Is Nuclear Power Ship Propulsion an Option for Pacific Island Maritime Decarbonization?

Peter Nuttall[1,2] **and Jack Newell**[1]

[1] *Micronesian Center for Sustainable Transport, Majuro*
[2] *University of Fiji*

Abstract

Globally there is increased interest in nuclear-powered shipping. Recent reports and papers respond to a strengthening lobby advocating for the commercial deployment of nuclear options for shipping in the context of Greenhouse Gas (GHG) emissions reduction negotiations at the International Maritime Organization (IMO). In the Pacific, there is a proposal to now deploy a nuclear-powered emergency response vessel in Fiji. This article discusses the global opportunities and barriers to nuclear shipping and assesses where these factors differ in a Pacific context. We conclude that there is no near- or short-term case to make for such deployment and considerable peer-reviewed research is needed specific to a Pacific domestic scenario if decision-makers are to make well-informed decisions in the longer term. Regardless of the technical readiness of this technology, any future role of this energy source will need to overcome substantive financial, technical, regulatory, liability, and political barriers before it could be considered a viable option for any Pacific Island State.

Keywords: Fiji; Ship Design; Renewable Energy; Zero and Near-Zero (ZNZ) Shipping Fuels; Nuclear Ship Propulsion

Corresponding author: Peter Nuttall *E-mail address:* pete@s4sfiji.com

Nuclear-powered shipping is successfully deployed in naval contexts, such as aircraft carriers, submarines and Russian icebreakers in the Arctic Ocean. However, over the last 50 years international merchant maritime nuclear vessels have been extremely rare, and economically unsuccessful. Despite these failures, interest in nuclear-shipping has increased in the last few years, because nuclear-vessels offer an energy-dense and low-carbon propulsion source, which could help international shipping meet its GHG decarbonisation targets. The extent to which nuclear ships can make a useful contribution to IMO targets depends on whether well-known barriers to their deployment can be overcome.

Section 1 considers the global context and identifies eight primary issues constraining uptake sourced from current literature. Each is discussed within a global and Pacific Islands context. Section 2 examines the recent proposal to deploy a nuclear-powered vessel in Fiji. Section 3 discusses the key opportunities and barriers Pacific leaders and maritime decision-makers will need to consider in evaluating this option in the context of their future maritime decarbonisation programming.

International commercial shipping has committed to GHG emissions reduction targets. The IMO's 2023 Strategy saw unanimous agreement to reduce emissions by 30% by 2030 and 80% by 2040, reaching net-zero by 2050 [1]. A range of alternative technologies and fuels are being considered for meeting this objective [2,3]. Nuclear power has potential maritime application as a non-GHG emitting onboard energy source and as a shoreside or floating supplier of clean electricity, including battery charging of electric powered vessels, cold-ironing for vessels while in port and production of green electro-fuels. With the IMO negotiations on GHG reduction gaining increasing traction, there is now an active lobby advocating that nuclear power should be seriously considered. In just six to seven years, this idea has transformed from an unlikely prospect to one gaining considerable support [4].

There are strong proponents and critics as to the viability of nuclear power for commercial shipping and a growing body of literature identifies both high potential and significant barriers including technical viability, regulation, safety and security, cost, risk, liability and political credibility [5,6,7,8,9,10].

Recent announcements by a collaboration of Lloyd's Register (LR), Australia's ship design group Seatransport and Houston-based Deployable Energy actively considering micro modular reactors (MMRs) to power an emergency response landing craft based in Fiji as a credible climate and disaster response priority for central Pacific Island States [11, 12]. Fiji's Prime Minister announced in 2024 Fiji's commitment to such a vessel program [13]. Japan has subsequently announced FJD27.2m (USD12m) to assist Fiji in its procurement of a 73m emergency response landing craft [13], although it is not immediately clear that this vessel will be nuclear powered at build or it is a potential retrofit option. The Fiji project is the first serious consideration of use of nuclear power for commercial shipping in Pacific Island States. There is no available reviewed literature specific to potential Pacific Island deployment of this energy source and almost none for Small Island Development States and Lesser Developed States more generally. The Fiji project, therefore, sets a precedent for which little reviewed background research or assessment appears to have been undertaken.

Nuclear power for international shipping

Proponents contend that nuclear provides a reliable, emissions-free energy source for shipping, but acknowledge substantial challenges stand in the way [10,15]. In such narratives, nuclear reactors are highly energy-dense, requiring much less fuel to generate the same amount of power compared to fossil fuels without the accompanying GHG emissions. The availability of this energy source, as opposed to the nascent and speculative electro-fuels (e.g. hydrogen, ammonia, methanol) market, the long historical record with military deployment and recent reactor fuel and technology advances, particularly in regard to increased safety, are stressed. For such proponents it is not a case of whether the wider maritime sector embraces nuclear power, but when [10].

