AN ANALYSIS OF

JAPAN'S CARBON NEUTRAL PORT INITIATIVE

AND

YOKOHAMA PORT & HARBOR DECARBONIZATION PLAN

MARCH 2026

GOLDMAN SCHOOL OF PUBLIC POLICY
UNIVERSITY OF CALIFORNIA BERKELEY

Commissioned by
PACIFIC ENVIRONMENT

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Cover and Page 16: Photo credit: Yokohama City Visitors Bureau.

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INTRODUCTION

Japan has established strong targets and implementation plans to achieve a deep reduction in national emissions of greenhouse gases (GHG). One important aspect of these plans is the Carbon Neutral Port (CNP) certification initiative. The "CNP certification (Container Terminal)" was established by the Ports and Harbours Bureau of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) in 2025 and is currently in initial stages of implementation. It sets benchmarks and measurement criteria to assess progress by Japanese maritime terminals to reduce GHG emissions and improve air quality in port communities.

The CNP certification is a very thoughtfully constructed program that will encourage and enable Japanese maritime terminals to reduce GHG emissions from port operations. It provides transparency and stimulates effective planning and coordination among the many businesses and people that make up port communities. The plan documents show appropriate concern for the impact on air quality of port communities and transport workers. The CNP certification is a remarkable achievement, especially considering the rapid changes in technology, trade practices, energy supply and policy at the international, national and local levels. In many ways Japan is ahead of other nations on decarbonization of maritime terminals and related industrial operations. The recommendations in these comments are made in recognition of this and in expectation that leading nations and subnational governments can learn from each other about maritime decarbonization in this dynamic time.

Yokohama's plan serves as a model for other port decarbonization efforts in Japan and will positively influence port decarbonization efforts internationally.

This document also includes a review of and recommendations on the city of Yokohama's "Port and Harbor Decarbonization Plan for the Port of Yokohama." The city and Port of Yokohama were early leaders in port decarbonization efforts in Japan and internationally. While the CNP certification is a rating system that aims to advance maritime terminal decarbonization efforts nationally, Yokohama's plan is a detailed decarbonization strategy specific to a single port complex. Consequently, the Yokohama plan addresses a much wider range of emission sources and decarbonization efforts than the CNP certification. In many ways Yokohama's plan serves as a model for other port decarbonization efforts in Japan and will positively influence port decarbonization efforts internationally.

These comments include observations and recommendations on the CNP certification and Yokohama's Carbon Neutral Port plan, based primarily on experience with maritime port decarbonization in the United States and California. As noted below, the author has limited understanding of certain engineering and other technical aspects of Japan's maritime economy. This is not a comprehensive evaluation of the CNP certification or the Yokohama plan. Rather, the objective is to identify, highlight and assess selected aspects of these initiatives.

REGIONAL AND GLOBAL CONTEXT FOR CNP CERTIFICATION AND PORT OF YOKOHAMA CARBON DECARBONIZATION PLAN

Port and terminal operations are critical not only for maritime trade, but also for other industries that share infrastructure and supply chains. As in other nations, maritime trade operations are a significant part of Japan's GHG emission inventory and can facilitate decarbonization of other industry sectors, including refineries, steel, cement, manufacturing, municipal services and electric power. An example of this is the planning at the Port of Yokohama for a shared network of pipelines[2] to supply green hydrogen, captured carbon and low-carbon liquid fuels. City governments often interact with maritime terminal operators in planning, finance and construction of critical infrastructure. In short, maritime terminals and ports are often a critical hub for a wide range of business activities and public services related to climate protection and public health and safety.

Japan's economy is undergoing several major changes that form the context for the CNP certification process. Battery-powered road transport appears to be increasing, relative to historic focus on hydrogen.

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[2] A shared network of pipelines is a regionally planned, multi-user system of interconnected pipelines, centered on ports as energy and industrial hubs, that enables the integrated transport and distribution of green hydrogen, captured carbon dioxide (CO_2), and low- or zero-carbon fuels across ports, municipal infrastructure, and adjacent industrial facilities. See,

Kanto Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT), *Discussion Points on Developing the CNP Framework for Yokohama and Kawasaki Ports*, March 18, 2021 (in Japanese): https://www.pa.ktr.mlit.go.jp/kyoku/cnp/shiryou/dai%203%20kai/34_shiryou4.pdf;

Policy Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT), *Summary of the White Paper on Land, Infrastructure, Transport and Tourism in Japan, 2022*: https://www.mlit.go.jp/en/statistics/content/001579732.pdf?utm_source=chatgpt.com;

Port and Harbor Bureau, City of Yokohama and Coastal Area International Strategy Headquarters, City of Kawasaki, *Kawasaki and Yokohama Partner to Advance Hydrogen and Next-Generation Energy Sources in the Coastal Area*, July 26, 2022 (in Japanese): https://www.city.yokohama.lg.jp/city-info/yokohamashi/yokohamako/kkihon/torikumi/cnp/top.files/0071_20240719.pdf;

Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry (METI), *Overview of Basic Hydrogen Strategy*, June 2023: https://www.meti.go.jp/shingikai/enecho/shoene_shinene/suiso_seisaku/pdf/20230606_4.pdf;

Ports and Harbours Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT), *Development of a Roadmap to Promote the Formation of Carbon Neutral Ports (CNPs)*, November 26, 2024 (in Japanese): https://www.mlit.go.jp/kowan/content/001845481.pdf?utm_source=chatgpt.com

Nuclear power and offshore wind electric power generation are expected to grow quickly over the next decade, complementing remarkable and continuing expansion of solar energy and stationary battery storage. Electric propulsion for intercoastal shipping and zero-carbon liquid fuels for ocean-going vessels are recognized as new opportunities in Japan to reduce fossil fuel imports, GHG emissions and cargo shipping costs. These trends will drive changes in electric power generation, transmission and distribution infrastructure and could alter how sustainable biomass (agriculture/forestry residues and solid waste) are used in electric power systems and low-carbon liquid fuel production. Similarly, demand for green hydrogen, zero-carbon liquid fuels and captured carbon is growing and will drive changes in pipeline networks and supply chains.

Japan has in recent years set ambitious targets to reduce GHG emissions and is implementing a carbon emission trading market. Set to take effect in April 2026, the emissions trading scheme (ETS) requires companies with emissions of over 100,000 tons of carbon dioxide-equivalent per annum to enroll in the ETS. Three to four hundred businesses are expected to participate in the ETS, accounting for about 60% of total carbon dioxide emissions in Japan.[3] This is part of a policy commitment to achieve carbon neutrality by 2050, with interim goals of a 46% reduction in GHG emissions by Fiscal Year (FY) 2030 and a 60% reduction by FY2035 (compared to FY2013 levels).[4] In FY 2028, Japan plans to introduce a carbon levy on importers of fossil fuels and domestic fossil fuel extractors, with revenues used to fund green technologies and infrastructure. Japan may also issue "GX economy transition bonds" to support these goals.[5] Although we could find no specific reference in the public frameworks or government documentation, fossil-derived marine bunker fuels appear to be subject to the surcharge at the upstream importer level.

All of this occurs during global negotiations over climate pollution controls for ships. The International Maritime Organization (IMO) was expected to complete an agreement in October 2025 to establish a global framework built around GHG-intensity targets and compliance fees. The decision was delayed by at least one year, due to an unfortunate intervention by the U.S. government. But momentum toward global emission controls for shipping appears unstoppable, and national or subnational rules are emerging in the interim (e.g., FuelEU Maritime). Nations and businesses are planning, for a time perhaps two to three years ahead, when new emission control requirements will require new fuel supply chains and infrastructure for vessels worldwide.

