asia and the Middle East, although most remain at feasibility or conceptual design stages.

Policy implications of FNPP technical design

From a governance perspective, several technical characteristics of FNPP systems have direct policy implications:

Reactor modularity and platform mobility complicate licensing jurisdiction and liability allocation: Because floating reactors can be relocated between ports or national jurisdictions, clarifying which authority is responsible for licensing, oversight, and liability becomes a key regulatory consideration.

Cogeneration systems benefit from coordinated regulatory oversight between nuclear and water authorities: Nuclear regulators oversee reactor safety, radiation, and fuel, while water authorities manage desalination, environmental discharge, and resource allocation. Integrated systems may benefit from joint licensing, coordinated assessments, and clear accountability to help avoid regulatory gaps or conflicts.

Offshore siting introduces maritime governance considerations under the United Nations Convention on the Law of the Sea (UNCLOS) [17]: Issues such as jurisdiction over territorial waters, environmental protection obligations, and rights of navigation may influence how floating nuclear facilities are deployed and regulated.

Fuel handling, waste transport, and reactor export arrangements raise nonproliferation and safeguards concerns: These activities may call for robust international monitoring and compliance mechanisms to help ensure that nuclear materials associated with floating reactors remain under strict safeguards and are not diverted for non-peaceful purposes.

Cyber-physical integration of reactor and desalination systems introduces additional digital security concerns: Advanced cybersecurity frameworks may be needed to protect interconnected digital control systems from potential cyber intrusions that could disrupt plant operations or compromise safety [18].

Policy and regulatory landscape

The deployment of FNPPs for desalination operates at the intersection of nuclear safety governance, maritime law, environmental protection, and water policy. While each of these domains is supported by established regulatory frameworks, offshore nuclear desalination introduces institutional overlaps and ambiguities not fully addressed by existing regulations [19]. Understanding how these frameworks interact—and where they fall short—is central to assessing the feasibility of FNPP deployment [20].

Nuclear regulation and international safety standards: International nuclear governance is structured primarily around the safety standards, safeguards system, and conventions administered by the International Atomic Energy Agency (IAEA) [19]. These instruments establish principles for reactor design, radiation protection, emergency preparedness, and waste management. At the national level, independent regulatory authorities oversee licensing processes that evaluate site suitability, safety analysis reports, environmental impact assessments, and emergency planning frameworks.

FNPPs complicate this model in several respects. Traditional licensing regimes are territorially bounded and site-specific. FNPPs, by contrast, may be constructed in one state, flagged under another, and deployed within the territorial waters or EEZ of a host country. For example, a floating reactor constructed in Russia (supplier state), registered under the maritime flag of Panama (flag state), and deployed to supply electricity within the EEZ of Indonesia (coastal or user state) would involve multiple layers of jurisdiction and regulatory oversight. Determining the allocation of regulatory authority, i.e., between flag state, supplier state, and coastal state, can therefore be complex. Emergency planning zones, liability arrangements, and inspection protocols may require adaptation when facilities operate offshore or near maritime boundaries.

Cases in which the supplier state retains responsibility for and maintains control over the full nuclear fuel cycle can reduce proliferation risks while simplifying safeguards implementation. Such arrangements limit the number of states that directly handle sensitive nuclear materials [21], allowing the supplier state to ensure that fuel fabrication, transportation, and spent fuel management remain within established regulatory, safety, and security frameworks. This approach is particularly attractive for user states that lack the technical infrastructure, institutional expertise, or regulatory capacity to independently manage the nuclear fuel cycle.

However, these arrangements also introduce institutional and legal complexities. Responsibilities for safety oversight, safeguards compliance, operational monitoring, and emergency preparedness may be distributed among multiple actors, including the supplier state, the host (user) state, and in some cases the flag state if the platform is maritime. This overlapping jurisdiction can complicate accountability, particularly in situations involving operational incidents, liability claims, or regulatory disputes.

Maritime jurisdiction and offshore governance and regulatory gaps: FNPPs deployed offshore operate within the legal framework established by UNCLOS [22]. However, UNCLOS was not developed specifically for mobile nuclear infrastructure, leaving several jurisdictional and classification issues unresolved. Article 60 of UNCLOS [22] grants coastal states authority over artificial islands, installations, and structures within EEZs, including jurisdiction related to safety zones, environmental protection, and operational oversight. Yet it remains unclear whether floating nuclear power plants would be legally classified as artificial islands, fixed installations, or maritime vessels, particularly when designed for relocation between jurisdictions [17].