Only four nuclear powered vessels have ever been operated commercially on international routes, with only one, a Russian carrier, still active. Russia also operates a national fleet of nuclear-powered icebreakers. Using nuclear power for commercial ships has re-surfaced periodically but not then been actively pursued [9]. Nuclear power has been deployed in more than 700 reactors on military vessels since 1955 with 200 reactors today fitted to 160 naval vessels. Most of these ships use enriched uranium, an input to producing weapon-grade uranium.

Research work on commercial applications has now accelerated, particularly in South Korea, US, China and UK, with classification societies LR and Det Norske Veritas (DNV) and academic researchers among those producing major reports on technical viability and the complex international regulatory architecture that would need to be developed [5,6,7,8,9,10]. Commercial deployment would likely utilize low-enriched uranium or thorium reactors, in large part to avert safety and security fears. Advanced reactor designs (e.g. molten salt reactors, pebble-bed reactors) are considered inherently safer because they operate at lower pressures and use materials that solidify in the event of malfunction, reducing the risk of a catastrophic meltdown.

LR expects to see nuclear ships on specific trade routes sooner than many people currently anticipate and has announced a range of collaborations for advancing regulatory standards [16]. They agree the challenges may be significant but consider all are resolvable and increasingly being addressed. In partnership with the International Atomic Energy Agency (IAEA), LR announced they are launching the Atomic Technologies Licensed for Applications at Sea (ATLAS) project later this year, aiming to establish a framework for the safe and secure deployment of commercial nuclear applications at sea [7].

IAEA and LR anticipate a range of first-mover projects by the early 2030s operating under special regulatory measures, with a fully developed regulatory framework by 2035 enabling broader uptake of nuclear technologies. They argue this phased approach reflects the complexity of integrating nuclear power into an industry governed by diverse international standards [7]. DNV is more circumspect, projecting commercial trials of advanced reactors by 2035 with nuclear propulsion potentially making a significant contribution to maritime decarbonization by 2050 [5].

Most literature focuses on recent and rapid advances in nuclear fuel and reactor technology, particularly thorium fuel and the development of alternatives to pressure water-cooled reactors (PWR) in small and micro reactors, some now in advanced testing stages. Technical readiness is, of course, only one factor that is required for successful introduction and uptake. However significant barriers - including cost, risk, liability, safety, public perception, regulatory and political - suggest that the other necessary components are not so well developed and are less certain. Given this, the projection that active proof-of-concept vessels by 2030 and increasing commercial deployment by 2035 appears probably aspirational. Agnostic as to whether this technology provides a viable pathway for the international fleet, the focus of this paper is on the availability of nuclear power for the transition pathway for Pacific Islands domestic shipping. It has been consistently argued that this sector is unique and as such requires a bespoke solution; it is not simply a case of importing down-scaled international solutions, many of which are not appropriate for deployment at Pacific Island scale [17,18].

There appears consensus across the literature that there are a number of core barriers to successful uptake. These can be grouped into the eight primary issues, summarized in Table 1, noting the interconnectedness between them. For example, to advance the technical readiness of current proposals to operational trials, the technology needs to be insurable. To be insurable nuclear propulsion will first need a regulatory framework that identifies who is liable and how to cap liability [19]. There appears high risk that failure to address any of these barriers satisfactorily is a 'showstopper' for the overall agenda.

Technical readiness

The literature confirms that nuclear power for commercial shipping is technically available and being actively pursued by some States and industry interests. Major research advances in fuel type and reactor design are regularly reported; however the other barriers (especially regulation, insurance and liability) are delaying progression beyond the laboratory. We conclude that SMR/MMRs are likely at a Technical Readiness level of TR5-TR7 in a small number of countries (e.g. China, Korea, US, Norway).[1]

In 2021 Samsung Heavy Industries (SHI) announced that it would partner with Korea Atomic Energy Research Institute (KAERI) to develop compact molten salt reactors to power ships as well as market offshore power plants [20]. In 2023 SHI completed a conceptual design for a floating nuclear powerplant based on molten salt reactors with plans to commercialize by 2028 [21]. In 2023 China State Shipbuilding Corporation (CSSC), announced that it would create one of the largest cargo container ships powered with a thorium reactor [22]. Of particular interest are recent research advances in small modular reactors (SMRs) and MMRs [23]. HD Korea Shipbuilding & Offshore Engineering unveiled a design for a future SMR-powered 15,000 TEU container ship in 2025 [24]. Emerald Nuclear Norway reports they will have an MMR ready for shipboard installation by 2029, one of several similar claims by technology developers [25].

The size and geography of the Pacific means that if nuclear power were deployed it can be assumed to be at MMR-scale. Having such technology developed in a leading industrialized State, where deployment has the advantage of advanced support services and high levels of technical expertise - for operations, quality control, maintenance, refueling, disposal, etc. - does not mean that it will be ready for deployment in remote Pacific Island scenarios where none of these are available. Single vessel pilots of proof-of-concept will require a range of such service support to be in place before a vessel could be safely or effectively operated, assuming other barriers (especially regulation, insurance, liability) can be resolved. No significant detailed research appears to have been undertaken on the technical requirements necessary specific to a Pacific Island scenario. Given this, Technical Readiness for a Pacific domestic scenario can be assumed to be at TR3 - TR4.

