NUCLEAR POWERED INTERNATIONAL COMMERCIAL SHIPPING: A NOTE ON THE GREENEST SOLUTION AND THE CHALLENGES OF INTERNATIONAL REGULATIONS

Rebecca McReynolds[*]

I. INTRODUCTION

The current global economy relies heavily on an efficient and fast-moving supply chain. In the last few years, it has become quite clear how susceptible the world's supply chain is to disruptions. The key to an efficient supply chain is an effective international commercial shipping industry as 90% of global trade is conducted by commercial ships.[1] With an ever-increasing demand for goods, which has no indication of this slowing, the shipping industry now deploys a greater number of merchant ships each year. The ships rely on marine diesel fuel for power, and this diesel fuel emits high levels of pollutants.[2] With more ships in the water, the challenge of dealing with their pollution is becoming increasingly important.

In 2015, the United Nations ("UN") developed a plan to reduce the risk of carbon emissions by implementing Goal 13.[3] The International Maritime Organization ("IMO") is part of the UN and is a "specialized agency" that centers on "the safety and security of

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[*] Rebecca McReynolds, Juris Doctor Candidate Spring 2024, Barry University School of Law.

[1] *Marine Env't.*, IMO, https://www.imo.org/en/OurWork/Environment/Pages/Default.aspx, (last visited Nov. 17, 2022).

[2] Maria Gallucci, *The Struggle to Make Diesel-Guzzling Cargo Ships Greener*, IEEE (May 29, 2018), https://spectrum.ieee.org/the-struggle-to-make-dieselguzzling-cargo-ships-greener.

[3] *Initial IMO GHG Strategy*, IMO, https://www.imo.org/en/MediaCentre/HotTopics/Pages/Reducing-greenhouse-gas-emissions-from-ships.aspx, (last visited Nov. 17, 2022).

shipping and the prevention of marine and atmospheric pollution by ships."[4] More importantly, the IMO sets mandatory actions that the international shipping industry must follow and the policy set by the IMO becomes law.[5] The IMO is the global leader in international shipping concerns and in an effort to reduce the emissions of greenhouse gases, adopted "mandatory measures … under [their] Pollution Prevention Treaty ('MARPOL')."[6] It is important to note that within the IMO's preliminary strategy, their efforts "focus on a reduction in carbon intensity of international shipping [by attempting to] reduce carbon dioxide emissions per transport work, as an average across international shipping, by at least forty percent by 2030".[7]

The ultimate goal of the IMO regulations is the overall reduction of carbon emissions by international shipping companies by forty percent by 2050.[8] In order to achieve this goal across all commercial shipping, companies are going to face significant challenges, both logistically and financially. International commercial shipping companies will need a major shift in fuel use and efficiency in order to meet the mandates set by the IMO.

A balance is needed between the ever-increasing demand for easily attainable goods, the efficiency in which they are delivered, and the pollution these ships emit. Though there are current trends towards new technological advancements that can reduce the emissions created by ships, the eventual way to completely eradicate

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[4] *Introduction to IMO*, IMO, https://www.imo.org/en/about/pages/default.aspx, (last visited July. 26, 2023).
[5] *IMO's Work to Cut GHG Emissions From Ships*, IMO, https://www.imo.org/en/MediaCentre/HotTopics/Pages/Cutting-GHG-emissions.aspx (last visited July 26, 2023).
[6] *Initial IMO GHG Strategy*, IMO, https://www.imo.org/en/MediaCentre/HotTopics/Pages/Reducing-greenhouse-gas-emissions-from-ships.aspx, (last visited Nov. 17, 2022).
[7] *Id.*
[8] *Id.*

carbon emissions is to implement nuclear energy.[9] Currently and historically, ninety-nine percent of total energy for commercial shipping has come from oil products.[10] Nuclear energy, however, is a zero-emission solution that can be implemented safely.[11] Unfortunately, international rules and regulations on nuclear-powered commercial shipping has not kept pace with these advancements in nuclear propulsion. Commercial shipping companies do not want to assume the risk of costly investment into nuclear power without set, international standards in place.

This note will begin with a brief introduction to the benefits of nuclear energy will along with addressing the current environmental challenges facing the commercial shipping industry. Next, it will tackle why nuclear power is the best option even when compared to current, short-term, and more inexpensive environmentally friendly options, while also discussing historical examples of nuclear merchant ships. It will then lead to a discussion on the largest hurdle of a lack of current international regulations, safety concerns, and how, in order to encourage commercial adoption of nuclear-powered shipping, an international legal effort must address and standardize the numerous issues of bringing nuclear ships into international ports. That discussion will be compared to the successful Japanese model and some current legislation efforts addressing nuclear ships. Finally, this article will propel towards the endorsement that the ultimate green future for international shipping must anchor on nuclear power, an effort that must be led by the United States ("U.S.").

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[9] The Editorial Team, *Is Nuclear Power the Future of Shipping?*, SAFETY4SEA, (Feb. 1, 2021), https://safety4sea.com/cm-is-nuclear-power-the-future-of-shipping/.
[10] *Int'l. Shipping*, IEA (Sept. 2022), https://www.iea.org/reports/international-shipping.
[11] *Id.*

II. THE ENVIRONMENTAL PROBLEM AND WHY NUCLEAR IS THE ANSWER

A. The IMO's Initial Strategy Against The Pollution Caused By Commercial Shipping.

The IMO's vision details how it remains "committed to reducing greenhouse gas ("GHG") emissions from international shipping and, as a matter of urgency, aims to phase them out as soon as possible in this century."[12] Further, within their Initial Strategy, the IMO recognizes "that technological innovation and the global introduction of alternative fuels and/or energy sources for international shipping will be integral to achieve the overall ambition."[13] Moreover, the IMO is the only organization that has adopted legally binding environmental energy-efficiency measures across the entire global industry of commercial shipping.[14] Because the IMO is one of the most influential organizations as it relates to international commercial shipping, if it enacts mandates, it is likely to have an enormous effect on pollution reduction.

On the positive side, "shipping – which transports about [ninety percent] of global trade – is, statistically, the least environmentally damaging mode of transport, when its productive value is taken into consideration."[15] Even so, "if global shipping were a country, it would be the sixth largest producer of greenhouse gas emissions."[16] It is also important to note that while most of the environmental effects created by ships are carbon dioxide emissions, other pollutants such as "black carbon, nitrogen oxides, and nitrous oxide" are also incessant demand for goods, it is clear

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[12] *Initial IMO GHG Strategy*, IMO, https://www.imo.org/en/MediaCentre/HotTopics/Pages/Reducing-greenhouse-gas-emissions-from-ships.aspx, (last visited Nov. 17, 2022).
[13] *Id.*
[14] *Id.*
[15] *Marine Env't.*, IMO, https://www.imo.org/en/OurWork/Environment/Pages/Default.aspx, (last visited Nov. 17, 2022).
[16] *Id.*

why the IMO has prioritized the need to reduce emissions as quickly as possible.

In response to these valid concerns, the IMO has adopted mandatory measures to ensure the world pollution issue caused by commercial ships is reduced, if not eradicated.[17] This initial strategy mainly prioritizes the need to decrease GHG emissions.[18] The IMO is committed with a goal to re-confirm or revise in 2023 in order to address changes implemented and developments in technology.[19] Setting a lofty goal, it was nonetheless approved by roughly 100 IMO member states and sets the IMO's vision:

> Under the identified "levels of ambition", the initial strategy envisages for the first time a reduction in total GHG emissions from international shipping which, it says, should peak as soon as possible and to reduce the total annual GHG emissions by at least 50% by 2050 compared to 2008, while, at the same time, pursuing efforts towards phasing them out entirely.[20]

Though these goals are comforting in theory, in reality, the ability to implement them, especially when given such a short timeline may be problematic.