Additional legal complexity arises under UNCLOS Article 19 [22] governing innocent passage through territorial seas. The movement of floating nuclear platforms carrying reactor fuel or radioactive materials may generate disputes if coastal states interpret such transit as prejudicial to national security, environmental protection, or maritime safety. These concerns may become more pronounced in geopolitically sensitive maritime regions where offshore

nuclear infrastructure intersects with contested waters or strategic shipping corridors. UNCLOS Article 56 [22] further grants coastal states sovereign rights within EEZs for resource management and environmental protection, but does not clearly define how regulatory authority would be allocated for offshore nuclear facilities operated through multinational supplier arrangements. These unresolved jurisdictional issues create regulatory uncertainty [23].

Environmental responsibilities under UNCLOS Article 194 [22] also have direct relevance to FNPP-based desalination systems. States are required to prevent marine pollution and protect the marine environment, raising important regulatory questions regarding thermal discharge, brine disposal, accidental radiological release, and cumulative ecological impacts associated with offshore nuclear desalination operations.

Although the IAEA establishes international nuclear safety and safeguards principles, existing maritime and nuclear governance frameworks remain only partially integrated for mobile offshore nuclear infrastructure. As a result, FNPP deployment exposes legal and institutional gaps that existing conventions were not originally designed to address.

Mobility and licensing: Existing nuclear licensing regimes assume fixed land-based installations. Clear procedures for relocation, multinational operation, or decommissioning of mobile reactors remain limited.

Multinational liability and oversight: Export-based deployment models create shared responsibilities between supplier and host states, complicating accident liability allocation and regulatory enforcement.

Offshore emergency preparedness: Maritime accident response typically involves coordination among nuclear regulators, coastal authorities, naval services, and environmental agencies.

Integrated cogeneration oversight: Thermal coupling between nuclear reactors and desalination systems may call for joint regulatory review across traditionally separate policy domains.

Safeguards and security: Mobile nuclear assets introduce inspection, monitoring, fuel logistics, and cybersecurity considerations that extend beyond conventional stationary plant models.

These gaps do not indicate regulatory absence but rather reflect the novelty of offshore nuclear desalination within existing governance structures. Furthermore, it is important to distinguish between legally binding international treaty obligations and national regulations, and the non-binding guidance provided through IAEA safety and nuclear security standards.

Governance pathways for FNPP deployment: Addressing regulatory and institutional gaps for floating nuclear power plants may call for alternative governance structures. Because FNPPs integrate nuclear, maritime, and desalination systems, their oversight cannot rely on a single institutional model, but instead may follow multiple governance pathways that differently distribute regulatory authority, financial responsibility, and risk.

Based on the existing literature, four representative governance pathways can be identified. Table I depicts the governance models for FNPP deployment and highlights that each model involves tradeoffs among sovereignty, regulatory capacity, financing structure, supplier dependence, liability allocation, and geopolitical exposure. It shows that FNPPs are not only a technological option but also an institutional and geopolitical choice, as the selected governance structure shapes regulation, liability, financing, and strategic relations around nuclear infrastructure.

The national sovereign model (Table I) is the traditional nuclear governance framework, where the host state retains full control over licensing, regulation, and operations through national agencies. Financing is typically state-led via public investment or state-owned utilities. Its main advantage is institutional clarity, with unified jurisdiction enabling streamlined regulation and clear political accountability. However, it requires substantial capital, technical expertise, and regulatory capacity, which many developing countries may lack. As a result, it is most suitable for technologically advanced states with established nuclear sectors. While it maximizes sovereignty and control, it may limit wider FNPP adoption.

The export-supplier or Build–Own–Operate (BOO) model (Table I) shifts financial and operational responsibility to a technology-exporting state or vendor [24]. The supplier designs, constructs, and operates the FNPP, while the host state primarily receives energy or desalinated water. Regulatory oversight is often shared when ownership remains with the supplier. Financing is based on long-term service contracts, fuel leasing, and spent fuel management agreements. This model reduces the host state's technical and institutional burden and can enhance continuity in safeguards and fuel cycle management. However, it introduces risks of long-term dependence on the supplier for fuel supply, maintenance services, operator training, digital control systems, spent-fuel management, and decommissioning, along with complex liability arrangements in accident scenarios. Questions may also arise regarding operational authority and accountability if host-state political, environmental, or security priorities diverge from those of the supplier. In such cases, decision-making authority related to continued operation, relocation, decommissioning, or emergency shutdown procedures may become contested, highlighting the importance of clearly defined contractual and regulatory responsibilities prior to deployment. Geopolitically, it may also serve as an instrument of energy diplomacy, extending the supplier's influence through sustained infrastructure ties [26].