Regulation

Due to safety and environmental concerns, nuclear-powered ships are subject to a long list of international regulations. However, we are still well short of a harmonized international regulatory framework covering all facets across the lifespan (e.g. construction, installation, operations, port-entry and licensing, decommissioning) of civilly deployed nuclear vessels. Current IMO and IAEA safety and environmental protection rules are outdated.

Existing frameworks are being updated to accommodate new reactor designs, but regulatory uncertainty remains a barrier to widespread adoption. Although initiatives by IMO and the IAEA and major classification societies are making progress, substantive work (and time) is required by multiple agencies to establish and enable the requisite international architecture.[2] Significant gaps persist particularly in the areas of maritime-specific risk assessments, emergency response procedures, and consistent cross-border regulations. Further improvements are required in design standards for commercial use. In particular, more detailed criteria are needed for the installation, operation, and decommissioning of reactors on merchant ships. Current guidelines also lack sufficient clarity regarding crew training and cybersecurity protections for reactor control systems. They provide limited guidance on how nuclear propulsion can be integrated with other sustainable technologies. To enable wider adoption, regulatory authorities should also address international concerns about port access for nuclear-powered ships [7,26,].

Moving current research advances out of the laboratory and into real world deployment cannot happen outside of the regulatory architecture, indicating realistic scenarios for initial practical application will involve either a single jurisdiction, bilateral agreements between States and/or fixed routes negotiated by States with high existing competence[19].

[1] The Technical Readiness Levels (TRL) scale of 1- 9 is a method for estimating the maturity of technologies during the acquisition phase of a program. Originally adopted by NASA for space exploration research, now widely used across many technology sectors. https://en.wikipedia.org/wiki/Technology_readiness_level

[2] Notably the recent IMO Maritime Safety Committee (MSC 110) decision to initiate revision of the Code of Safety for Nuclear Merchant Ships and relevant parts of the SOLAS Convention, tasking the Sub-Committee on Ship Design and Construction to start work on a framework to bring nuclear propulsion into the mix to achieve net-zero emissions by around 2050.

Table 1. Summary of core barriers to successful uptake of commercial use of nuclear power for shipping at international and Pacific Island scale

Issue	Challenges for international deployment	Additional challenges for Pacific island deployment
Technical Readiness	Multiple reactors at development of new reactor technologies: majority at conceptual / paper design stage with very limited licensing data packages available; others at detailed design or pre-licensing stage with partial licensing data package available.	Minimal readiness for technology in Pacific Island Countries (PICs). Most countries do not have nuclear installations, few have a national regulatory body or technical support organisation, and only some have basic radiation protection systems in place.
	Reactor types, designs and major component testing requirements still being confirmed: limited experience in operation with limited or no experience in tropical maritime conditions.	Additional technology-specific requirements not fully understood: for example, capacity for water production as a co-product, waste heat use, and integration into island grids with high renewable energy penetration.
	Manufacturing, supply chains and construction methods being established; learning from first-of-a-kind deployments will be needed for cost and schedule reduction.	Key local capabilities (ports, shipyards, maintenance and repair facilities) may need substantial upgrades or new development to accommodate nuclear-powered ships and their support vessels.
	Demonstration and early commercial projects required to prove performance, safety and economics at scale.	Demonstration projects will be politically and socially sensitive; site selection, stakeholder engagement and risk communication will be particularly challenging in small island settings.
Regulatory	Need for robust, internationally accepted safety and security standards; harmonisation across flag, port and coastal states remains incomplete.	Few Pacific island states have comprehensive nuclear legislation or independent regulatory authorities; development of these frameworks will require significant time, funding and specialist support.
Insurance / liability	Nuclear risks are excluded in marine insurance policies; specialised nuclear liability arrangements are required, often backed by state guarantees or international conventions.	Many PICs are not party to nuclear liability conventions and have limited capacity to negotiate complex insurance arrangements; uncertainty over jurisdiction and compensation mechanisms in case of an incident.
Cost	Very high capital costs, particularly for first vessels and supporting infrastructure; financing conditions strongly influenced by perceived technology and regulatory risks.	Small market size, limited creditworthiness and higher perceived country risk in PICs further raise financing costs; competition for scarce public resources and development finance.
Safety and security	Strict marine, port and nuclear safety / security requirements; needs strong safeguards, security-by-design and emergency response capabilities in multiple jurisdictions.	Additional vulnerabilities from remote locations, limited local emergency response capacity and challenging logistics for evacuation, medical support and environmental monitoring.
Workforce	Nuclear ships need highly specialised crews and shore-based staff with nuclear, marine and security expertise; global shortage of experienced nuclear professionals.	A competent Pacific workforce would need to be built largely from scratch; limited local training institutions for nuclear engineering, radiation protection and nuclear security.
Waste, decommissioning and spent fuel management	Long-term arrangements for spent fuel, decommissioning and radioactive waste disposal remain undecided for many new reactor concepts; responsibilities between reactor vendor, shipowner and states must be clearly allocated.	Geographic isolation, small land area and high environmental sensitivity of islands exacerbate siting and transport challenges for waste and decommissioning materials; public concern is likely to be acute.
Political support	Nuclear power use at sea may face resistance in non-nuclear states, from environmental groups, and from some shipping customers and ports.	The history of political opposition to nuclear power in the Pacific, including resentment about past nuclear testing and waste dumping, may further constrain political willingness to host or service nuclear-powered ships.