B. Background On Current Nuclear-Powered Ships And A Discussion On Their Effectiveness

When one thinks of nuclear power, one's thought might trend towards negative. The worst of nuclear accidents include: Three Mile Island, Fukushima, and, of course, Chernobyl.[21] These

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[17] *Initial IMO GHG Strategy*, *supra* note at 12**.**
[18] *Id.*
[19] *Id.*
[20] *Press Briefings*, IMO, https://www.imo.org/en/MediaCentre/HotTopics/Pages/Reducing-greenhouse-gas-emissions-from-ships.aspx, (last visited Nov. 17, 2022).
[21] *The Five Worst Nuclear Disasters in History*, PROCESS INDUS. F., https://www.processindustryforum.com/energy/five-worst-nuclear-disasters-history, (last visited on Jan. 20, 2023).

three events involved land-based power plants and had varying issues that caused these accidents.[22] Though these concerns about nuclear power plants are valid, nuclear-powered ships are indeed different. Today's technological advancements and ever-changing developments in the field, the U.S. Navy has allowed been allowed to effectively utilize nuclear ships for approximately seventy-five years.[23] During that time period, about "700 nuclear reactors have served at sea and today there are about 200" in use.[24] A large quantity of naval ships are powered by small, onboard reactors.[25] These reactors work by splitting atoms, which in turn creates heat.[26] The heat is used to create high-pressure steam that turns propulsion turbines that power the propellers in order to drive the ship.[27] Not only do these reactors last a long time without a need to be refueled, they also make the ship extremely efficient as they are the source of a ship's electricity.[28] In addition to less fuel usage nuclear powered ships "go about [fifty percent] faster than oil-fired ships of the same size."[29]

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[22] Edward Moore Geist, *What Three Mile Island, Chernobyl, and Fukushima can teach about the next one*, BULLETIN OF THE ATOMIC SCIENTISTS (April 28, 2014), https://thebulletin.org/2014/04/what-three-mile-island-chernobyl-and-fukushima-can-teach-about-the-next-one/.

[23] James Conca, *America's Navy The Unsung Heroes of Nuclear Energy*, FORBES (Oct. 28, 2014), https://www.forbes.com/sites/jamesconca/2014/10/28/americas-navy-the-unsung-heroes-of-nuclear-energy/?sh=678db0f93eeb.

[24] *The Nuclear Propulsion of Merchant Ships*, NUCLEAR ENG'G. INT'L. (Aug. 15, 2011), https://www.neimagazine.com/features/featurethe-nuclear-propulsion-of-merchant-ships/

[25] *Nuclear Submarines and Aircraft Carriers*, EPA, https://www.epa.gov/radtown/nuclear-submarines-and-aircraft-carriers, (last visited Nov. 17, 2022).

[26] *Id.*

[27] *Id.*

[28] *Id.*

[29] James Conca, *Int'l. Marine Shipping Industry Considers Nuclear Propulsion*, FORBES (Nov. 9, 2020, 8:00 AM), https://www.forbes.com/sites/jamesconca/2020/11/09/international-marine-shipping-industry-considers-nuclear-propulsion/?sh=398a0b84562c.

Interestingly enough, "America's Nuclear Navy is one of the oldest and largest nuclear organizations in the world and has the best safety record of any industry." When discussing safety onboard nuclear ships, "the Nuclear Navy has logged over 5,400 reactor years of accident-free operations and travelled over 130 million miles on nuclear energy, enough to circle the earth 3,200 times."[30] Though, understandably, civilians may have some reservations regarding nuclear reactors aboard a moving, large vessel, the U.S. Navy operates its nuclear ships "all over the world, sometimes in hostile environments, with no maintenance support except their own crew."[31]

The safety standards aboard these ships are defined and effective, especially given "the fact that operators and crews have to live in close proximity to the nuclear reactor requires that the reactor have redundant systems and comprehensive shielding."[32] Furthermore, regarding environmental effects, the Navy has not experienced any "adverse effect on marine life" in the more than fifty years it has utilized nuclear propulsion.[33] It is clear that if the commercial shipping industry intends to adopt nuclear energy to power merchant vessels, the best reference and guide will come from the current standard set by the U.S. Navy.

C. Short Term Greener Options That Prove Ineffective Compared to Nuclear Propulsion

Due to the IMO's strong push towards greener fuel sources and decreased emissions, many international shipping companies have sought short term solutions that effectively band aid the issue. Though the maritime shipping is considered one of the greenest means of transporting goods "in terms of carbon emissions per ton

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[30] Conca, *supra* note 23.
[31] *Id*.
[32] Ryan White, *How Safe Are the U.S. Nuclear Powered Warships?*, NAVAL POST (Mar. 17, 2021), https://navalpost.com/how-safe-the-u-s-nuclear-powered-warships/.
[33] *Id.*

per mile", the fuel source depended on by the industry contains "a cocktail of pollutants".[34] The majority of large container vessels "use heavy fuel oil, a residue of crude oil distillation with a high level of sulphur."[35] High levels of sulphur in the environment has disastrous effects on the atmosphere, can damage crops, and harms aquatic species.[36] The most obvious solution for commercial shipping companies is to switch to a less pollutant causing and lower sulphur containing fuel source. These types of greener fuels include ultra-low sulphur fuel oil, very-low sulphur fuel oil, liquified natural gas ("LNG"), and marine gas oil.[37] Though these types of low sulphur containing fuel sources are better for the environment, they are unfortunately still fuel, which requires refueling and are therefore held captive to the fluctuating and unpredictability of the global fuel market.[38] The unpredictability is due to the lack of availability and the unstable price market.

In recent years, liquified natural gas has become a more dependable alternative fuel source for the shipping industry and is currently considered the shipping fuel of the future.[39] In support of using LNG as a shipping fuel source, the LNG global market has expanded, creating more of a supply and a decrease in price.[40] Due to the uptick in LNG usage in the shipping industry, Royal Dutch Shell has developed the first floating liquified natural gas platform

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[34] Shanaathanan Shivanandan, *The Shipping Industry's Green Revolution*, ACUITY KNOWLEDGE PARTNERS (Oct. 27, 2021), https://www.acuitykp.com/blog/the-shipping-industry-green-revolution/.
[35] *Id.*
[36] *Id.*
[37] *Id.*
[38] *Id.*
[39] Bikram Singh, *Liquified Natural Gas (LNG) as Fuel for the Shipping Industry*, MARINE INSIGHT (Feb. 8, 2019), https://www.marineinsight.com/green-shipping/liquified-natural-gas-lng-as-fuel-for-the-shipping-industry/.
[40] John England, *LNG Industry Trends*, DELOITTE, https://www2.deloitte.com/us/en/pages/energy-and-resources/articles/lng-industry-trends-oil-natural-gas-report.html (last visited Feb. 2, 2023).

to refuel ships that utilize LNG.[41] This floating platform is an incredible innovation as it "removes the need for pipelining systems to land-based processing plants."[42] Though the Prelude is a feat of engineering that moves the industry away from fossil fuels, it does come with its own problems, including multiple fires onboard.[43] These fires have shut down production numerous times since the floating vessel was created and is a serious danger to those on board.[44]

Though there are short-term greener advantages to employing fuel solutions such as LNG, they do come with their own unique challenges that have not been fully addressed. Furthermore, given that the low sulphur fuels are relatively new, shipping companies are also strained by both their availability and quality.[45] The high cost and low availability does not help incentivize companies to implement them. Also, though these fuels decrease emissions, it does not eliminate them entirely. For these reasons, although it is clear these innovative means of fuel are a viable option for short-term use, they are still not as dependable or as safe as nuclear power.