A third approach (Table I) is the public–private partnership (PPP) model, which combines government oversight with private-sector participation in financing, construction, and

TABLE I: Governance pathways for floating nuclear power plant deployment

Governance Model	Regulatory Authority	Financial Structure	Advantages	Limitations / Risks	Geopolitical Implications
National Sovereign Model [20]	Host state nuclear regulator; domestic environmental and maritime authorities	Fully state-funded or nationally financed utility model	Clear jurisdiction; unified oversight; strong political accountability	High capital requirements; limited technical capacity in developing states; concentrated liability exposure	Enhances sovereignty but may limit deployment to advanced nuclear states
Export-Supplier / Build-Own-Operate Model [24]	Shared oversight between supplier and host state; supplier may retain operational control	Long-term contractual agreements; fuel leasing; possible take-back of spent fuel	Reduced technical burden for host; standardized safety practices; safeguards continuity	Long-term dependency; complex liability allocation; potential strategic leverage	May shift influence toward exporting state; energy diplomacy tool
Public–Private Partnership (PPP) [25]	Hybrid oversight across national regulator and contractual governance mechanisms	Mixed public–private financing; potential involvement of multilateral banks	Risk-sharing; diversified capital sources; operational efficiency incentives	Regulatory fragmentation; insurance and indemnification complexity; layered accountability	Market-oriented approach; may reduce political risk but increase contractual exposure
Regional / Multilateral Consortium [24]	Joint regulatory mechanisms or harmonized national oversight; possibly treaty-based framework	Shared financing across participating states; multilateral institutional support	Burden-sharing; transparency; potential confidence-building in sensitive regions	Complex treaty negotiations; dispute resolution challenges; coordinated emergency planning required	May reduce geopolitical tension through shared ownership; requires high institutional trust

operation [25]. Private actors provide capital and expertise, while the host state maintains regulatory authority and defines safety, performance, and liability frameworks. Financing typically mixes public funds, private equity, and multilateral loans. PPPs can improve economic viability by sharing risk and increasing efficiency through market incentives. However, they can also complicate governance, as layered contractual arrangements may add complexity to already stringent nuclear oversight. Strong provisions for insurance, liability, and long-term responsibility may help limit regulatory fragmentation. While PPPs can reduce political exposure and attract diverse funding, they increase the need for robust contractual governance.

The regional or multilateral consortium model (Table I) is a cooperative approach in which multiple states jointly finance, own, and oversee an FNPP. It relies on treaty-based institutions or harmonized regulatory frameworks, with costs shared among members and potentially supported by international financial institutions [24]. Its main advantage is the distribution of financial and technical burdens, along with increased transparency and trust in politically sensitive regions. However, it also introduces significant complexity, including the need to align regulatory standards, negotiate treaties, coordinate emergency response, and manage cross-jurisdictional disputes. Its effectiveness depends on strong political trust, institutional maturity, and sustained regional cooperation.

All these governance models suggest that FNPP deployment may require new forms of institutional coordination. No single model is universally preferable: national models maximize sovereignty, supplier-led models may accelerate deployment but increase dependence, PPPs diversify financing but complicate accountability, and multilateral models distribute risk but require high levels of trust. Unlike land-based facilities, FNPPs sit at the intersection of various fields, requiring hybrid regulatory frameworks that combine domestic licensing, maritime jurisdiction, and cross-border oversight.

Over time, FNPP expansion may also encourage more standardized approaches, particularly for offshore emergency preparedness, liability allocation, and safeguards for mobile systems, similar to how governance evolved in civil aviation and maritime nuclear propulsion. Understanding these trajectories is key to anticipating how FNPPs integrate into nuclear regulation and energy security. Notably, water governance—especially quality standards, brine discharge, and public health oversight—remains a critical but often underemphasized component of FNPP-based desalination systems.

Geopolitical dimensions

FNPP deployment in coastal or offshore environments involves a complex mix of geopolitical, security, and energy considerations [27]. Beyond technical and environmental aspects, such projects intersect with national security, regional energy dynamics, and international cooperation. Issues such as siting, operational control, technology transfer, and fuel supply introduce diplomatic and strategic dimensions that extend beyond technical assessment. Understanding these factors is therefore essential for evaluating the policy context and implementation challenges of FNPP deployment.