Regionally, many Pacific nations are working to reduce import of fossil fuels, both as a prudent economic measure and to achieve climate stability and air quality goals. This suggests the need for international cooperation on efforts to electrify intercoastal and short-sea trade vessels, expand offshore wind generation[6] and expand maritime transport electric power supply.[7]

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[3] Offset8Capital, *Japan's Carbon Credit Market Guide: Structure, Government Initiatives, Credit Systems, and Future Outlook*, July 28, 2025, https://offset8capital.com/articles/japans-carbon-credit-market-guide-structure-government-initiatives-credit-systems-and-future-outlook/.

[4] *Plan for Global Warming Countermeasure*s (Oct. 22, 2021 Cabinet Decision): https://www.env.go.jp/content/000249336.pdf; *Plan for Global Warming Countermeasure*s (Feb. 18, 2025 Cabinet Decision): https://www.env.go.jp/content/000338677.pdf

[5] METI, GX Policy, *Achieving Decarbonization and Economic Growth Together (Provisional translation, (English Version Dec. 5, 2025),* https://www.enecho.meti.go.jp/en/category/special/article/detail_214.html?ui_medium=enecho_mailmag.

[6] "In light of this, we aim to form 10 GW of projects by 2030 and 30 GW to 45 GW by 2040, including floating projects, through the public solicitation and other systems, based on the Act on Promoting the Utilization of Sea Areas for the Development of Marine Renewable Energy Power Generation Facilities." (Referencing Act No. 89 of 2018).

[7] "Proposals and Requests Regarding National Policies and Budgetary Measures (for fiscal year 2026)" (in Japanese) (Page 169)

OBSERVATIONS AND RECOMMENDATIONS ON JAPAN'S CNP CERTIFICATION

Main structure and elements of CNP certification

The development of this certification system was undoubtedly a difficult and ambitious task given the huge diversity of container terminals in Japan (e.g., regarding size, age, proximity to other industries and other factors). The development of the CNP certification initiative began in June 2022 with final certification documents released in March 2025.[8] The result here is a very good one.

The scope of the CNP certification (Container Terminal) is focused on:

- Terminals rather than ports.
- Container terminals, with plans for future certification standards for other types of terminals.
- Excluded from the scope is:
  - Hinterland transport, maritime transport, logistics facilities outside the container terminal warehouses and container cargo users.

[8] https://www.mlit.go.jp/kowan/kowan_fr4_000093.html. The Ports and Harbours Bureau of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) awarded the first round of certificates in September 2025 and the second round of certificates in November 2025 to terminals that submitted applications under the CNP certification (Container Terminal). The bureau aims to complete and publicize the "Roadmap for Promoting the Formation of CNPs" by March 2026, as part of their broader CNP initiatives. See also, Ministry of Land, Infrastructure, Transport and Tourism (MLIT), "*Basic Policy for the Development, Use, and Maintenance of Ports and Harbours and for the Development of Waterways to be Developed and Preserved*" and the "*Comprehensive Plan for Keihin Port (Yokohama Port Long-term Concept)*."

- Requires decarbonization plans based on emission factors for specific equipment, rolled up into an overall emission inventory and terminal average tons carbon dioxide/TEU.[9]
- Relies on key performance indicators (KPI), targets and achievement monitoring.
- The Certification addresses a wide range of terminal facilities and functions, including:
  - Building energy efficiency.
  - Lighting for buildings and yards.
  - Reefer operations.
  - Vessels (at-berth, in-transit).
  - Vehicles and cargo handling equipment.
  - Vehicle and vessel congestion management.
  - Terminal gate efficiency and priority gates for low-emission equipment.
  - Supply and bunkering of low- or zero-carbon vessel fuels and cargo handling equipment.[10]
  - Carbon neutrality in electricity power supply.
  - Container pickup and delivery reservation systems.
  - Other decarbonization initiatives.[11]

Recommendations

Cargo transportation technology and marine port practices are in a period of rapid change. The CNP certification criteria reflect knowledge at a point in time but also recognize the need for periodic adjustments to account for changes in technology and other dynamic factors. For this reason, our comments, respectfully, include recommendations for future versions of the CNP certification. Some of these ideas could be applied while the current version is implemented or adopted by terminal operators as part of their planning to participate in the CNP certification process.

- **Expand scope of CNP certification to other types of ports:**
  While containerized ports handle most of the cargo at maritime terminals, other ports in Japan manage "roll-on/roll-off" (RORO) cargo including vehicles and mobile equipment, bulk cargo such as agricultural commodities, building materials, liquids and gases.

  Any effort to expand the scope of the CNP certification will be a substantial effort; it makes sense that the authors of the current CNP certification started with container terminals. Each

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[9] See, *Guidelines for the Certification System for Decarbonization Efforts at Port Terminals,* 2nd Edition, May 2025, https://www.mlit.go.jp/common/001896130.pdf (hereafter referred to as *Guidelines*) at Page 18:

"The annual CO2 emissions will be divided by the annual cargo handling volume at the terminal (in principle, TEU) are defined the CO2 emissions per unit. The annual cargo handling volume at the terminal should be based on data consistent with port surveys (port statistics)."

[10] *Guidelines*, Item A-2 Page 21.

"To promote the use of low or zero emission fuel ships at the terminal, participation in the ESI program, implementation of incentives such as port fee reductions for LNG and other low-carbon fuel ships, or the efforts of regulations on fossil fuel-powered ships is required. This requirement applies to certification levels 4 and above."

See discussion below in these comments, under subheading, "Treatment of LNG."

[11] *Guidelines*, Item C, Page 21,

"Other decarbonization initiatives at the terminal that do not fall under categories (1) and (2) are considered recommended items and should be detailed in the application. Although this evaluation items are free to enter, they will be included in the certification document after certification review enhancing public relations (PR) efforts to such as stakeholders. Examples: Introduction of low-carbon and decarbonized electricity or fuel, environmentally friendly tugboats, implementation of emission reduction technologies (e.g., urea injection), efforts for elimination of offshore waiting, utilization promotion of inland ports, development of blue carbon ecosystems, and efforts for carbon offsetting."

type of terminal has very different infrastructure, and even within a single category there is huge diversity in size, infrastructure, access to bulk electric power/transmission and other factors. The expanded scope might initially focus on the largest terminals in each category, with care to avoid creating a competitive disadvantage for the first movers.[12]

- **Require on-shore power for ships at-berth:**
  The CNP certification's "recommendations" for shore power could be made "requirements."[13] Shore power technologies are established technologies, increasingly required by major import and export authorities in the European Union, California and Asia. Major ports — including the Port of Seattle, which now requires all homeported cruise vessels to use shore power by 2027 — are moving from recommendations to mandatory shore power rules.

  Shore power infrastructure should be a priority because it can significantly reduce exposure to ship engine emissions to port workers and port communities, while also reducing GHG emissions.

  Shore power for ships is an important first step toward modern port electrical infrastructure needed to charge batteries for port-based cargo-handling equipment and drayage trucks used to convey containers and other cargo into hinterlands. Expansion of maritime terminal electric power supply capacity will also be needed for electric-powered intercoastal and short-sea cargo voyages.