The use of massive battery packs, or the more commonly utilized, hydrogen fuel cells, come with short-term environmental advantages.[46] "A key advantage of hydrogen over other fuel alternatives is the relative ease of retrofitting existing ship" with the

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[41] *Here's All You Need to Know About Shell Prelude FLNG*, MAX GROUPS (Oct. 25, 2016), https://max-groups.com/shell-prelude-flng-facts/.
[42] *Id.*
[43] Ajsa Habibic, *Shell Suspends Production at Prelude FLNG After Fire Breaks Out*, OFFSHORE ENERGY (Dec. 22, 2022), https://www.offshore-energy.biz/shell-suspends-production-at-prelude-flng-after-fire-breaks-out/.
[44] *Id.*
[45] Shanaathanan Shivanandan, *The Shipping Industry's Green Revolution*, ACUITY KNOWLEDGE PARTNERS (Oct. 27, 2021), https://www.acuitykp.com/blog/the-shipping-industry-green-revolution/.
[46] Maria Gallucci, *The Struggle to Make Diesel-Guzzling Cargo Ships Greener*, IEEE (May. 29, 2018), https://spectrum.ieee.org/the-struggle-to-make-dieselguzzling-cargo-ships-greener.

fuel cells."[47] Another value to fuel cells a global hydrogen market already exists, providing for relatively accessible hydrogen where "seventy million metric tons of hydrogen are produced for industrial use worldwide every year."[48] Also, hydrogen is easier to store in large quantities for an extended period of time, which is an advantage to the shipping industry as merchant ships utilize large amounts of fuel.[49] In addition, hydrogen fuel cells "provide a continuous supply of energy as long as the cell is fed with fuel, which is an advantage over batteries" as batteries will "need to be recharged."[50]

Though there are many positives to using hydrogen fuel cells as a greener solution, there are some major disadvantages to their use. The first major disadvantage is its extremely flammable nature and it "has a larger ignition range than traditional fuels, meaning that hydrogen will burn at both low and high concentrations when combined with oxygen." [51] Every sailor knows that an onboard fire is the biggest concern at sea. Another problem with using of hydrogen to fuel ships is that "hydrogen, even in liquid form, is less energy-dense than bunker fuel, meaning that hydrogen fuel cells will take up more volume on cargo ships."[52] With more space being utilized by fuel than cargo, this could cause a problem for shipping companies that rely on efficiently optimizing space for transporting goods. The largest environmental issue facing the use of hydrogen lies in the fact that hydrogen fuel cells still require refueling.[53] When compared to nuclear propulsion that requires no refueling for approximately twenty years, this fact alone creates a clearer case that hydrogen fuel cells, though more effective than other options,

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[47] William Alan Reinsch, *Hydrogen: The Key to Decarbonizing the Global Shipping Industry?*, CSIS (April. 13, 2021), https://www.csis.org/analysis/hydrogen-key-decarbonizing-global-shipping-industry.
[48] *Id.*
[49] *Id.*
[50] *Id.*
[51] *Id.*
[52] *Id.*
[53] *Id.*

are still a short-term greener solution that will not solve the ultimate goal of completely eliminating emissions from the shipping industry.[54]

The use of "scrubbers" is another option the commercial shipping industry is experimenting with.[55] These so-called "scrubbers" are an installed system that works to "clean exhaust gases."[56] The IMO has allowed shipping companies to comply with its mandates by adopting equivalent compliance measures so long as they fulfilled their obligation to reducing emissions.[57] As a result, shipping companies have installed scrubbers on their ships, mainly because they are the cheapest and simplest way to reduce the vessel's carbon emissions.[58] These scrubbers "sit in the funnels, or exhaust stacks, of ships" and "use seawater to spray or 'scrub' the sulphur dioxide pollutants from the engine's exhaust".[59] Though, in theory, the exhaust produced by ships that use scrubbers is less pollutant, it really is a double edged sword. While it is an easy and cheaper way to comply with the IMO's directive, the scrubbers allow for these large ships to continue to use pollutant heavy fuel.[60] The end result causes an estimated "[ten] gigatonnes of scrubber washwater" to be emitted each year without any "additional regulations".[61] After the seawater is used to "scrub" the exhaust vents on ships, the remaining water is disposed of back into the ocean, often without further treatment to the discharge.[62] The wash

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[54] *Nuclear Submarines and Aircraft Carriers, supra* at note 25.
[55] Shivanandan, *supra* at note 34.
[56] Richa Syal, *Shipping's Dirty Secret: How 'Scrubbers' Clean the Air – While Contaminating the Sea*, THE GUARDIAN (Jul. 12, 2022, 5:45PM), https://www.theguardian.com/environment/2022/jul/12/shippings-dirty-secret-how-scrubbers-clean-the-air-while-contaminating-the-sea.
[57] *Id.*
[58] *Id.*
[59] *Id.*
[60] *Id.*
[61] Liudmila Osipova, *Global Scrubber Washwater Discharges Under IMO's 2020 Fuel Sulphur Limit*, THE INT'L. COUNCIL ON CLEAN TRANSP. (April 29, 2021), https://theicct.org/publication/global-scrubber-washwater-discharges-under-imos-2020-fuel-sulfur-limit/.
[62] *Id.*

water is "more acidic than the surrounding seawater and contains polycyclic aromatic hydrocarbons, particulate matter, nitrates, nitrites, and heavy metals including nickel, lead, copper, and mercury."[63] The major concerns of this byproduct in the ocean is that it "is toxic to some marine organisms" and "can worsen water quality."[64] Only a few countries have noticed this growing issue and have banned the use of scrubbers in their ports.[65] Given that scrubbers create such a negative result, it is unlikely that they will be the ultimate answer to the IMO's mandates towards net-zero emissions and a greener shipping industry.

Overall, it is clear that there is a major environmental concern facing the global marine shipping industry. Though a few solutions are being used to address the IMO's need for a greener industry, they are short-term, and their negative aspects outweigh the positives. This raises the question as to why nuclear energy is not implemented in the global shipping industry. As a clean, reliable, safe, and effective energy source, nuclear propulsion systems, similar to those used today in the U.S. Navy, are the true way to fully commit to the green initiative. Though nuclear energy has outstanding benefits, it does have its own problems.

III. PREVIOUS ATTEMPTS AT NUCLEAR COMMERCIAL SHIPS

A. NS Savannah and Her Failure to Change the World

Nuclear propulsion in American ships is nothing new. In 1955, nuclear propulsion was first introduced with submarines when the U.S. launched the submarine U.S.S. Nautilus.[66] With the success of the Nautilus, the U.S. launched the nuclear ship ("NS") Savannah,

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[63] *Id.*
[64] *Id.*
[65] *Id.*
[66] John Carlton, *The Nuclear Propulsion of Merchant Ships*, NUCLEAR ENG'G INT'L. (Aug. 15, 2011), https://www.neimagazine.com/features/featurethe-nuclear-propulsion-of-merchant-ships/.

the world's first "passenger-cargo demonstrator ship."[67] In 1959, the NS Savannah sailed under President Eisenhower's "Atoms for Peace progra[m]."[68] The Atoms for Peace program was designed to push world leaders to use nuclear power for peaceful purposes rather than simply using them for weapons.[69] After completing its mission as a demonstrator ship, "the ship was removed from service and the reactor was defueled."[70] Interestingly, the NS Savannah followed her predecessor with the same name, a ship from 1819 that traveled into the new age of ships by being "the first vessel to use steam on a transatlantic crossing."[71] The original Savannah "ushered in the Steam Age in ocean travel" and "it is fitting that another Savannah should usher in the Atomic Age."[72] Though the Savannah should have been the flagship of using nuclear energy for commercial shipping in a peaceful manner, it "was designated as a National Historic Landmark in 1991" and ultimately failed to change the merchant shipping industry.[73]