Strategic deployment in water-scarce regions: One significant driver for FNPP deployment is the acute water scarcity faced by many regions globally. Countries in the Middle East, North Africa, South Asia, and numerous small island nations struggle with chronic freshwater deficits due to arid climates, high population growth, and limited renewable water resources. Conventional desalination plants powered by fossil fuels exacerbate carbon emissions and often require extensive land-based infrastructure [28]. In contrast, FNPPs may offer a compact, modular solution capable of providing both electricity and desalinated water directly offshore, potentially reducing land-use constraints and mitigating environmental impacts.

For instance, in the Gulf Cooperation Council (GCC) countries, where freshwater demands exceed local renewable supplies, FNPPs could offer a reliable and low-carbon alternative to traditional thermal desalination plants. Similarly, island nations in the Pacific and Caribbean face logistical challenges in importing energy and freshwater. Offshore nuclear desalination facilities could enhance their energy independence and resilience against climate-driven disruptions. The strategic selection of deployment sites, therefore, is closely linked to regional resource scarcity, existing infrastructure, and socio-economic priorities.

FNPPs for energy diplomacy and soft power: FNPPs are not only energy-generation assets; they may also function as instruments of energy diplomacy, creating long-term relationships between supplier and host states through fuel supply, operations, maintenance, and spent-fuel arrangements [26]. The export of floating nuclear technology enables countries with advanced nuclear capabilities to engage in energy partnerships that can attract foreign investment. By providing secure, low-carbon energy solutions, exporting nations can support developmental objectives in recipient countries while fostering economic cooperation and investment opportunities [29].

The geopolitical implications of such partnerships depend on the degree of reliance placed on supplier states for the FNPP operation. Under export-based models (see Table I), host countries may depend on external vendors not only for reactor technology, but also for arrangements associated with operational and maintenance services, While these arrangements facilitate deployment for newcomer states, they may also create long-term strategic dependencies over critical energy and water infrastructure. The extent of such dependence is likely to vary across ownership structures and governance models, ranging from supplier-led Build-Own-Operate arrangements to frameworks that incorporate greater domestic participation and regulatory control.

FNPPs and regional stability: The offshore nature of FNPPs inherently intersects with maritime law and regional geopolitics. Coastal states may view FNPP deployments in nearby waters through different lenses: as opportunities for collaboration or potential sources of tension. Exporting countries face complex legal frameworks governing EEZs, territorial waters, and transboundary environmental impacts. Disputes over maritime jurisdiction or access to resources could escalate if deployment plans are perceived as encroaching upon national sovereignty.

FNPPs can also reshape regional energy interdependencies. For import-dependent nations, access to nuclear-powered desalination and electricity could reduce reliance on fossil fuel imports and diversify energy portfolios, thereby enhancing resilience and bargaining power. Conversely, neighboring states may perceive such deployments as altering strategic balances, particularly in geopolitically sensitive regions like the South China Sea or the Eastern Mediterranean, where maritime disputes already heighten tensions [30].

In addition, FNPP-based desalination may also create transboundary governance challenges, particularly in shared or semi-enclosed marine environments. Established principles of international environmental law, reflected in cases such as the Trail Smelter [31] and the Pulp Mills judgment [32], recognize state obligations to prevent significant cross-border environmental harm and exercise due diligence where activities may affect neighboring states. Consequently, these transboundary issues may become not only environmental concerns but also sources of diplomatic tension and regional governance disputes.

Physical, cyber and maritime security considerations: While FNPPs offer strategic advantages, they also introduce novel security vulnerabilities. Physical security remains a foremost concern, particularly because offshore platforms may be exposed to risks such as sabotage, unauthorized access, vessel collision, piracy, or military tension in contested maritime regions. Furthermore, floating reactors, often moored near shorelines, are inherently exposed to natural hazards such as storms, tsunamis, and extreme weather events. Designing FNPPs with robust structural integrity, redundant safety systems, and secure anchoring mechanisms are therefore relevant design considerations.

Cybersecurity is another critical dimension. Modern FNPPs rely on digital control systems for reactor operation, desalination processes, and remote monitoring. These systems are potential targets for cyberattacks aimed at disrupting energy supply, compromising safety, or manipulating operational data. Ensuring secure, resilient digital infrastructure is as important as physical defenses, especially in regions with limited local technical expertise or heightened cyber threat exposure.

Maritime security considerations further complicate FNPP deployment. Floating reactors could become focal points in regional conflicts, either as strategic assets or as potential targets. The presence of FNPPs may require coordinated naval protection, monitoring of shipping lanes, and engagement with international maritime authorities to prevent accidental or deliberate interference. In high-tension areas, these security obligations may pose logistical and

financial challenges that would need to be accounted for in deployment planning.