No prior consideration appears to have been given as to what the regulatory requirements will be for operating any MMR, let alone a specialized maritime MMR, in any Pacific Island State. Domestic maritime regulation across the Pacific is already substandard and human capacity and government budget allocations available to develop new regulations are minimal. There is currently no regulatory framework or physical experience for management of this energy source, in particular its safety, security and disposal. Fiji, the sole Pacific Island State so far to endorse this technology, lacks a nuclear regulatory authority, national nuclear legislation or maritime-nuclear expertise capable of inspection, licensing, accident investigation, or enforcement. This could be overcome by bringing in foreign expertise, but this would bring in long-term structural dependency.

It is assumed that developing Pacific regulations would follow the establishment of the international framework. Again, proponents' predictions about how quickly this architecture can be agreed are contestable and likely highly optimistic. It can also be assumed the establishment costs of a regulatory framework will be comparatively high in the Pacific. And once the regulatory architecture is established, implementing, monitoring and enforcing its provisions will require additional (and potentially significant) investment, assuming the requisite skill capacity is available.

Overcoming the regulatory barriers alone would suggest that this technology will not be available for trialing in the Pacific Islands in the immediate or near term.

Insurance and Civil Liability

Insurance of nuclear vessels is not like that of conventional ships. Nuclear risks, and the use of nuclear fuel, are excluded in the conventional insurance market and need to obtain specialty insurance. The consequences of an accident could span national boundaries, and the magnitude of possible damage is beyond the capacity of private insurers [27]. Lack of insurance options and recognition by commercial insurers have knock-on effects on the financial viability of nuclear vessels [6]. This extends past the operational phase of a vessel's lifespan to hazards involved with constructing and decommissioning maritime nuclear reactors. Along with the potential of major contamination or disaster, this makes civil liability and insurance a major obstacle and, if securable, likely high cost.

Existing nuclear liability frameworks, such as the Vienna and Paris Conventions, exclude nuclear powered ships, primarily due to concerns stemming from outdated reactor designs. Although the Brussels Convention of 1962 attempted to address this, it was never ratified. To make nuclear-powered ships commercially viable, a new liability convention will be needed that allows for insurability and accounts for the safety of modern nuclear technologies [28]. This barrier strongly suggests realistic scenarios for initial practical application will involve either a single jurisdiction, bilateral agreements and/or fixed routes as first movers. None of these options apply realistically in Pacific Islands domestic deployment scenarios.

Few domestic vessels in the Pacific today carry insurance and most fleets, including government vessels, operate a self-risk approach. This reflects the overall poor standards of vessels, crews and aids to navigation; the high-risk operating environment; low economic viability of most routes and the length of supply chains to any large-scale salvage or emergency response resources. The lack of access to affordable and appropriate maritime insurance at domestic vessel scale is a major driver of the current operating scenario where vessels are either donated or bought as cheaply as possible, often at end-of-life condition, and then operated with minimal upkeep and maintenance [18]. As any nuclear-powered vessel would need to obtain specialty insurance, it is difficult to envisage how an MMR powered vessel would ever afford the likely premiums for cover in Pacific domestic operations.

This in turn raises significant issues of where liability would lie in the event of any type of disaster, noting the Pacific Islands are the most vulnerable region globally to natural disasters including tsunamis, extreme cyclones and underwater volcanoes. Strandings, sinkings and mechanical breakdowns are commonplace across the Pacific. These issues have been explored in some detail recently with the sinking of the uninsured and conventionally powered NZ Navy specialist survey vessel HMNZS Manawanui in Samoa where salvage is not physically practicable [29] and the uninsured container ship Southern Phoenix [30] and ro-ro passenger ferry Lomaiviti Princess II [31] wrecks in the center of Suva Harbor. Such incidents result in long and drawn-out legal processes. In the case of the merchant vessels, the costs primarily fall to Pacific Island governments, local communities and the environment.