Despite the NS Savannah's seemingly successful voyages, it never sparked any further development of nuclear commercial ships. The NS Savannah is one of only four "nuclear-powered cargo ships ever built."[74] Successfully, the Savannah "proved without question that a nuclear reactor could power a commercial ship."[75] Impressively, the Savannah was fitted with a "two-loop eighty [mega-watts] pressurized water reactor" that produced enough power to "allow it to sail around the globe fourteen times at twenty

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[67] *Id.*
[68] *Id.*
[69] *World's First Nuclear-Powered Merchant Ship to Be Decommissioned*, NUCLEAR NEWSWIRE (Jan. 11, 2023), https://www.ans.org/news/article-4634/worlds-first-nuclearpowered-merchant-ship-to-be-decommissioned/.
[70] *Nuclear Ship Savannah*, U.S. DEPT. OF TRANSP. MARITIME ADMIN. (April 16, 2020), https://www.maritime.dot.gov/nssavannah.
[71] *NS Savannah*, S.F. MARITIME NAT'L. PARK ASS'N. (Mar. 9, 2011), https://maritime.org/tour/savannah/press/part1.php.
[72] *Id.*
[73] *World's First Nuclear-Powered*, *supra* at note 69.
[74] *Id.*
[75] *Id.*

knots without refueling."[76] Also, the NS Savannah carried cargo commercially to thirty-seven foreign ports with 737 reactor start-ups and met "all advanced schedules without a single plant failure."[77]

With all this power and effectiveness that is required for a commercial ship, why did the Savannah ultimately fail? The NS Savannah unfortunately was not "economically viable" for its time and "did not lead to an effort to build a fleet of nuclear-powered vessels as originally hoped."[78] Furthermore, the NS Savannah failed with overall costs attributed to specialized labor training, shore staff operations, and the cost of indemnity insurance.[79] Specialized labor was critical because, since the ship ran on nuclear power, the personnel onboard needed to be highly trained with years of schooling in operating a nuclear vessel.[80] The average cost for specialized training were estimated to be over $300,000.[81] Shore staff operations also added significantly to the overall operating cost of the vessel as they also required specialized training at an estimated "$409,000 average annual cost".[82] The shore staff included legal counsel that were responsible for the "development of port entry arrangements with foreign governments."[83] Furthermore, the NS Savannah was required to have indemnity insurance, which contributed heavily to the overall operating costs of the vessel.[84] An analysis conducted by the U.S. General Accounting Office found a "relatively small amount of claims paid by the underwriter compared with the premium paid for protection

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[76] *Id.*
[77] Ferhat Celik, *Nuclear Powered Merchant Vessels*, MORE THAN SHIPPING (Jan. 4, 2017), https://www.morethanshipping.com/nuclear-powered-merchant-vessels/.
[78] *World's First Nuclear-Powered, supra* at note 69.
[79] *Costs of Operating the Nuclear Ship Savannah*, U.S. GEN. ACCT. OFF. (June 26, 1970), https://www.gao.gov/assets/b-136209.pdf.
[80] *Id*.
[81] *Id*.
[82] *Id*.
[83] *Id.*
[84] *Id.*

and indemnity insurance."[85] The high cost of insurance ultimately was one of the factors that attributed to the NS Savannah's demise and would need to be reevaluated if nuclear commercial shipping has a future. The NS Savanah proves that nuclear propulsion is possible in commercial ships but requires economic efficiency and public acceptance.

B. Other Attempts At Nuclear Commercial Ships

Similarly to its American counterpart, the German nuclear cargo ship, NS Otto Hahn, was launched in 1968 to similarly to show that nuclear propulsion could be used peacefully.[86] The ship housed thirty researchers, technicians, and engineers that monitored the ship's progress and allowed for advancing science in the field of nuclear energy.[87] After fifteen years of service, the ship was eventually decommissioned, but not without providing a valuable diagnosis of the question on whether nuclear propulsion could work for commercial ships.[88] Overwhelmingly, "the conclusion of those in charge of the project" was that "from the scientific and technical perspectives, the pressurized water reactor had proved itself as a means of propulsion."[89] The ship was very successful in what it was deigned to do and is a good stepping stone for future success of nuclear propulsion in commercial ships. Unfortunately, despite its success, many countries denied the Otto Hahn entrance to their ports due to the public's perspective of safety concerns about using nuclear energy.[90] Ultimately, the denial of the Otto Hahn did not make a much of economic sense for its time period.[91]

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[85] *Id.*
[86] *40 Years Back: Bulk Carrier & Research Vessel "Otto Hahn" Heads to Sea for Hapag-Lloyd*, HAPAG-LLYOD (Mar. 30, 2017), https://www.hapag-lloyd.com/en/company/about-us/newsletter/2017/03/40-years-back--the-nuclear-powered-bulk-carrier-and-research-ves.html.
[87] *Id.*
[88] *Id.*
[89] *Id.*
[90] *Id*.
[91] *Id.*

Another attempt at using nuclear for commercial ship came with the Japanese commercial ship, NS Mutsu, which launched in 1969 in the hopes that it would be the flagship of a fleet of nuclear ships.[92] Unfortunately, the Mutsu was far less successful than the Otto Hahn and the Savannah as it had major structural problems with its reactor shield.[93] Similar to the ships mentioned above, it also faced problems with public outcry. An example of negative public perception towards the Mutsu was when a group of local Japanese fishermen feared the Mutsu would destroy their fishing grounds. To fight against the Mutsu, the fisherman decided to block the harbor with their boats to prevent the ship from leaving the port.[94]

Ultimately at the end of the Mutsu's tenure, the Japanese government was forced to shell out more money to fix the nuclear ship issue than the ship was actually worth.[95] Despite these problems with the Mutsu, it is argued that Japan has put more time and energy into making nuclear merchant ships work and has learned from all its mistakes.[96] Ultimately, the Mutsu was decommissioned and transitioned by taking out the nuclear reactor to a weather research ship called the Mirai.[97] A common theme emerged from the three attempts at commercial nuclear propulsion ships: the public perception of the use of nuclear ships, and even with advancements in technology, economic issues of implementing nuclear plants aboard.

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[92] Ronald E. Yates, *Setbacks Submerge Japan's Nuclear Ship*, CHICAGO TRIBUNE (Sep. 2, 1990), https://www.chicagotribune.com/news/ct-xpm-1990-09-02-9003130692-story.html.
[93] *Id.*
[94] *Id.*
[95] *Id.*
[96] *Id.*
[97] *Nuclear Ship Mutsu*, GLOB. SEC., https://www.globalsecurity.org/military/world/japan/ns-mutsu.htm (last visited on Feb. 1, 2023).

IV. A NEED FOR CIVILIAN NUCLEAR PROPULSION REGULATIONS

A. Current Regulations That Address Commercial Nuclear Propulsion Ships

Currently, in the U.S., there is no governing regulations that specifically address nuclear powered commercial ships. However, "a nuclear ship without a core is a ship like any other" and therefore should be subjected to current regulations.[98] Safety aboard nuclear ships is the main issue. Safety concerns for both the workers on the ship and any third parties that can potentially be affected by an accident. The governing law concerning private and military use of nuclear materials, in general, is the Atomic Energy Act of 1954 ("The Act").[99] The Act was amended by the Energy Reorganization Act of 1974, which established the United States Nuclear Regulatory Commission ("NRC").[100] The Act encourages civil use of nuclear energy in that it states "'the development, use, and control of atomic energy shall be directed so as to promote world peace, improve the general welfare, increase the standard of living, and strengthen free competition in private enterprise.'"[101] This commission regulates nuclear energy for mainly public, military uses of nuclear energy, but does address private uses as well.[102]

Another current regulation involving nuclear energy is Title 15 of the Code of Federal Regulations. Title 15 states that "it is the policy of the United States Government to encourage United States firms and individuals to participate in maritime (civil) nuclear propulsion plant projects in friendly foreign countries provided that

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[98] Julia Kroenke, *What is Nuclear Ships in SOLAS Regulation?*, COAST GUARD S. (Dec. 17, 2022), https://www.coastguardsouth.org.nz/what-is-nuclear-ships-in-solas-regulation.
[99] *Governing Legislation*, NRC, https://www.nrc.gov/about-nrc/governing-laws.html#atomic (last visited Dec. 18, 2022).
[100] *Id.*
[101] *Id.*
[102] *Id.*

U.S. naval nuclear propulsion information is not disclosed."[103] The first part of this regulation requires licenses for transportation of any nuclear technology related to nuclear propulsion.[104] These current regulations show that U.S.'s policy is not opposed to the use of nuclear energy within a civil context even if they do not specifically describe the use of nuclear propulsion for commercial shipping. Without specific regulation to address the use of nuclear energy in commercial ships, the implementation of this clean energy source is seemingly unlikely.