- **Plan for enhanced electric power infrastructure:**
  Future rounds of CNP certification could include requirements that maritime terminals forecast and plan for infrastructure needed to meet growing electric power demand driven by decarbonization of maritime terminals.

  Our review of the CNP and related documents suggests a need for greater attention to electric distribution systems upgrades and increased terminal access to bulk power supply (transmission upgrades). Based on experience in the U.S., we recommend that the CNP certification be revised to add planning criteria for enhanced electric power infrastructure for marine terminals. It may be that Japan's existing electric grid planning and implementation make this change to the CNP certification unnecessary, due to planning processes not specific to marine terminals. But over the next 20 years port and vessel electrification will be in a dynamic phase that can alter regional and national electric power demand and system planning. Marine terminals will experience growing demand for electric power and will need to engage with electric grid operators to ensure they can access increased bulk power supply. Action to add requirements or recommendations into the CNP certification system on electric power planning will ensure that electric grid operators and maritime terminal operators talk to each other and interact to ensure electric power infrastructure is optimized to enable decarbonization of port/terminal operations.

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[12] This is similar to how California staged its at-berth shore power regulations. California first required electric power connections (to allow ships to run hotel-load from on shore electric systems and turn off auxiliary engines while in port) for container and passenger cruise vessels. Several years later it expanded these requirements to terminals receiving cargos from tankers, bulk carriers and RORO vessels. See generally, California Air Resources Board, *Ocean-Going Vessels At Berth Regulation*, https://ww2.arb.ca.gov/our-work/programs/ocean-going-vessels-berth-regulation

[13] "Related to Ships Using the Terminal, (1) Measures for Power Supply. It is *recommended* to implement measures to reduce CO2 emissions from ships berthed at the terminal, such *as introducing onshore power supply equipment for the ships berthed at the terminal*. Additionally, establishing a supply system for low-carbon fuels, such as LNG, or decarbonized fuels, such as hydrogen and ammonia. (*Emphasis added*). *Guideline* at Page 21.

Japan experiences some of the same electric load growth and infrastructure constraints that we see in the United States: [14, 15, 16]

- Unexpected rapid growth in electric power demand from road-transport, building and industrial electrification.[17]
- Aging electric grid infrastructure.
- Data center development to meet power demand from artificial intelligence (AI) systems.
- Delays in electric infrastructure construction and financing due to rising costs for electric cable, steel, batteries and transformers.
- Global disruption of supply chains can slow access to these critical components.
- Electrification of manufacturing, including industries typically located near maritime terminals (e.g., refining, hydrogen production/storage, cement, steel and carbon capture).

All of these factors can affect maritime ports. For example, in California, the Port of Oakland's previous requirements for shore power and electrification of road transport and cargo handling equipment were about 16-18 megawatts at peak load, mostly driven by lighting. Today, the load for this maritime port is about 21 MW, and headed to increasing load requirements at about 105-110 MW in 5-7 years.[18] The Port of Oakland has experienced difficulties in securing new bulk power supplies to meet this new load.

Planning and construction of electric distribution and transmission systems requires a long lead time and must be in place before a marine terminal can plan for and construct equipment for shore power and heavy equipment charging stations. Moreover, electric power infrastructure will need to continuously expand to support later stages of marine terminal decarbonization, to support electrification of coastal short-sea shipping and production of hydrogen-based e-fuels.

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[14] See, METI Agency for Natural Resources and Energy, "A Detailed Outline of Latest Strategic Energy Plan, Insights into Japan's Energy in a Drastically Changing World, Part I." Hereinafter referred to as *Strategic Energy Plan.* https://www.enecho.meti.go.jp/en/category/special/article/detail_209.html?ui_medium=enecho_mailmag

> Electricity demand in Japan has been on a downward trend due to energy conservation/efficiency improvement and falling population numbers for about 20 years. However, it is expected to take an upward turn in line with the advancement of DX (digital transformation), such as the new construction or expansion of data centers and chip factories. A substantial increase in electricity demand will also be brought about by the implementation of GX (green transformation), such as the popularization of electrified vehicles and industrial electrification with energy sources switching to electricity.
>
> The electricity demand outlook published annually by the Organization for Cross-regional Coordination of Transmission Operators, Japan (OCCTO) forecasts overall electricity demand to be on an upward trend over the next ten years.

[15] *Mitsubishi withdraws from three offshore wind projects in Japan,* https://www.japantimes.co.jp/business/2025/08/27/companies/mitsubishi-withdraws-from-offshore-wind-project. See also, https://www.windpowermonthly.com/article/1940493/japan-plans-offshore-wind-auction-adjustment-amid-viability-concerns

[16] For example, substantial upgrades in Japan's transmission grid are needed to support planned offshore wind energy. See, IEEFA, *Japan's offshore wind sector: Down but not out,* Dec. 9, 2025, https://ieefa.org/resources/japans-offshore-wind-sector-down-not-out.

[17] See, *Strategic Energy Plan*, February 2025, Pages 14, 34. pdf

> "According to the "Demand Projections for the Entire Nation and Each Supply Area" (FY2025) published by the Organization for Cross-regional Coordination of Transmission Operators, Japan (OCCTO) in January 2025, electricity demand had been on a downward trend until FY2023 due to population decrease, electricity conservation, and energy efficiency improvements. However, from FY2024 onward, despite the continued impact of conservation efforts, electricity demand is expected to increase due to economic growth and increased demand associated with the construction of new data centers and semiconductor factories, with growth projected through FY2034. … Furthermore, it is essential to promote next-generation electricity networks in order to ensure a stable supply of electricity and promote decarbonization of the power system. To this end, it is necessary to steadily promote the development of inter-regional interconnection lines and the reinforcement of local backbone grids, based on the long-term policy for nationwide networks (Master plan of Nation-wide Power Transmission Networks)." https://www.enecho.meti.go.jp/category/others/basic_plan/pdf/2025_strategic_energy_plan.pdf.

[18] The Port of Oakland is primarily a container terminal port. It handled 2.24 Million TEUs in 2024.

The main elements for planning of future electric power needs at marine terminals include:

- **Forecast of future demand:** This is a complex project involving data gathering, technology projections, identification of uncertainties and risk management. Future electricity demand will be affected by:
  - Shore power for ships at-berth.[19]
  - Charging demand from:
    - Electrification of cargo handling equipment (CHE) and drayage trucks.
    - Stationary batteries used to support the local distribution systems.
  - Charging load for battery-powered electric cargo ships, passenger ferries and harbor craft (tugs, work boats and fuel barges), which is likely to grow as intercoastal ships gradually increase use of battery propulsion.
  - New power demands from neighboring refinery, steel, cement and chemical industries that increase electric demand for:
    - Electrolysis to produce hydrogen needed for low- or zero-carbon liquid fuels ("e-fuels") for ships (e.g., green methanol, ammonia).
    - Electric arc furnaces to increase production of steel from scrap metal.
    - Capture carbon from flue gases and industrial processes for sequestration or as feed stocks for e-fuels.
- **Transmission and distribution infrastructure:** Planners will need to assess the need for additional bulk power system connections and the adequacy of the local electric distribution systems to serve rising charging loads.
- **Assessment of new power supply options:**
  - Energy efficiency and demand response systems: Energy efficiency improvements and demand flexibility for lighting, building energy use and cargo handling equipment are key first steps.
  - Battery vessels: Research is needed to carry out Japan's plan for development of ships able to receive, distribute and store large amounts of electric power (from offshore wind generation) in large on board battery banks for delivery to port electric systems.
  - Microgrids: on-site generation at marine terminals and nearby industrial plants may be helpful to reduce or delay upgrades to regional bulk power transmission capacity. Microgrids can be constructed at marine terminals using rooftop solar, near-shore offshore wind generation, stationary battery systems, linear generators, thermal storage and renewable methane generators at nearby waste-water treatment plants.[20]

The author of these comments is not an electrical engineer, so this is only a rough sketch to illustrate the complexity of this task and the staffing, cooperation and time needed to complete it.