High Capital Cost

Unlike land-based applications, at sea tight space limits dictate that a marine reactor must be physically small, so it must generate higher power per unit of space. Components are subject to greater stresses than those of a land-based reactor. Mechanical systems must operate flawlessly under the adverse conditions encountered at sea. Reactor shutdown mechanisms cannot rely on gravity to drop control rods into place as in a land-based reactor that always remains upright. Saltwater corrosion is an additional problem that complicates maintenance [32]. All these factors add significantly to the overall construction and operational costs of such vessels, comparative to conventional ones.

Constructing nuclear-powered merchant ships remains unfeasible without significant reductions in life-cycle costs and infrastructure enhancements, which must demonstrate clear economic benefits over conventionally powered vessels today and other zero-emission technologies in the future (e.g. green ammonia for deepwater shipping and wind - electric hybrids for short seas). Construction and maintenance require a significantly higher initial investment, due to the complex systems, specialized materials, and rigorous safety features required, with SMR powered container vessels estimated to be up to five times the cost of conventional vessels [32]. Additional financial burdens include increased crew expenses, high insurance premiums, and significant decommissioning costs. In addition to building the reactors, operators must install specialized port infrastructure to handle nuclear refueling and waste management [27].

Against this, proponents argue broadly that: vessel service speeds can be much higher; economies of scale mean costs will come down with increased uptake (a larger fleet could share fixed costs among more operating vessels); lifetime fuel savings and carbon tax reductions outweigh the initial cost of construction, fuel purchase and higher crew and operational safety compliance costs; and that there are no unpaid environmental externalities as there are no emissions.

The costs present a major barrier to Pacific Island deployment. Very few newbuild vessels are purchased for domestic use in Pacific islands where the dominant operating business model is old vessels replaced with old given the marginal, at best, economic returns on many routes and lack of appropriate investment finance [21]. Certainly no government or private sector operator can afford to purchase new vessels equipped with nuclear propulsion. Most new merchant vessels deployed are donated through bilateral agreements, the majority across the Pacific historically supplied by Japan.[3] So any nuclear-powered vessel construction and operation will have to be funded externally and as such, compete with all other needed maritime investment.

No information was found on the projected costs of maritime nuclear deployment in Pacific Islands. In the case of the proposed Ocean of Peace ship, the FJD27.2 million grant from Japan must be assumed to be the cost of procuring a conventional diesel-powered ship. For comparison, the most recent new ship procured for domestic Pacific islands use is the M.V. Manu Sina in Tuvalu, a 1,890GT general purpose cargo/passenger ship costing USD28 million to procure [33]. In 2022 Japan donated a 31m medical ship to the Marshall Islands valued at approximately USD5 million [34, 35].

[3]This does not include the 22 Guardian Class Patrol Vessels donated by Australia. https://thedefensepost.com/2024/10/22/australia-21st-guardian-patrol-boat/

Construction is only one cost component

In addition to the standard operational costs of such a vessel, which appear likely higher than a conventional vessel in all aspects bar fuel, there would be an initial cost for upscaling maritime training of crews, operators and regulatory controllers and administrators.

To these costs will need to be added the costs of ensuring adequate response capacity in the case of a breakdown, accident, stranding or sinking. It is assumed this cost will often be borne by the States, which already lack adequate capacity for maritime disaster response. Vessel strandings and sinkings are commonplace throughout the region. Media outlets regularly carry items detailing the vessels already littered (either abandoned afloat or sunk) across many of the region's harbors and coastlines [29-31, 36-37]. There were more than 32 large wrecks across the Fijian ports of Suva, Lautoka and Levuka in 2022 [37]. The current capacity to address vessel strandings and sinkings is marginal and well below any realistic ability to respond to a major incident in a timely or effective manner. There is certainly no apparent capacity to adequately respond to an incident involving a nuclear-powered vessel and upgrading any Pacific capacity to this level would require a large and ongoing investment and a significant lead-in time.

Public perception and safety concerns

Nuclear-powered commercial ships have not yet gained widespread acceptance [38]. The idea of nuclear-powered ships still carries a significant stigma due to historical nuclear testing legacy in the Pacific, past accidents and the fear of radiation leaks. Critics argue the technology, while attractive in some aspects, simply isn't available in real terms - in this narrative the costs, security and safety concerns (real or imagined) far outweigh the benefits of nuclear power. While a high reduction in risk through technology, design and operational advances can theoretically be made, ultimate risk can still not be avoided due to the operating environment.

Proponents counter that while concerns exist about radiation exposure, extensive operational experience spanning over 800 reactor-years suggests that under normal conditions, the risk is minimal. In the maritime setting, the reactor compartment is reinforced with double bulkheads, a double bottom, and double hull protection to mitigate risks in the event of a collision or grounding [26]. In contrast to military vessels designed to resist damage, commercial ships are relatively thin-skinned and not nearly as damage-tolerant as military hulls. In addition to the risk of pirate, terrorist or wartime attacks, nuclear-powered commercial vessels will still face the risks of collision, grounding, and weather-related damage.