The key international treaty that affects the use of nuclear energy in a civil context is the Nuclear Non-Proliferation Treaty ("NPT").[105] The treaty encourages three main ideas: disarmament, nonproliferation, and peaceful use of nuclear energy.[106] This treaty was created in 1970 and was voted to be extended indefinitely in 1995.[107] To address the use of nuclear energy for civilian purposes even further, the Convention of Nuclear Safety ("CNS") and the Convention on the Physical Protection of Nuclear Material ("CPPNM") were adopted and signed by several contracting parties.[108] Some of the contracting parties for the CNS include the United States, the United Kingdom, and China.[109] The CNS is "an incentive instrument based on the Parties' common interest to achieve a high level of safety" where the contracting parties participate in a "peer review process."[110] The CPPNM and its amendment are "the only legally-binding international agreement mandating standards of physical protection for civil nuclear materials."[111] The CPPNM is a comprehensive document that

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[103] 15 C.F.R. § 744.5(c) (2022).
[104] *Id.*
[105] *Treaties & Conventions,* NRC, https://www.nrc.gov/about-nrc/ip/treaties-conventions.html (last visited Dec. 18, 2022).
[106] *Id.*
[107] *Id.*
[108] *Id.*
[109] *Convention on Nuclear Safety*, IAEA (June 3, 2022), https://www.iaea.org/sites/default/files/22/06/nuclearsafety_status.pdf.
[110] *Id.*
[111] *Id.*

details and mandates participating states "to enact measures for physical protection during international nuclear material transport, requires states to criminalize the malicious use of nuclear material, and sets standards for prosecution and extradition."[112] The adoption of the CPPNM and its amendment "were crucial milestones in the development of the international legal framework for nuclear security, as they remain the only internationally legally binding undertakings in the area of physical protection of nuclear material […] used for peaceful purposes."[113] The CCPNM also established the International Atomic Energy Agency ("IAEA"), which "helps facilitate adherence to and effective implementation of the CPPNM and its Amendment."[114] This legal framework provided by the CNS and CCPNM are key to the safe usage of privatized nuclear energy.

The IAEA also provides legislative assistance for partnering and member countries in order to promote effective nuclear legislation.[115] The IAEA recognizes the importance of "comprehensive and coherent national legislation" in that it is "essential to ensure the safe, secure, and peaceful use of nuclear technologies."[116] This program assists member states "in complying with their international obligations and commitments, as well as with the drafting of corresponding national nuclear legislation."[117] With the help of the IAEA, member states can address all areas of nuclear use, including "nuclear safety; nuclear security; safeguards and non-proliferation; and liability for nuclear damage."[118] This prolific and international program is crucial in developing commercial ships' nuclear legislation.

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[112] *Id.*
[113] *Convention on the Physical Protection of Nuclear Material (CPPNM) & its Amendment*, IAEA, https://www.iaea.org/publications/documents/conventions/convention-physical-protection-nuclear-material-and-its-amendment (last visited Dec. 18, 2022).
[114] *Id.*
[115] *Legis. Assistance*, IAEA, https://www.iaea.org/services/legislative-assistance (last visited Dec. 18, 2022).
[116] *Id.*
[117] *Id.*
[118] *Id.*

B. Proposed Regulations That Could Turn the Tides

Based on the necessity imposed by the IMO to reduce pollutants and emissions caused by the commercial shipping industry, the possibility of changing to nuclear propulsion is an increasingly popular option.[119] The true way for the commercial shipping industry to move towards nuclear energy is for countries with large holds on the international market to adopt nuclear friendly legislation. In response to this growing interest in nuclear propulsion, the United Kingdom ("UK") is taking steps to add nuclear regulations to address commercial and merchant shipping.[120] "The U.K.'s Department of Transportation and Maritime and Coastguard Agency are taking final steps toward the enactment of the Merchant Shipping (Nuclear Ships) Regulations."[121]

These regulations will incorporate aspects of Chapter VII of Annex to the International Convention for the Safety of Life at Sea ("SOLAS"), which will allow the "nuclear code" to be adopted for merchant ships.[122] SOLAS is arguably the "most important of all international treaties concerning the safety of merchant ships."[123] The main purpose of SOLAS is "to specify minimum standards for the construction, equipment and operation of ships, compatible with their safety."[124] Furthermore, SOLAS dictates that the country that the ship is under is responsible for its safety compliance.[125] Chapter VII of SOLAS further details the safety standards that must be

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[119] *UK to Adopt Regulations for Nuclear Powered Commercial Ships*, MARITIME EXECUTIVE (Aug. 25, 2022), https://maritime-executive.com/article/uk-to-adopt-regulations-for-nuclear-powered-commercial-ships.
[120] *Id.*
[121] *Id.*
[122] Jasmina Ovcina Mandra, *Nuclear Ships Regulations to Enter Into Force in UK on December 8*, OFFSHORE ENERGY (Nov. 22, 2022), https://www.offshore-energy.biz/nuclear-ships-regulations-to-enter-into-force-in-uk-on-december-8/.
[123] *International Convention for the Safety of Life at Sea (SOLAS) 1974*, IMO, https://www.imo.org/en/About/Conventions/Pages/International-Convention-for-the-Safety-of-Life-at-Sea-(SOLAS),-1974.aspx (last visited Jan 30, 2023).
[124] *Id.*
[125] *Id.*

complied with by ships that are transporting dangerous goods. Chapter VIII of SOLAS specifically discusses nuclear ships, though it only gives basic requirements and references a comprehensive Cody of Safety for Nuclear Merchant Ships.[126] Since SOLAS is overwhelmingly applied within the industry, it is a large step forward that the U.K. is adopting these provisions within their regulation for nuclear commercial ships.

This development in regulation is a result of a "multi-year effort by the U.K. designed to make nuclear power an option for the commercial shipping industry."[127] To enhance their efforts and to support this proposed regulation, the U.K. Maritime and Coastguard Agency ("MCA") "conducted a consultation period" where they asked experts, including class societies, shipping organizations, and researchers in the maritime industry "to provide input on the regulation."[128] Of those asked, fourteen companies replied to the MCA's request for input.[129] Eleven out of the fourteen "respondents agreed with the MCA that there is an appetite for nuclear ships over the next [ten] years, specifically with a growing interest in nuclear propulsion for large vessels."[130] With the responses, the MCA decided to move forward with the proposed regulation without major amendments.[131] Overall, this proposed regulation has overwhelming support and seems to coincide with the market and environmental demand for nuclear propulsion in the commercial shipping industry.