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[19] Shore power is fast becoming a standard requirement for port decarbonization and air pollution control. See, Transportation & Environment (T&E) Briefing – July 2025, *European ports unplugged: The state of shore power deployment Assessing EU ports' readiness for shore power requirements, https://www.transportenvironment.org/uploads/files/20250711_OPS_-Briefing_Final.pdf; Future Market Insights Inc, Shore to Ship Power Supply Market Forecast and Outlook 2025 to 2035, https://www.futuremarketinsights.com/reports/shore-to-ship-power-supply-market,* Nov. 12, 2025.

[20] For example, see https://www.mainspringenergy.com.

Supply chains for sustainable biomass feedstocks for low- or zero-carbon liquid marine fuels

Globally, ocean-going vessels emit over 1 billion tons of GHG annually, along with large amounts of particulate matter, sulfur and nitrogen oxides, toxic metals and other air pollutants. In California, even after the implementation of shore power requirements for container ships at-berth, emissions from vessels while in-transit to and from ports are a large portion of the emission inventory for pollutants that harm public health and damage climate stability.

Maritime terminals play an important role in facilitating supply chains and bunkering systems for low- and zero-carbon fuels for ocean-going vessels, including green methanol and green ammonia. Supply chains for these fuels are growing in Japan,[21] China,[22] Europe and other nations. These fuels can dramatically reduce emissions of GHG and other air pollutants from ocean-going vessels.[23]

Negotiations to establish international controls over GHG emissions from ships are underway and came close to an agreement (October 2025) for a global fuel standard to reduce emissions from ships. An agreement at the International Maritime Organization (IMO) appears to be likely sometime in the next two to four years, structured similar to emission controls on GHG emissions adopted in Europe (FuelEU Maritime). States on the U.S. West Coast are considering "in-transit" rules to reduce GHGs and other air pollutants for large ships calling at marine ports (patterned in part on controls to reduce sulfur in fuel limits initially adopted by California, and later by the IMO in the 2000s).[24]

As refineries near ports transition to production of low- or zero-carbon marine fuel, ports may need to facilitate handling of biomass feedstocks and fuel products. Japan produces large quantities of domestic biomass, including: woody biomass from forestry; agricultural residues (e.g., rice straw, orchard clippings); food processing residues; biosolids and methane from water treatment plants; green-waste fractions of municipal solid waste; and waste paper.[25] These non-crop-based forms of biomass are sustainable and suitable for production of low- or zero-carbon

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[21] Ministry of Land, Infrastructure, Transport and Tourism, *Outline of the Summary of the Study Group on the Formation of Methanol Bunkering Hubs*, https://www.mlit.go.jp/kowan/content/001873703.pdf.

[22] See, 24ChemicalResearch, *Green Bio-Methanol Market surges Ahead,* August 1, 2025, https://www.24chemicalresearch.com/blog/11036/green-bio-methanol-surges-ahead-2025; World Ports, *Asia driving biomethanol as bunker demand shits east,* Sept. 2, 2025, https://www.worldports.org/asia-driving-biomethanol-as-bunker-demand-shifts-east/

[23] Energy & Environmental Research, *Ocean going Vessel Decarbonization Technology Assessment, https://gspp.berkeley.edu/assets/uploads/page/Ocean-Going-Vessel-Decarbonization--Technology-Assessment.pdf,* Pages 33-35 (hydrogen), 53-56 (methanol), 72-73 (ammonia), 89-92 (biofuels), 115 (shore power).

[24] CARB, *Potential Ocean-Going Vessel (OGV) In-Transit Regulation*, https://ww2.arb.ca.gov/our-work/programs/potential-ocean-going-vessel-ogv-transit-regulation.

[25] See, *Mitsubishi Gas Chemical Becomes First Company to Produce Bio-methanol from Digester Gas in Japan*, June 20, 2024, https://www.mgc.co.jp/eng/corporate/news/2024/240620e.html. In April 2025, ENEOS (formerly JXTG Nippon Oil & Energy Corporation), A.P. Møller Holding and A.P. Møller – Mærsk agreed to invest $100 million to advance a green methanol production in the U.S. state of Louisiana, using forestry biomass and papermill waste as gasifier feedstock.

> "Investment will primarily be used to fund the final development phase of the BLRE project which C2X is developing together with SunGas Renewables Inc. ("SunGas") in Alexandria in the State of Louisiana. Once operational, BLRE will produce over 500,000 tonnes of green methanol per annum and is in discussions to secure long-term offtake from Maersk and other high-quality customers in the shipping, chemicals and industrial sectors. The project will use SunGas' industry leading S-1000 gasification system to convert biomass into low carbon methanol. The project will also capture and permanently sequester approximately 1 million tonnes per year of surplus biogenic CO2 from the gasification process, generating high quality and cost-competitive carbon dioxide removal (CDR) credits. The multibillion-dollar project aims to start construction in second half of 2026."

https://www.eneos.co.jp/english/newsrelease/2025/pdf/20250402_01.pdf. See also footnote 29 of this paper in retaliation to green methanol research by Mitsubishi.

liquid fuels (including green methanol and sustainable aviation fuels). Production processes include biomass gasification followed by catalytic synthesis, hydrothermal liquefaction[26] and others. In Japan many of these domestic biomass resources are currently burned to generate electricity (either directly or via cofiring with fossil fuels) and disposed of in landfills.

Japan has a sophisticated set of policies to optimize domestic biomass as an energy resource.[27] The Third Basic Plan for Promoting Biomass Utilization (September 2022)[28] states that utilization rates for sewage sludges, food waste and non-edibles are 10% below targets. In that study, authors wrote:

> In order to maximize the use of biomass as a resource, *it is important not to simply burn biomass*, but to reuse it as much as possible in order of value as a product, taking into account its economic efficiency and the reduction of greenhouse gases through the Life Cycle Assessment (LCA), and to use energy by burning it in the final stage. With this in mind, it is promoted the [sic] establishment of a utilization system that maximizes utilization of biomass according to the characteristics of each type and composition, for instance, forming utilization technology systems for each stage of biomass.
>
> *(emphasis added)*

We found limited references to the use of domestically sourced biomass for the production of zero- or low-carbon marine fuels in Japan. This is understandable since the initial development of supply chains for green bio-methanol began only a few years go in China and Europe. During this period, demand for new forms of maritime fuel rose in anticipation of regional and global requirements to reduce carbon emissions from ships. Today, however, there is significant experience with these supply chains, and Japan has substantial domestic biomass resources on which to base domestic production of green methanol.

In light of these developments, burning biomass to make electric power generation may not be the most optimal use of this resource. Japan plans to increase electric power generation from new and reopened nuclear plants and from offshore wind energy. As these forms of electric power generation increase, it may be possible to gradually shift sustainable biomass resources away from incineration and power plant fuel to production of sustainable liquid fuels that help reduce imports of fossil fuels into Japan while reducing GHG emissions. Similarly, as crude oil refining declines due to reduced use of gasoline and diesel in road transport, oil refinery

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[26] *Conceptual framework for advancing hydrothermal liquefaction technologies in sustainable biofuel production*, November 2024, https://srrjournals.com/ijsrst/sites/default/files/IJSRST-2024-0038.pdf.