In nuclear-powered ships, the high initial cost of a reactor makes it likely that only a single unit will be installed, capable of generating sufficient power for both propulsion and auxiliary systems. To ensure operational safety, a backup propulsion system is essential in case of reactor failure, enabling the vessel to return to port and maintain critical emergency functions [6]. Again, this need for hybrid systems requires increased technical complexity and adds further to the construction and operational costs.

Existing maritime reactors are primarily in the service of State governments and are generally removed from the public. Commercial operation by private sector interests is highly likely to encounter public skepticism and opposition. Insurance and treaty agreements will need to be structured to ensure that the public is adequately compensated in case of an accident. The potential costs are not negligible.

There is a strong public legacy across the Pacific of the negative effects on communities and the environment from nuclear weapons testing (by the US, British and French) and the potential impacts of commercial nuclear power generation contamination as a result of low probability but high impact events (e.g. Fukushima wastewater discharges caused by a tsunami). As a result, Pacific communities are highly likely to be more resistant to any use of nuclear energy in their region than most, regardless of what level of safety precautions are offered.

From the literature it is clear that major advances have been made in advancing the safety agenda associated with MMRs in normal operating conditions. But this does not acknowledge that in a domestic Pacific operating scenario there are many situations where the vessel would need to operate in abnormal conditions, including tsunamis, underwater volcanic eruptions and extreme tropical cyclones in addition to the high risk of strandings.[4] Pacific Island States are the most vulnerable globally to natural disaster [39]. Many Pacific maritime communities have first-hand experience of vessel strandings in their areas, most with a legacy of reef damage, pollution, oil spills and inadequate response from operators, maritime authorities and governments. It can be assumed that arguments as to why these risks can be avoided or minimized in the case of a nuclear-powered vessel will be met with a high degree of skepticism at community level.

Workforce

Nuclear ships need a highly specialized workforce, both for crewing and operating the vessel and for all the necessary support services - including regulation and governance. Such a workforce requires internationally harmonized competency frameworks and training colleges. In naval deployment, military vessels demand a large number of highly trained and professional crews to operate nuclear generators. This may not be mirrored in civilian settings where crewing costs are a significant opex budget line.

In the case of the Pacific, a nuclear competent workforce would need to be built from scratch. Given the extremely current rundown status of maritime training institutions across the Pacific this is a much larger task than just adding additional curriculum to existing training programs. With the high levels of out-migration from the region, especially skilled workers, the costs of maintaining and retaining a skilled workforce capable of operating and regulating nuclear powered vessels will be ongoing. Resourcing adequate training for the existing maritime workforce to operate conventional fuel vessels is already beyond the capacity of most, if not all, Pacific governments.

The only alternative appears to be importing the required expertise. In addition to the increased external dependency this causes, this comes at high cost and high risk of not being able to be retained in the long term.

Waste management

Managing spent nuclear fuel is another challenge. While nuclear power can result in greatly reduced GHG emissions, it carries other major environmental risks. Issues of spent fuel handling, transport and disposal are complex: both legally and logistically. Decommissioning nuclear-powered naval vessels has become a major task for US and Russian navies [40]. While reactors designed for shipping may produce less waste than traditional reactors, handling and disposing of radioactive material in a maritime context still presents logistical and environmental risks and requires specific infrastructural capacity.

While relevant capacity may exist in developed States with an existing nuclear industry footprint, it is completely absent in the Pacific. Under normal operations, it can be expected that nuclear vessels would be sent to nuclear capable facilities outside the region for refueling / waste handling. However, there are many risks facing Pacific island deployment that could eventuate in the need for localized waste management capacity.

Political Support

Given it is states that determine regulation, deployment of nuclear power requires political support. Major generation disasters (e.g. Chernobyl, Fukushima) saw a major reduction in political appetite for civil nuclear power globally but there are numerous signs this is reversing due to a number of geo-political trends. Recently the EU included nuclear energy as a sustainable transition energy equivalent

[4] In the past 5 years, three new Australian built Pacific Guardian class patrol vessels and a NZ naval vessel have all been written off after Pacific Island reef strandings, despite being fitted with high quality instrumentation and with NZ and Australian standard trained crew.

to renewable energy such as wind and solar [41]. Policies blocking nuclear development are under re-evaluation in Belgium and Denmark [42]. In a significant pivot, the government of Japan plans to reactivate 14 of its 54 nuclear reactors [43]. The World Bank has lifted its ban on nuclear financing, in response to surging developing world electricity demand [44].