Another country that is making waves to change legislation for commercial nuclear shipping is the U.S.[132] Though further behind than the U.K., the U.S. Department of Energy ("DOE") has

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[126] *Id.*
[127] *UK to Adopt Regulations, supra* at note 119.
[128] *Id.*
[129] *Id.*
[130] *Id.*
[131] *Id.*
[132] *DOE & ABS Launch New Studies on Nuclear Energy for Com. Ships*, MARITIME EXECUTIVE, https://maritime-executive.com/article/doe-and-abs-launch-new-studies-on-nuclear-energy-for-commercial-ships, (last visited Jan. 30, 2023).

awarded a research contract to the American Bureau of Shipping ("ABS") on "the adoption of advanced nuclear propulsion on commercial vessels."[133] This $800,000 contract will "address the challenges of adopting new reactor technology in commercial maritime applications."[134] Among these topics of incorporating nuclear energy to commercial ships, the research project will also work to "publish guidance for addressing key… regulatory and policy issues for maritime demonstration projects."[135] Importantly, support is being given by the Idaho National Laboratory's National Reactor Innovation Center ("NRIC").[136] In a smaller project, the DOE has also issued a contract for ABS to research, in partner with the University of Texas, "the concepts for molten salt reactors."[137] These research projects could be the catalyst for future regulations as the Department of Energy is heading the project and has strong weight in implementing federal legislation. With the idea that nuclear technologies keep gaining traction as a solution to the shipping industry's decarbonization movement and the growing demand for a fuel source that is less dependent on fluctuating market prices, it is only a matter of time before the U.S. adopts its own regulations for commercial shipping.[138]

V. OTHER ASPECTS NEEDED TO ALLOW NUCLEAR COMMERCIAL SHIPS TO SAIL

A. The Japanese Model: Nuclear Ship Monitoring at Japanese Ports

Japan, unfortunately, has a turbulent history with nuclear energy and, with this history, comes understandable public cautiousness and sensitivity of any potential problems that may arise

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[133] *Id.*
[134] *Id.*
[135] *ABS to Study Nuclear For Commercial Maritime Applications*, NUCLEAR NEWSWIRE (Aug. 19, 2022), https://www.ans.org/news/article-4239/abs-to-study-nuclear-for-commercial-maritime-applications/.
[136] *Id.*
[137] *DOE & ABS Launch New Studies, supra* at note 132.
[138] *Id.*

from a nuclear ship in one of their ports. For example, in 2008, Japanese locals by the hundreds protested the arrival of the U.S. Navy aircraft carrier U.S.S. George Washington.[139] The ship was to be stationed at the Yokosuka Naval Base permanently, which caused locals to be concerned about their own government's lack of safety measures.[140] Given that the U.S. Navy calls a few Japanese ports home and within these ports the U.S. houses several nuclear ships, the Japanese government began to monitor the port anytime the ship leaves, returns, and at quarterly intervals.[141] With an understanding that there is a healthy concern for safety, the "U.S. Government has made firm commitments" to the Japanese government to observe strict safety standards concerning their ships visiting and harboring in Japanese ports.[142] For example, the US Navy has procedures that require the reactor to typically be powered down while in port and very strict control over any nuclear waste.[143] By adhering to this rule, the Navy reports "that there has never been a reactor accident nor any release of radioactivity" and has allowed no adverse effect on human, marine, or environmental life.[144]

The Japanese government has a Nuclear Regulation Authority that "conducts surveys on radioactivity levels at ports that nuclear powered warships call in."[145] These surveys are conducted with cooperation between local Japanese governments near the ports, the Japanese Coast Guard, and the Japanese Fisheries

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[139] Hiroyuki Muramoto, *U.S. Nuclear Warship Arrives in Japan Amid Protests*, REUTERS (Sept. 25, 2008), https://www.reuters.com/article/us-usa-japan-warshipnews1/u-s-nuclear-warship-arrives-in-japan-amid-protests-idUSTRE48O20720080925.

[140] *Id.*

[141] *Radioactivity Survey on Nuclear Powered Warships*, ENV'T. RADIOACTIVITY & RADIATION IN JAPAN, https://www.kankyo-hoshano.go.jp/en/library-en/nuclear-ship-en/ (last visited Feb. 2, 2022).

[142] *Fact Sheet on U.S. Nuclear Powered Warship (NPW) Safety*, MINISTRY OF FOREIGN AFFS. OF JAPAN, https://www.mofa.go.jp/region/n-america/us/security/fact0604.pdf (last visited Jan. 29, 2022).

[143] *Radioactivity Survey, supra* at note 141.

[144] *Fact Sheet, supra* at note 142.

[145] *Radioactivity Survey, supra* at note 141.

Agency.[146] The reports take environmental samples such as seawater and sea sediment which are analyzed for any radioactivity.[147] In support, the U.S. Navy also conducts their own monitoring reports.[148] For example, the US Navy released a report in 2018 stating that "[t]he policy of the U.S. Navy is to reduce to the minimum practicable the amounts of radioactivity released from naval nuclear-powered ships … each quarter year."[149] Similarly to the Japanese monitoring reports, the U.S. navy measures radiation levels and analyzes samples within the port area by looking at the harbor water, sediment, and marine life.[150]

In the 2018 report released by the Department of the Navy, the total amount of radioactivity found collectively "within all U.S. and foreign harbors visited by nuclear-powered ships in the U.S. Navy was … less than 0.002 curie in 2017."[151] When measuring radioactive material, "the curie is the traditional unit of radioactivity" and the curie is equivalent to thirty seven billion becquerel ("Bq"), with one Bq being equivalent to one decay per second.[152] In other words, 0.002 curie is "too small to have had any discernible effect on the radioactivity of any harbor environment."[153] To continually monitor radioactivity, the U.S. Navy also has on-site sensitive thermoluminescent dosimeters ("TLDs").[154] These TLDs' are posted around the port and along the

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[146] *Id.*
[147] *Id.*
[148] *Id.*
[149] *Fact Sheet on U.S. Nuclear Powered Warship (NPW) Safety*, MINISTRY OF FOREIGN AFFS. OF JAPAN, https://www.mofa.go.jp/region/n-america/us/security/fact0604.pdf (last visited Jan. 29, 2022).
[150] *Id.*
[151] *Id.*
[152] *Guidance for Radiation Accident Mgmt.*, OAK RIDGE INST. FOR SCI. & EDUC., https://orise.orau.gov/resources/reacts/guide/measuring-radiation.html#:~:text=The%20curie%20(Ci)%20is%20the,curie%20is%2037%20billion%20Bq (last visited on Jan. 30, 2023).
[153] *Fact Sheet on U.S. Nuclear Powered Warship (NPW) Safety*, MINISTRY OF FOREIGN AFFS. OF JAPAN, https://www.mofa.go.jp/region/n-america/us/security/fact0604.pdf (last visited Jan. 29, 2022).
[154] *Id.*

harbor to better analyze the radioactivity levels and compare them to control levels.[155]

The U.S. Navy also takes radioactivity samples from local marine life in the harbor such as mollusks, crustaceans, and marine plants to determine whether any radioactivity has penetrated the marine food chain.[156] Surprisingly, from all the tests conducted by the U.S. Navy, the results showed that there is "no increase in radioactivity above background levels in" any of the U.S. Naval bases.[157] With results such as this, it is important to realize that procedures in place by both the U.S. and Japanese governments are effective in "protecting the environment" and the "health and safety of the general public."[158] The Navy shares any results from these monitoring efforts with the Japanese government, and vice versa, to allow for an open dialogue.[159] Importantly, the Japanese independent reports show comparable results to those made by the U.S. government, "showing no discernible impact on the environment."[160] Taking these efforts by both the Japanese and U.S. governments, it is clear that for any international port to welcome nuclear powered commercial ships, a joint effort will need to be made between the local government and the shipping company in order to effectively monitor potential radioactivity. The Japanese model is an important tool and successful standard to show that these efforts can be done successfully to protect the health and safety of the environment.