[27] See, *The situation Surrounding the Use of Biomass, November 2022, Ministry of Agriculture, Forestry and Fisheries, Environment and Biomass Policy Division, Minister's Secretariat.* In April 2022, Japan enacted the *Act on Promotion of Business Activities to Reduce Environmental Impact for the Establishment of a Food System in Harmony with the Environment* (Act No. 37 of 2022. Hereinafter referred to as the "MeaDRI Act"). This law seeks to "promote the Strategy for Sustainable Food Systems and … to improve both the productivity and sustainability of agriculture, forestry and fisheries, and to promote the cyclical use and maximum utilization of biomass, which is a regional resource." See also biomass elements of *Act for Partial Amendment to the Act on Promotion of Global Warming Countermeasures* (Act No. 54 of 2021). The sixth Basic Energy Plan approved by the Cabinet in October 2021 defines biomass power generation as a locally distributed and locally produced energy source. The policy aims to expand the introduction of biomass power generation while ensuring stable procurement and sustainability of biomass fuel. National policy also seeks to introduce biofuels in light of international trends and technological developments for next-generation biofuels. The *Basic Act on Establishing a Sound Material-Cycle Society* (Act No. 110 of 2000) comprehensively promotes the reduction, reuse and recycling of waste, heat recovery and the comprehensive use of biomass while considering the sustainability of entire life cycles.

[28] https://www.maff.go.jp/e/policies/env/attach/pdf/biomass-2.pdf

footprints can be converted to green methanol and green ammonia production. Policies that reduce disposal of organic materials in landfills and redirect those resources toward sustainable biofuel production can help achieve several important national goals.[29]

Ministry of Land, Infrastructure, Transport and Tourism (MLIT)'s CNP Guidelines[30] states:

> "Port users (shippers, shipping lines, logistics companies are interested in initiatives that support supply chain decarbonization.
>
> "Promoting the shift from fossil fuels to non-fossil fuels and electricity through decarbonization efforts … serves as a mitigation measure for climate change [and] helps prevent air pollution by reducing SOx, NOx, and diesel particulate matter (DPM) emissions at the ports."

Nevertheless, actions to achieve these objectives are limited in the CNP certification system:

> "To promote the use of low- or zero-emission fuel ships at the terminal, participation in the ESI program, implementation of incentives such as port fee reductions for LNG and other low-carbon fuel ships, or the efforts of regulations on fossil fuel-powered ships is required."

This does not seem sufficient if supply chains for alternative fuels in Japan are not available or being planned. Maritime terminals can be influential to promote domestic supply chains for low- or zero-carbon vessel fuels. Actions to promote domestic supply chains of sustainable biomass and low- or zero-carbon liquid fuels could be added to the CNP certification system as a measure that can generate credits under the scoring scheme.

For example, the CNP certification could specifically credit these activities in the same way that other emission controls are considered. See Guidelines at pages 21-22:

> "Other Decarbonization Initiatives (Free Entry) initiatives at the terminal that do not fall under categories (1) and (2) are considered recommended items and should be detailed in the application. … Examples: Introduction of low-carbon and decarbonized electricity or fuel, environmentally friendly tugboats, implementation of emission reduction technologies (e.g., urea injection), efforts for elimination of offshore waiting, utilization promotion of inland ports, development of blue carbon ecosystems, including the formation of seaweed beds and shallow water, and efforts for carbon offsetting."

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[29] In 2017, there were about 1,600 landfills and 1,200 incineration facilities in Japan. In 2014, 358 of these plants also generated electricity. Takashi, Amemiya (Aug. 13, 2018). "Current State and Trend of Waste and Recycling in Japan". *International Journal of Earth & Environmental Sciences*. 3 (155). "…existing landfill space was expected to last another twenty years, though certain regions, unable to find enough space locally, had to ship garbage to other landfills in Japan for disposal." Too Much Waste Straining Japan's Limited Landfill Space *nippon.com*. Sept. 10, 2018. In 2014, 15 million tons of garbage were sent to landfills. In Tokyo, a typical incinerator can handle 600 tons of garbage a day, which is the waste produced by about 600,000 people. See, *Waste management in Japan*, https://en.wikipedia.org/wiki/Waste_management_in_Japan#cite_note-Takashi_2018-12.

[30] *Guidelines*, Page 3.

Many resources are available to guide ports and terminals to prepare for alternative fuel bunkering and supply chain development.[31]

Expand the CNP certification to methane emissions

The CNP certification metrics for greenhouse gases are limited to emissions of carbon dioxide. The certification would be improved by changing the metric to carbon dioxide equivalent (CO_2e) or by adding methane (CH4) emissions to the required emission factors, terminal emission inventory and tons/TEU reporting.

Treatment of LNG

The Guidelines for the Certification System for Decarbonization Efforts at Port Terminals repeatedly refer to liquefied natural gas (LNG) as a low- or zero-carbon maritime fuel and the certification system appears to encourage terminals to offer financial incentives and other support for LNG use. While there may be many important business and strategic reasons to support LNG bunkering in Japan, reduced carbon emissions is not one of them. We recommend that the CNP certification system take a more neutral position to LNG as a maritime fuel. While it may well be that, in the short-term, some LNG-powered ships have lower overall carbon emissions than older traditional bunker-fueled ships, that advantage may be short-term.[32] Proposed IMO rules and FuelEU Maritime regulations appear to allow credits for LNG for a limited time. While the future regulatory landscape is highly uncertain, LNG fuel use may eventually produce compliance deficits in carbon markets. "The IMO's evolving regulation may impact LNG's long-term viability as a transition fuel."[33] states Ship Universe in their *LNG in Maritime Shipping: 2025 Outlook and Industry Developments*.

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[31] See:

- Port Readiness Level for Marine Fuels (PRL-MF):
  https://fuelreadyports.org/
  https://sustainableworldports.org/wp-content/uploads/Port-Readiness-Level-for-Marine-Fuels-assessment-tool-July-2024.pdf
- IAPH Clean Marine Fuels Working Group,
  https://sustainableworldports.org/clean-marine-fuels/about-our-cmf-working-group/
- Summary of the Study Group on the Formation of Methanol Bunkering Hubs:
  https://www.mlit.go.jp/kowan/content/001873705.pdf
  https://www.mlit.go.jp/kowan/content/001873703.pdf
- Workshop on the Use of Biofuels for Shipping (in Japanese):
  https://www.mlit.go.jp/maritime/maritime_tk7_000065.html
- Current Guidelines for Handling Biofuels for Shipping (in Japanese):
  https://www.mlit.go.jp/maritime/maritime_tk7_000048.html

[32] ICCT, *Four changes would make the IMO Net-Zero Framework more effective*, April 11, 2025.