The Pacific is the only region to declare itself nuclear free. The nuclear debate in the Pacific has always been highly politically charged, largely due to the nuclear weapons testing legacy which triggered strong protests and resistance as disarmament and peace groups mobilized against the radioactive fallout across the inhabited islands. This intensified in the 1970s, as churches, trade unions, academics, university students, women's groups and customary leaders actively opposed the tests [45]. The Nuclear Free and Independent Pacific (NFIP) movement that evolved was broadly supported by Pacific Islands States. Fiji's then Prime Minister Ratu Mara took a strong oppositional stance on nuclear weapons testing in the Pacific. Fiji's advocacy during this time represented an important moment in Pacific Way politics, tying nuclear resistance to self-determination struggles, giving voice to small States [46].

While the primary focus of NFIP was ending weapons testing, it extended to broader opposition to nuclear energy by linking the industry to colonization, militarized violence and the long-term dangers of radioactive waste [46]. The 1983 Peoples' Charter for a Nuclear Free and Independent Pacific included a ban on "all nuclear power reactors, excepting very low capacity experimental units, all nuclear powered satellites, surface and sub-surface vessels and all transit, storage, release or dumping of radioactive material" [47].

Pacific States came together to create a Nuclear Weapons Free Zone through the South Pacific Nuclear-Free Zone Treaty of Rarotonga in 1985 [48]. This Treaty, which included Australia and other major powers, is far more specific to banning nuclear weapons and dumping of nuclear waste and supportive of peaceful nuclear energy use. Pacific voices have long been critical that the Treaty did not go far enough, specifically that it did not it prohibit nuclear-powered or equipped ships from calling in ports within the area [49]. The issue has re-arisen recently with Pacific Island governments and civil society groups expressing concern over Australian plans to purchase nuclear powered submarines from the UK and US under the AUKUS agreement [50].

Throughout 2021–24, Pacific Islands Forum leaders raised concern about Japanese proposals to dump contaminated wastewater from Fukushima into the Pacific Ocean. In August 2023, to the concern of civil society organizations, the Fiji government changed its stance, with Prime Minister Rabuka backing Japan's plans to release over one million tons of wastewater. Rabuka announced he was "satisfied with Japan's efforts and the IAEA's assessment that the release will be safe [51].

Given this collective legacy, in announcing that Fiji will be first Pacific state to embrace MMR technology to provide the country with electricity and power its maritime fleet, it is highly likely that the broader debate on the applicability of nuclear energy use within the Pacific will be re-opened.

Nuclear power potential for maritime deployment in Pacific Island States

In contrast to the literature available for nuclear power use for commercial shipping generally, the library specifically considering potential Pacific Island deployment is sparse. There have been some historic suggestions that commercialized small floating modular nuclear reactors could be developed for power generation in Pacific Island States, e.g. Hyperion Power Generation, USA (2010) [52]. Such opinion pieces favor the potential advantages that such power sources could provide but supply little or no analysis of costs, risks, liability or the regulatory complexity that needs to be addressed before serious consideration of such options can be considered further.

In regard to use of nuclear reactors aboard vessels for propulsion in Pacific Island maritime scenarios, no direct references prior to 2023 were found. In November of that year, a consortium including Australian-based design group Seatransport and LR unveiled plans to use MMR technology to propel a 73m amphibious vessel, designed for emergency response and disaster relief duties in remote areas. An initial concept video rendering of such a vessel operating from various Fijian ports and from Fiji to other Pacific Island States to provide disaster response was made available along with specific references to vessel design [12].

The story has been carried by multiple industry websites and blogposts [11, 52, 53-55]. By 2025, this collaboration was reported to be joined by US nuclear battery manufacturer Deployable Energy with designs refined to realize a hybrid-powered Stern Landing Vessel (SLV) incorporating two MMRs with the ability to supply power to Pacific islands hit by cyclones and the resulting energy blackouts [56]. Operating from Fiji it is argued these vessels could deliver aid to surrounding countries within days instead of weeks, significantly improving emergency response times compared to aid from Australia or New Zealand. The partners assert the vessels would require minimal coastal infrastructure to operate—just a simple concrete ramp and berthing pile—making them suitable for deployment in remote coastal regions with limited port facilities [11]. It is also contended that the environmental and economic benefits of nuclear-powered vessels extend beyond zero-emission propulsion. Seatransport estimates that a single SLV operating out of Fiji's Lautoka Port could reduce the country's diesel consumption by more than five million liters annually if used to provide nighttime power to complement daytime solar generation, arguing this hybrid approach to energy production could significantly contribute to decarbonisation efforts in Pacific Island States, which depend heavily on imported fossil fuels for electricity generation.[5]

Fiji government has confirmed that the proposal has the full support of the Fiji government which has committed to ordering a nuclear-powered vessel to be named "Ocean of Peace". In March 2025, media outlets reported an official statement by the Fiji Prime Minister that confirms Fiji's commitment to obtain the 73m vessel, but appears to walk back the intention for this to be nuclear powered vessel at build [13]. "Fiji is the first [Pacific Island] State to adopt micro modular nuclear reactor technology to provide the country with electricity", Prime Minister Rabuka said. "MMR will gradually replace the importation of petrol, which already costs Fiji over $1 billion a year, in addition to the expense of distributing power to remote parts of the country." Rabuka said the time had come for the creative use of technology to make Fijian life cleaner and provide power at lower costs. "At that point, the initial diesel engines would be replaced by an MMR, which would not require refueling for 10 years," he said. "The MMR power could be deployed on the Ocean of Peace ship and other vessels and used for emergency response and long-term power supply to Fijian communities at far lower costs than the present diesel-powered electricity generation". "All alternatives were being investigated, and the new, safe nuclear technologies of MMRs appeared to be within cost and emissions targets" [13].