Integrating geopolitics into deployment strategy: The geopolitical dimensions of FNPP deployment point to the relevance of planning frameworks that extend beyond purely engineering and economic considerations. Strategic site selection could incorporate environmental vulnerability, water scarcity, regional political dynamics, and evolving security risks. Several geopolitical deployment zones emerge where the convergence of energy demand, freshwater scarcity, and coastal accessibility creates favorable conditions for integrated FNPP–desalination systems. These include water-stressed hydrocarbon economies in the Persian Gulf—such as Saudi Arabia, the United Arab Emirates, and Kuwait—where desalination is already central to national water security. Additional opportunities exist in arid coastal regions of North Africa and parts of South America, as well as in island and archipelagic states across the Pacific Ocean and the Caribbean that face persistent freshwater constraints and dependence on imported fuels. Remote northern regions in the Arctic and drought-prone coastal areas of the Mediterranean Basin also present potential deployment contexts where modular floating systems could supply both electricity and freshwater without extensive land-based infrastructure [2].

International cooperation frameworks may help mitigate proliferation risks, facilitate the peaceful resolution of maritime disputes, and strengthen regulatory capacity in recipient states. At the same time, geopolitical sensitivities represent an important consideration for exporting nations, as FNPP deployment may be perceived as an instrument of political leverage or strategic influence. Without careful diplomatic engagement and transparency, such initiatives risk intensifying existing regional tensions. Accordingly, the development of internationally coordinated governance mechanisms and transparent deployment standards may support efforts to ensure that FNPP technologies contribute to water and energy security while minimizing geopolitical friction.

Strategic implications for future water security

Beyond the technical and regulatory considerations discussed above, the potential deployment of floating nuclear power plants for desalination raises broader strategic questions about how energy infrastructure can contribute to long-term water security [4]. Notably, the deployment of FNPPs for desalination can be examined within a broader systems-level framework that integrates both energy generation and freshwater production. In regions experiencing water scarcity, the ability to simultaneously provide electricity and desalinated water may strengthen resource security and support essential services.

FNPPs may offer broader strategic and infrastructure benefits in certain contexts. In water-scarce regions, reliable desalinated water can support industry, improve public health, and enhance regional resilience. Integrating power generation and desalination on a single offshore platform may also enable faster deployment in areas with limited land availability or weak or damaged grid infrastructure.

FNPPs have also been proposed as potential tools for disaster response or post-crisis reconstruction, particularly in coastal areas where conventional infrastructure has been compromised. Their modular and transportable design could, in principle, allow redeployment to locations experiencing acute water shortages or energy disruptions.

While FNPP-based desalination may strengthen long-term energy and water security in water-stressed, energy-import-dependent regions, its deployment will depend on overcoming technical, regulatory, environmental, and governance challenges. Its value extends beyond economic considerations, particularly where integrated energy–water resilience is a strategic priority. Ultimately, the success of FNPP deployment will depend on whether the benefits of integrated electricity and freshwater production justify the institutional and operational complexity of offshore nuclear infrastructure.

Conclusion

Floating nuclear power plants coupled with desalination represent a shift in how future energy and water infrastructure may be conceptualized; not as separate power or water projects, but as integrated systems operating within complex technical, institutional, and geopolitical environments. Their value lies in addressing multiple challenges simultaneously, particularly in coastal regions where water scarcity, energy security, and infrastructure constraints intersect.

However, the successful deployment of FNPP-based desalination will depend on more than reactor technology or desalination performance. Its success will ultimately depend on governance frameworks that effectively coordinate nuclear regulation, maritime jurisdiction, environmental protection, and long-term operational responsibilities. In this context, regulatory clarity, international cooperation, and clearly defined responsibilities may prove as important as engineering advances.

Future deployment decisions may depend more heavily on regional needs and institutional readiness than on technology availability alone. For some water-stressed coastal regions, FNPPs may become a strategic infrastructure option that complements existing energy and water systems. Their broader significance may ultimately depend on whether international frameworks evolve to manage mobile nuclear assets while enabling their potential contribution to climate resilience, energy diversification, and water security.

Acknowledgements

The author acknowledges the editors, Tina Zhang and Dr. Mariliis Eensalu, for their guidance in developing a manuscript that draws on the author's technical background while remaining accessible to a non-technical audience.

Citation

Miltiadis Alamaniotis. Floating nuclear power plants for

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