> IMO's LCA Guidelines underestimate methane slip from LNG-fueled ships that use the most common LNG engine technology. Methane has a 100-year global warming potential (GWP) nearly 30 times higher than carbon dioxide (CO2); its 20-year GWP is more than 80 times higher. Measurements of methane slip from ships using the most common LNG engine (LPDF 4-stroke) averaged 6.4%, much higher than IMO's assumption of 3.5%. Real-world measurements of other LNG engine technologies are underway.
>
> Increasing IMO's default methane slip assumption for LPDF 4-stroke engines to at least 6% would result in life cycle GHG emissions nearly 20% higher than conventional marine fuels for LPDF 4-stroke engines; continuing to use 3.5% methane slip results in LNG having GHG emissions that are about the same as conventional fuel. (Shipowners could get credit under the Net-Zero Framework for measuring and certifying lower methane emissions.) IMO's LCA Guidelines lack a default emission factor for well-to-tank (upstream) emissions for fossil LNG, which ranges between 18.5 and 28 g CO2e/MJ. That's 20%-30% of the life cycle GHG intensity of heavy fuel oil. IMO will agree on a value as it amends the LCA guidelines prior to implementing the Net-Zero Framework.

https://theicct.org/four-changes-would-make-the-imo-net-zero-framework-more-effective-apr25/. See also, T&E, *How much does LNG emit before it burns on a ship? Fossil gas is almost as bad as the dirty fuels it is trying to replace*, November 2024, https://www.transportenvironment.org/uploads/files/Final_202411_LNG-WTT.pdf

[33] Ship Universe, *LNG in Maritime Shipping: 2025 Outlook and Industry Developments,* Feb. 27, 2025, https://www.shipuniverse.com/news/lng-in-maritime-shipping-2025-outlook-and-industry-developments/ See also, Riviera, *IMO climate rules challenge LNG fuel assumptions*, April 17, 2025,

> …LNG's future viability as a transition fuel has been called into question in a Bureau Veritas initial analysis which has suggested that LNG-fueled vessels could fall into a lower non-compliance band as early as 2031 under IMO's metrics.

https://www.rivieramm.com/news-content-hub/news-content-hub/imo-climate-rules-challenge-lng-fuel-assumptions-84574.

LNG import terminals (re-gasification) and downstream pipeline systems release methane emissions, which run counter to Japan's goals to reduce greenhouse gas emissions. The next version of the CNP Certification Initiative Guidelines could recommend phase out of port entry fee discounts for LNG-powered ships. The guidelines might instead encourage terminals to collaborate with regional governmental agencies to establish methane emission monitoring systems and incentives to reduce methane losses from the operation of LNG receiving terminals and LNG-powered ships.

- **Make introduction of low-carbon cargo handling facilities a requirement**

  The availability of battery electric and renewable hydrogen-powered cargo handling equipment is rapidly expanding.[34] The March 2025 guidelines makes introduction of low-carbon and decarbonized yard tractors and other cargo handling facilities a "recommendation."[35, 36]

  In the next iteration of the guidelines, we recommend that decarbonization of yard tractors and other cargo handling equipment be a requirement to achieve the certification levels 3, 4 and 5.

- **Make evaluation of bunkering for low-carbon and decarbonized vessel fuels a requirement**

  One of the largest opportunities for maritime terminal decarbonization derives from conversion of vessels to low- and zero-carbon fuels. In the next iteration of the guidelines, we recommend that bunkering of low-carbon and decarbonized fuels be a requirement to achieve the certification levels 3, 4 and 5.

- **Treatment of carbon offsets**[37]

  Carbon offsets can create valuable compliance flexibility for entities that seek to reduce emissions. However, experience in the United States shows that emission offsets are often based on weak or non-existent emission reductions. We recommend that the next iteration of guidelines include best practices or other mechanisms to track and validate emission offsets used by terminals to achieve the higher certification levels.

- **Review evaluation items more frequently than every five years**

  Technologies, practices and markets supporting marine terminal operations are changing rapidly. The CNP certification guidelines expresses an intent to revise the certification documents and criteria every five years.[38] We recommend that the revision cycle be shortened

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[34] See, RMI, *The Time is Now for Zero-Emissions Cargo handling Equipment at America's Busiest Cargo Ports,* July 10, 2024, https://rmi.org/the-time-is-now-for-zero-emissions-cargo-handling-equipment-at-americas-busiest-cargo-ports/; Pacific Northwest Labs, *Port Electrification Handbook,* May 2024, https://www.pnnl.gov/sites/default/files/media/file/Port_Electrification_Handbook_Executive%20Summary_FINAL.pdf.

[35] See, *Guidelines* item 6 Page 20,

[36] The following statement in the CNP certification appears to be out of date. "Some of decarbonization technologies are currently under development or not yet widespread, such as … zero-emission CHEs etc." Carbon Neutral Port (CNP) Initiative - CNP Certification - Yusuke Suemune Ports and Harbours Bureau Ministry of Land, Infrastructure, Transport and Tourism (MLIT), Page 11. https://www.aivp.org/wp-content/uploads/2025/05/ICHCA-Presentation-CNP-Yusuke-Suemune-pdf-for-press-release.pdf.

[37] For example, Osaka Port Nanko Container Terminal C-1/4 received Certification Level2+, with the + based on introduction of a carbon offsetting system.

[38] "The evaluation items, indicators, and performance requirements for decarbonization efforts will be reviewed periodically—every five years—to reflect international deployments and technological advancements in decarbonization." *Guidelines,* Page 27.

to every two or three years to better reflect trends in maritime and port decarbonization. For example, a revision in two or three years might be an appropriate time to add requirements or recommendations on electric power supply planning and terminal roles in development of sustainable biomass and liquid fuel supply chains. More frequent revisions will help solidify Japan's leadership and on-going recognition in this field. In that same period CNP certifications can be written for bulk cargo, tanker, RORO and cruise terminals.

Hinterland transport

The CNP certification is somewhat ambiguous regarding requirements and recommendations for decarbonization of trucking and rail operations to move containerized freight from container terminals. Marine terminal leadership is critical to efforts to reduce GHG and diesel particulate emission from drayage trucking fleets and railroads. Charging infrastructure for electric trucks needs to be sited in or near the terminal areas and nearby warehouse facilities. Electric power supplies needed for shore power, intercoastal ship batteries and cargo handling equipment should be planned and potentially shared with drayage truck operations. The electric power demands for all these sites needs to be accommodated in bulk power, microgrid and electric distribution system planning. For these reasons it is desirable to include hinterland transport in the terminal decarbonization plans, emission inventories and emission factors.

Counting emissions

The guidelines state that carbon dioxide emissions from ships at-berth and vehicles experiencing gate congestion at the terminal boundary are not included in the calculation of a terminal's total carbon dioxide emissions. Emissions at-berth are a significant part of a terminal's emission inventory. If the emissions are not counted, there is a diminished incentive to reduce those emissions though shore power or similar measures to reduce carbon dioxide emissions from ships at-berth (e.g., onshore power supply equipment, ship exhaust gas recovery devices). The same is true for emissions from vehicles experiencing gate congestion. Solutions include gate reservation systems. But these measures are not listed as requirements in the CNP certification guidelines.

We recommend that CNP certification guidelines be revised to state that emissions from ships at-berth and vehicles should be included in the baseline emission inventory from which emission reductions are measured.

We recommend that CNP Certification Guidelines be revised to state that emissions from ships at-berth and vehicles should be included in the baseline emission inventory from which emission reductions are measured.

We are concerned that the current system creates a risk of double-counting by excluding these emissions from the baseline but then granting credits for voluntary emission reduction measures. This could distort the overall picture of a terminal's performance in reducing emissions.