Rabuka is also reported as calling for revitalizing the local shipbuilding industry to address skills shortages with a new shipyard in Lautoka to train steel and aluminum welders, electricians, carpenters, plumbers, draftsmen, technicians, and administrators [13]. The Australian Government has committed AUD1.2 million to support a detailed study and early works for a new shipbuilding and repair facility in Lautoka with the Phase 1 Report delivered to the Fiji government in March 2025 [57].

In June 2025 the governments of Japan and Fiji announced they had signed an Exchange of Notes to formalize the grant funding for

[5] It is not immediately apparent how these savings were calculated but would appear to be based on the vessel being plugged into a shore-grid on all nights. That would of course mean that the vessel could only be operated as a ship in daylight hours in close proximity to Lautoka.

the procurement of a Disaster Response Multipurpose Vessel with total funding of approximately FJD27.2 million [58]. Propulsion of this new vessel is not referred to in the announcement by either government. However, the budget would seem highly insufficient to include the construction of a 73m vessel and two MMR reactors.

Discussion

The inherently global and mobile nature of maritime operations, coupled with the fragmented and often unpredictable character of international shipping regulations, introduces significant ethical and governance challenges. These factors collectively complicate the adoption of nuclear propulsion for commercial vessels and underscore the need to critically assess its long-term feasibility within the sector.

The potential attractiveness of nuclear energy cannot be denied, at issue is whether the potential negative effects and risks to the environment and community can be sufficiently assuaged and whether the costs and benefits are real. An agreed international regulatory framework is required before insurance and liability issues can be addressed, in turn blocking research development and investment. Collectively the barriers are significant and strongly suggest that predictions of commercially deployed vessels in the short-term are likely highly optimistic.

When maritime nuclear power is used commercially, it is likely it would be deployed in niche areas most sympathetic to the unique nature of the energy source, at least initially. This implies vessels operating from and to ports that are fully capable of managing this energy source. The World Nuclear Association opines that nuclear power seems most immediately promising for a. large bulk carriers on a few routes between dedicated ports; b. cruise liners given the high hotel loads; c. nuclear tugs to take conventional ships across oceans; and d. some kinds of bulk shipping, where speed may be essential [32].

None of these characteristics applies in a domestic Pacific island operating scenario. Regardless of the technical readiness capacity of MMR technology internationally, it is clear that the barriers to real-time introduction as an alternative Pacific domestic or regional maritime fuel would be greatly amplified as discussed above in Section 1.

Given the scale and complexity of the challenges, it is difficult to see how a case can be made for using the Pacific as a test-bed in any near or short term scenario. Pacific vessels will be small-scale and operating far from any established nuclear technical expertise or services. There is no established regulatory, infrastructure or human capacity to operate or regulate such vessels. There appears to be no targeted research on other than technical design in the existing proposal. As yet, there is no publicly available information on how the initial vessels will be managed and regulated, any detailed cost benefit analysis and, most importantly, risk analysis. In the absence of clarity on these matters, it must be assumed that the majority of the risk falls to the environment, local communities and Pacific Islands governments. Even if the pilot technology is entirely grant funded or gifted, there are clearly high and ongoing additional costs to ensure a safe operating environment, which most likely will fall to Pacific governments.

Given that there is still no actual commercial deployment of MMR maritime technology globally, it must be argued that using small, remote and poorly equipped Pacific Islands as any type of test-bed or guinea pig for the introduction of nuclear energy technology is premature and potentially high risk and high cost. Before such technology can be considered there needs to be a significant advance in international use and in-depth analysis of the barriers specific to Pacific deployment. An informed conversation at technical and political levels within the Pacific as to the future role of nuclear energy in the region now needs to be had.

To conclude, there is no near or short-term case to make for nuclear powered domestic shipping and considerable peer-reviewed research is needed specific to Pacific deployment if decision-makers are to make well-informed decisions. Regardless of the technical readiness of this technology, any future role of this energy source will need to overcome substantive cost, technical, regulatory, liability and political barriers before it could be considered a viable option for any Pacific Island State. Whether it should be considered an option in the mid to long term requires a much deeper analysis.

If this assessment is correct, there is now a question as to whether the scant research resources available to prepare Pacific Island States for transitioning their domestic fleets away from fossil fuels is best expended on this particular technology.

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