B. Adoption of Safety Regulations to be Successful

To fully pave the way for nuclear powered vessels to successfully be adopted and to thereby eliminate the environmental

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[155] *Id.*
[156] *Id.*
[157] *Id.*
[158] *Id.*
[159] *Fact Sheet on U.S. Nuclear Powered Warship (NPW) Safety*, MINISTRY OF FOREIGN AFFS. OF JAPAN, https://www.mofa.go.jp/region/n-america/us/security/fact0604.pdf (Jan. 29, 2022).
[160] *Id.*

concerns held by the IMO, more than just radioactivity monitoring is needed. Regulatory measures that control safety standards and make them uniform across the entire international commercial shipping industry are crucial to protect seamen and so the public can get on board. In 1982, the United Nations Convention on the Law of the Sea ("UNCLOS") was created in order to address "the most sensitive questions" on safety and international relations and was seen as revolutionary for some of its solutions."[161] UNCLOS was revolutionary because it allowed for states to "limit the right to innocent passage" for nuclear-powered ships and ships that were carrying any dangerous material such as nuclear material.[162] Furthermore, UNCLOS created the same procedure for any damage inflicted, regardless of what type of material caused the damage.[163]

"The safety record of the U.S. nuclear navy is excellent" and is mainly credited towards a "high level of standardization."[164] Following the example of the U.S. Navy, safety precautions they have adopted can be easily transitioned into a civilian context to safely use nuclear propulsion safely aboard a commercial ship. Within the U.S. Navy ship, "the nuclear reactor compartment is shielded to protect the crew from the radiation released by the reactor."[165] Also, when the reactor is in use, the crew is prohibited from entering the area.[166] Furthermore, the crew must follow strict work schedules to limit any radiation exposure and must wear monitors that regularly check radiation levels.[167] These are simple procedures that any trained civilian crew can implement if they were to work aboard a nuclear vessel. Adopting protections for civilian

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[161] Iris Bjelica Vlajić, *Legal Framework for Nuclear Ships*, NUCLEAR ENG'G INT'L. (Aug. 6, 2020), https://www.neimagazine.com/features/featurelegal-framework-for-nuclear-ships-8063937/.
[162] *Id.*
[163] *Id.*
[164] *Nuclear-Powered Ships*, WORLD NUCLEAR ASS'N, https://world-nuclear.org/information-library/non-power-nuclear-applications/transport/nuclear-powered-ships.aspx, (updated Nov. 2021).
[165] *Nuclear Submarines & Aircraft Carriers, supra* at note 25.
[166] *Id.*
[167] *Id.*

crews might make the public more inclined to accept commercial ships running nuclear propulsion.

C. Indemnity Regulations for Potential Nuclear Accidents

Currently, the U.S. Navy follows federal legislation for the unlikely possibility of "a nuclear incident involving the nuclear reactor" aboard a ship.[168] The first regulatory scheme that allows for damages against government vessels operating with nuclear propulsion is the Public Vessels Act ("PVA").[169] The PVA "allows recovery of personal and property damages 'caused by public vessel of the United States'."[170] The act, importantly, waives sovereign immunity "and give[s] private owners and operators of vessels the same right of recovery from the government for damages caused by public vessels."[171] However, the act only allows for suit to be brought from a foreign national "where an American national could sue under the same circumstances in the country of the claimant."[172] As this regulation applies to nuclear Navy ships, it could be easily adopted to accommodate civilian ships and allow for damages to be brought against them if there were any incidents.

Another regulation that applies to U.S. nuclear warships is the Suits in Admiralty Act.[173] This act was developed to address any seamen that sustained injuries due to negligence from a ship owned and operated by the U.S. federal government.[174] Before this act,

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[168] *Fact Sheet on U.S. Nuclear Powered Warship (NPW) Safety*, MINISTRY OF FOREIGN AFFS. OF JAPAN, https://www.mofa.go.jp/region/n-america/us/security/fact0604.pdf (last visited Jan. 29, 2022).
[169] 46 U.S.C. § 31102.
[170] *Id.*
[171] *Id.*
[172] *Public Vessels Act*, USLEGAL, https://admiralty.uslegal.com/suits-by-or-against-the-united-states/public-vessels-act/, (last visited Feb. 1, 2023).
[173] 46 U.S.C. § 30901.
[174] *Navigating the Suits in Admiralty Act (SAA)*, SCHECHTER SHAFFER & HARRIS, https://maintenanceandcure.com/maritime-blog/navigating-the-suits-in-admirality-act-saa/, (last visited Feb. 1, 2023).

injured persons could not bring suit against the federal government.[175] More importantly, it protects injured parties that the PVA, the Jones Act, or any other maritime law do not cover.[176] Again, by applying this law to federal government-owned nuclear vessels ensures that individuals get proper protection to sue. These regulations can be changed or partially adopted in order to create a comprehensive legal framework to address any injuries sustained by negligent actions by a nuclear commercial ship.

To supplement the regulations discussed above, a specific provision of the U.S. Code, 42 U.S.C. § 2211, allows for payment of claims or judgments resulting from nuclear incident or involving nuclear reactors of a U.S. ship.[177] This authority is tailored towards the idea that it is within "the policy of the [U.S.] that it will pay claims or judgments for bodily injury, death, or damage" or even "loss of real or personal property" resulting from a "nuclear reactor of a [U.S.] warship."[178] The act further describes exceptions in that it will not pay for an injury resulting from when the warship was engaged in "combat or as a result of civil insurrection."[179] There is also no limit the amount "paid in the event of a U.S. Nuclear Powered Warship nuclear reactor incident."[180] By providing an extra layer of protection, potential injuries resulting from nuclear commercial ships can be covered, thereby providing more assurance to the public.

Another provision of the U.S. Code, 42 U.S.C. §2210, details specific requirements for insurance coverage in order for the Nuclear Regulatory Commission to issue a valid license to an organization utilizing nuclear power.[181] Within this code, the Nuclear Regulatory Commission has set "a condition as of the license requirement that the license have and maintain financial

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[175] *Id.*
[176] *Id.*
[177] 42 U.S.C. § 2211.
[178] *Id.*
[179] *Id.*
[180] *Fact Sheet, supra* at note 142.
[181] 42 U.S.C. § 2210.

protection" to cover any "public liability claims."[182] Specifically, 42 U.S.C. §2210 details that the "amount of primary financial protection required shall be the amount of liability insurance available from private sources."[183] This provision of the U.S. Code is very extensive, and includes multiple different subsections to accommodate for a variety of different outcomes, including the procedure for attending to a possible nuclear accident.[184]

D. Disposing of Nuclear Waste: A Concern in Optimizing Commercial Use

Spent nuclear substances need to be disposed of and requires unique protections given that is not able to be fully recycled. Unfortunately, compared to other less dangerous substances, nuclear waste is harder to remove as it needs to be stored and disposed of in a specific manner to "avoid any chance or radiation exposure to people or any pollution."[185] Luckily, "disposal of low-level waste is straightforward and can be undertaken safely almost anywhere."[186] Currently, there are issues concerning the Department of Energy on how to safely store and dispose of spent nuclear fuel, especially now that more civil nuclear plants are being used daily.[187]

Furthermore, in the U.S., the D.O.E. can only properly dispose of any spent nuclear fuel used commercially, which means there are no privately held companies that can dispose of nuclear waste.[188] For current operating nuclear ships, any spent fuel is properly and carefully stored and disposed of by the U.S. Navy.[189]

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[182] *Id.*
[183] *Id.*
[184] *Id.*
[185] *Storage & Disposal of Radioactive Waste*, WORLD NUCLEAR ASS'N (Jan. 2023), https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-waste/storage-and-disposal-of-radioactive-waste.aspx.
[186] *Id.*
[187] *Nuclear Waste Disposal*, U.S. GOV'T ACCOUNTABILITY OFF., https://www.gao.gov/nuclear-waste-disposal, (last visited Feb. 1, 2023).
[188] *Id.*
[189] *Nuclear Submarines & Aircraft Carriers, supra* at note 25.