Conclusions regarding potential changes to the CNP certification system

The CNP certification process is a model for other nations and subnational governments interested in reducing GHG emissions from maritime terminals and improving air quality for port communities. The recommendations described above would expand the range of activities subject to reporting and emission controls. These additions will increase the likelihood that Japan's leadership is recognized and followed internationally.

COMMENTS AND RECOMMENDATIONS ON PORT OF YOKOHAMA CARBON NEUTRAL PORT PLAN

Introduction and summary of Yokohama's port decarbonization planning

Yokohama is the second largest city in Japan and hosts one of the nation's largest and most diverse commercial and industrial ports. It manages 8,602 ocean-going vessel calls and 18,810 coastal vessel calls annually, including container, RORO, liquid bulk, dry bulk and cruise vessels. It covers six waterfront wharves, including recently constructed terminals on reclaimed land.

The city of Yokohama is transforming the Port of Yokohama into a carbon-neutral port with a net-zero greenhouse gas emission goal.[39] This will contribute strongly to the national goal of a decarbonized society by 2050.[40] The city of Yokohama's "Port and Harbor Decarbonization Plan for the Port of Yokohama," completed in March 2025, relies on an extensive network of public-private partnerships involving 42 business, government (city, regional and national), university and non-governmental entities.

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[39] The portal site for city of Yokohama and the port's CNP Initiatives outlines past and future decarbonization achievements. City of Yokohama released the "Port and Harbor Decarbonization Plan for the Port of Yokohama" on March 25, 2025. https://www.city.yokohama.lg.jp/lang/overseas/port/kankyo/cnp/initiatives.files/0057_20250520.pdf. Hereinafter referred to as "*the plan*" or "*Yokohama plan.*" This was in response to the provisions of Article 50-2 of the Ports and Harbors Act amended in 2022 — the act that addresses the orderly management and development of ports and harbors as well as navigation channels in Japan. See, press release (March 25, 2025). https://www.city.yokohama.lg.jp/lang/overseas/port/kankyo/cnp/initiatives.files/planpress.pdf

Yokohama's port decarbonization plan is based in part on the guidance manual provided by the Ports and Harbours Bureau of Japan's Ministry of Land, Infrastructure, Transport and Tourism (MLIT). https://www.city.yokohama.lg.jp/lang/overseas/port/kankyo/cnp/initiatives.html. See, *Yokohama Action Plan for Global Warming Countermeasures* (revised on Jan. 27, 2023) which calls for a 50% reduction of GHG emissions in Yokohama in FY2030 compared to the FY 2013, and for virtually zero greenhouse gas emissions from the city by 2050.

[40] The port decarbonization plan includes short-, medium- and long-term goals to reduce CO2 emission. See "*port decarbonization plan*" at Page 25. https://www.city.yokohama.lg.jp/lang/overseas/port/kankyo/cnp/initiatives.files/0057_20250520.pdf.

Yokohama's port decarbonization plan won the 2025 IAPH Sustainability Award for Climate and Energy.[41] This is well-deserved. The plan is a model for ports and marine terminals in Japan and globally. It includes plans for 121 projects, including:

- Harbor craft electrification.
- Energy efficiency, waste heat recovery.
- Next generation low- and zero-carbon marine fuels.[42]
- Plans for a decarbonized electric supply, involving
  - Solar on site.
  - Offshore wind energy (the latter to be supported by battery tanker ships).
  - Cofiring of existing fossil plans with zero carbon fuels.
- Onshore power supply facilities for ships at-berth.
- Decarbonized cargo handling equipment.
- Blue infrastructure to preserve marine life and capture/sequester carbon.
- Incentives for environmentally-friendly vessel calls.

Of note is the plan's commitments to next-generation, zero-carbon liquid maritime fuels (hydrogen and its derivatives/carriers such as green methanol and ammonia). Yokohama is a global leader in developing infrastructure to deploy green methanol to decarbonize container ship operations.

The Yokohama port decarbonization plan is supported by a detailed sustainable finance framework, which relies on partial financial assistance from large corporations as well as small- and medium-sized enterprises (SMEs).[43]

Image reference: https://www.city.yokohama.lg.jp/lang/overseas/port/kankyo/cnp/initiatives.html

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[41] See, https://sustainableworldports.org/iaph2025-sustainability-award-winners-announced/.

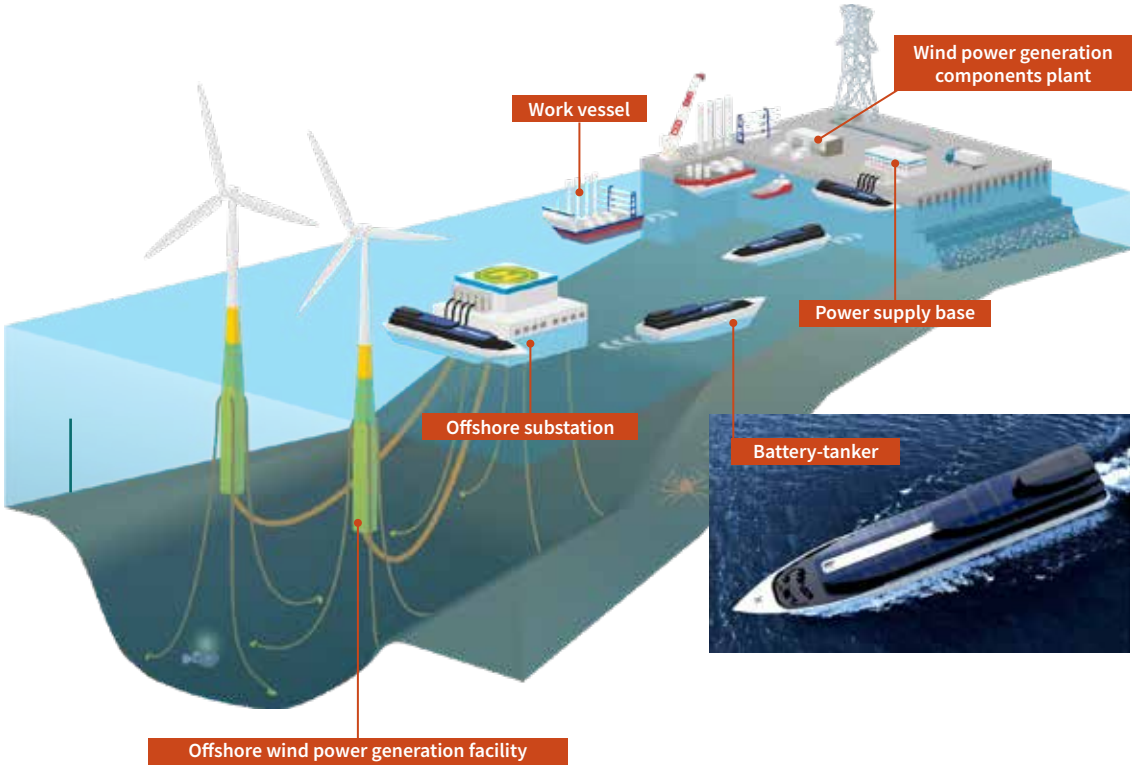
[42] Yokohama was the first port in Japan to host a "methanol bunkering simulation." https://www.city.yokohama.lg.jp/lang/overseas/port/kankyo/cnp/initiatives.files/0037_20240924.pdf

Yokohama has requested the national government to establish a national subsidy program to support the construction of bunkering vessels capable of supplying methanol to large ocean-going container ships. https://www.city.yokohama.lg.jp/city-info/seisaku/torikumi/bunken/yobo/yobo2025.files/yobo0706.pdf (in Japanese) (Page 169).