The procedure of disposal is that the nuclear fuel "is removed from the reactor and sent to the Naval Reactors Facility in Idaho for processing."[190] Although recycling of nuclear waste is not available at this time, there is hope in scientific research as there is currently a proposed project that allows used nuclear fuel by the Navy to be blended down to be utilized in high-assay low-enriched uranium ("HALEU") fuel.[191] This would allow the nuclear fuel to be recycled in a new way.[192] This HALEU fuel can be used in newer nuclear power plants operating on land and due to the potential benefits of this research, the plan has been approved by Congress.[193] This shows progress in the field and could provide a way for nuclear energy to be disposed of or reused more efficiently if used by commercial ships.

E. Proposal for Hypothetical U.S. Regulation

Given that there are no current regulations enacted to address the use of nuclear propulsion in the private industry, the U.S. should follow the U.K.'s example and enact their own law. By establishing a set of clear rules to implement nuclear energy, U.S. based commercial shipping companies would be more inclined to begin using nuclear propulsion. Luckily, drafters of this needed legislation have many examples and standards that are already in place from a variety of different sources. Each provision within the legislation can address the main hurdles of implementing nuclear propulsion: safety, negligence claims, and, of course, damages to the environment. Furthermore, strong U.S. legislation on the use of nuclear propulsion could be the catalyst to start the conversation of adopting one standard international law or treaty to allow for these ships to operate in ports across the globe.

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[190] *Id.*
[191] *U.S. Project to Recycle Naval Fuel Gets Senate Approval*, WORLD NUCLEAR NEWS (June 22, 2018), https://www.world-nuclear-news.org/WR-US-project-to-recycle-naval-fuel-gets-Senate-approval-2206188.html.
[192] *Id.*
[193] *Id.*

When drafting the hypothetical legislation, it would be beneficial to use the legal framework set forth by the existing CNS and CPPNM.[194] The usage of such framework and guidance is key as they are both the only international treaties to address civilian use of nuclear energy.[195] Furthermore, the IAEA would aid with the U.S.' legislative process because their main goal as an organization is to provide legislative assistance for countries looking to adopt nuclear energy laws.[196] Another effective tool would be to follow the current regulations that are being passed by the government of the U.K. Their legislation is current and addresses the needs of both the commercial shipping industry and the safety standards set out by SOLAS.[197] The U.K.'s legislation is backed by experts in the field and requires little to no major changes, which is a good indication that their current legislation is comprehensive and could act as an effective guide stone to the U.S. attempt to draft their own legislation.[198]

Secondly, to address the procedure when claims are brought against private commercial shipping companies, both for environmental and physical damages, the U.S. legislation should take parts of both 42 U.S.C. § 2211, 42 U.S.C. § 2210, the PVA, and the Suits in Admiralty Act as guidance. These pieces of legislation will help drafters towards providing comprehensive tortious claims and protections for any person or property damaged by an accident. It can also give the members working aboard the nuclear vessel peace of mind in that they will have legal protection from any injury they may incur.[199]

Negligent acts happen in any industry but a ship carrying a hazardous material will need a higher standard, and by default a higher insurance premium, as the effects of an accident from a

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[194] *Treaties & Conventions,* supra at note 105.
[195] *Id.*
[196] *Legis. Assistance,* supra at note 115.
[197] *UK to Adopt Regulations,* supra at note 119.
[198] *Id.*
[199] 42 U.S.C. § 2210

nuclear vessel could be extremely problematic.[200] The proposed legislation could also include provisions mandating vessels to have a certain level of insurance for their government issued license in order to legally operate both nationally and internationally. Within these provisions, safety standards will need to be specific and detailed.[201] The U.S. Navy's method of concrete standardization and the UNCLOS' safety standards can be followed in this theoretical legislation.[202] For the use of nuclear energy in commercial shipping to be "readily accepted in the major ports of all nations, adequate indemnity protection must be assured."[203] All of these provisions are to ultimately to help alleviate any public tension and incentivize safe behavior by operators of vessels.

Finally, addressing the environmental concerns caused by potential nuclear leakage and safe disposal of nuclear waste must also be included within the proposed legislation. The Japanese model for radioactivity monitoring and detection being used today is a fantastic tool to implement.[204] The hypothetical legislation could include provisions that mandates radioactivity monitoring and reporting by the commercial shipping company.[205] These reports could also be required to be periodically submitted to the U.S. government and any interested parties, including countries where the ship would call in to port.

The practice of requiring mandated reporting by a private industry that is heavily regulated to have a duty to report and abide by federal laws, including the banking and airline industry. A monitoring and reporting requirement would better incentivize environmental protection by commercial ships and, theoretically, should reduce the likelihood of potential radioactivity leakage, just

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[200] *Id.*
[201] *Id.*
[202] *Nuclear-Powered Ships*, supra at note 164.
[203] James Milton Brown, *Nuclear Ship Savannah & the L.*, 15 Fla. L. Rev 299, 324 (1962) (discussing international & maritime aspects of nuclear shipping).
[204] *Fact Sheet on U.S. Nuclear*, supra at note 159.
[205] *Id.*

as it has for the U.S. Navy.[206] Also, the issue of disposal or possible recycling of spent nuclear waste would need to be addressed. Since currently the U.S. government is the only one to be able to safely dispose of nuclear waste, it might be worth considering privatization contracts to allow for more effective means of disposal.[207] Ultimately, a hypothetical piece of legislation created by the federal government will need to be established to allow for de jure implementation of nuclear commercial ships, rather than allowing the commercial shipping companies de facto apply nuclear propulsion to their fleets. This argument centers on the idea that the law must not come *after* an accident occurs, it must be "armed" with "prescience requisite to keeping pace with scientific advancement."[208]

VI. CONCLUSION

To meet the environmental demands imposed by the International Maritime Organization, the commercial shipping industry's type of fuel used, and consumption, will need to change considerably. Though many solutions are being promulgated by the industry such as the use of biofuels, battery packs, and LNG, these are short-term solutions that will not fully meet environmental demands in the long run. Nuclear propulsion is a tried-and-true solution. It allows for virtually no environmental impact and has successfully been used by the U.S. Navy for the past seventy-five years.

Unfortunately, the public has a misconception that nuclear energy is dangerous. It could be argued that this misconception has aided in the nonexistent implementation of nuclear propulsion into the commercial shipping industry. However, a nuclear tide is turning with the U.K.'s adoption of new regulation that will provide the first true legal foundation for nuclear propulsion in the commercial

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[206] *Id.*
[207] *Nuclear Waste Disposal*, supra at note 187.
[208] James Milton Brown, *Nuclear Ship Savannah & the L.*, 15 Fla. L. Rev 299, 300 (1962) (discussing deliberations on strategy).

shipping industry. It could pave the way for other large and influential countries to adopt similar regulation. The U.S. is not far behind as the federal government approved a contract for the American Bureau of Shipping to conduct in-depth research into using nuclear propulsion for the private sector. In order to better curb the negative public perception of nuclear energy usage, stringent and uniform regulations that can be applied to any shipping company and standardized safety standards need to be implemented. In Japan, successful monitoring regulations and partnership efforts have allowed for no external radioactivity to be leaked by the numerous U.S. Navy ships. This is a well-defined model that can be adopted and formed to meet the needs of various international ports. Furthermore, with strong and strict tort regulations, any potential damages or injuries resulting from an accident involving a commercial ship could help further ease the public tension. All these options have already been implemented within the US Navy and through existing legislation. The environmental issues and concerns created by the continued growth of the commercial shipping industry will not change. What must change is the source of energy used and that ultimate answer lies with nuclear energy.