[43] https://www.city.yokohama.lg.jp/lang/overseas/port/kankyo/cnp/initiatives.files/fwpress.pdf

The plan is based on a detailed emission inventory of GHG, particulate, acid gas and air toxics emissions and a primary energy supply/use forecast. The forecast and plan envision large increases in renewable energy, renewable hydrogen and synthetic fuels after 2030. There will be dramatic reductions in coal and oil consumption, continuing and accelerating a downward trend since 2020. LNG use will modestly decline after 2040.

Planning is underway to make Yokohama a receiving site for power generated by floating offshore wind turbines. For distant offshore wind farms, the city and port are pioneering the concept of battery-tankers that would bring wind power to shore using ships filled with batteries that charge at floating substations near wind turbine farms and discharge in port ("battery-tankers).[44, 45]



Yokohama's leadership highlights the importance of local governments in the transition of maritime terminals to net-zero operations.[46] Yokohama's approach is in part grounded in the health and safety needs of its community. The city of Yokohama has inventoried GHG and other pollution emissions from all modes of vessel operation, utilizing the Maritime Emissions Portal (MEP) tool developed by *RightShip*.

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[44] See, the Yokohama decarbonization plan, Pages 57-59 for a discussion of "Expectations for Battery Tankers" and an MOU among the city of Yokohama, TEPCO Power Grid, Inc., Ocean Power Grid, Inc. and others (January 2025).
https://www.city.yokohama.lg.jp/lang/overseas/port/kankyo/cnp/initiatives.files/0057_20250520.pdf
https://www.city.yokohama.lg.jp/lang/overseas/port/kankyo/cnp/initiatives.files/0046_20250206.pdf

[45] Image reference: https://www.city.yokohama.lg.jp/lang/overseas/port/kankyo/cnp/initiatives.files/0057_20250520.pdf.

[46] C40 Policy Brief, *Port cities and a just transition: Local leadership in the global maritime industry,* October 2025. *https://www.c40knowledgehub.org/s/article/Port-cities-and-a-just-transition-Local-leadership-in-the-global-maritime-industry?language=en_US*
… examples from port cities worldwide that are accelerating just and equitable transition in the maritime industry…
https://c40.my.salesforce.com/sfc/p/#36000001Enhz/a/Vo000001c0xh/U8PjiUxIKeUymbOV5uOI_3Mz34Ag.Am02pQMPpWLNDM.

Yokohama also recognizes the economic potential from port decarbonization. It seeks to:

> Create a comprehensive port that *revitalizes Yokohama's economy* and enriches the lives of its citizens, based on the three pillars of '*an internationally competitive port*' … '*a port of tourism and prosperity*,' and 'a safe, secure, and environmentally friendly port.'
>
> *(emphasis added).*

Yokohama's port decarbonization plan is consistent with the Japanese government's "Plan for Global Warming Countermeasures."[47] This national plan aims to reduce GHG emissions by 46% by 2030 and 60% by 2035.[48] The Port of Yokohama also supports several international vessel decarbonization consortiums, including digital technology research to optimize vessel navigation and green shipping corridors with four California maritime ports (Port of Hueneme, Port of Long Beach, Port of Los Angeles and Port of Oakland).

It is also important to acknowledge the city and Port of Yokohama's leadership regarding important regional energy and electric power demand trends affecting GHG emissions and power supply. Yokohama, like many ports globally, is co-located with large electric power generation stations that are essential to both port operations and the regional economy. Also, like many cities in developed countries, Yokohama and regional electric utilities are planning for new power demand expected from data centers that support artificial intelligence (AI) technologies. This is an issue that other ports in Japan and globally will face as they plan to meet new electric power demand from port decarbonization and GHG emission controls. Yokohama's experience with these issues over the coming years could be instructive and useful to other port cities.[49]

Recommendations

It is certainly a difficult task to improve Yokohama's robust and comprehensive plan to decarbonize its maritime port and terminals. The following recommendations are offered with respect and admiration for the work of the city of Yokohama as the Port of Yokohama management body. These comments recognize that port technologies, practices and fuels are rapidly evolving, and that there are many uncertainties regarding best practices. Hence, it is important to create opportunities to exchange information among ports, cities and researchers, Pan-Pacific. With this understanding, we respectfully offer the following recommendations.

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[47] The city of Yokohama released the "Port and Harbor Decarbonization Plan for the Port of Yokohama" on March 25, 2025, in response to the provisions of Article 50-2 of the Ports and Harbors Act amended in 2022 — the act that addresses the orderly management and development of ports and harbors as well as navigation channels in Japan. Yokohama's port decarbonization plan is based in part on the guidance manual provided by the Ports and Harbours Bureau of Japan's Ministry of Land, Infrastructure, Transport and Tourism (MLIT). *Plan for Global Warming Countermeasures* (Oct. 22, 2021): https://www.env.go.jp/content/000249336.pdf.

[48] The Asahi Shimbun (Reuters), *Japan aims to cut greenhouse gas emissions by 60% by 2035 vs 2013 levels, Dec. 24, 2024,* https://www.asahi.com/ajw/articles/15563663.

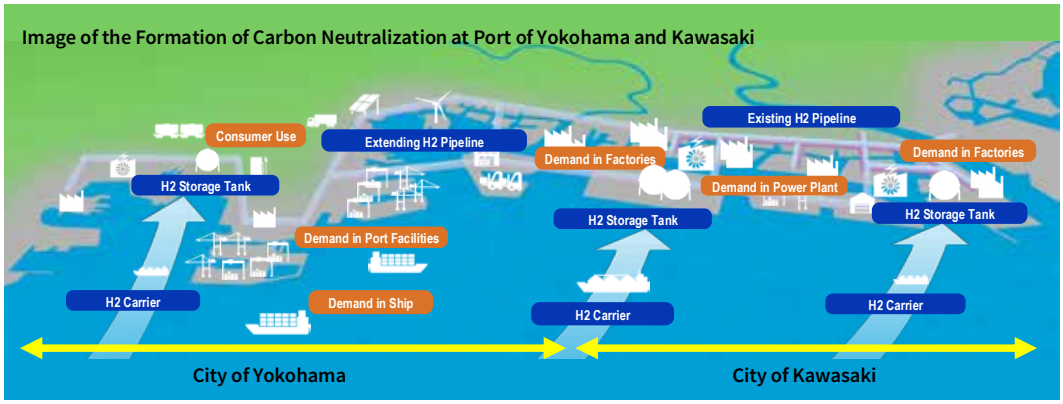
[49] On Oct. 3, 2025, the city of Yokohama signed a Memorandum of Understanding with JERA (Japan's largest power generation utility) regarding a planned data center project in the waterfront area of the port. This MOU is a noteworthy case in which data center development has been explicitly linked to efforts to quantify and manage potential CO2 emissions, using a port-level decarbonization planning framework. The partnership will advance the use of low-carbon and decarbonized electricity to power the data center, help achieve the efficient utilization of power infrastructure and contribute to a shift to low- and zero-carbon energy supply. JERA, *Memorandum of Understanding Signed Regarding Data Center Project on the Grounds of JERA Thermal Power Station in the Waterfront Area of the Port of Yokohama*. https://www.jera.co.jp/en/news/information/20251003_2283. See also, https://www.kaijipress.com/news/container/2025/11/196913/ (in Japanese).

Electric power supply planning:

As noted in the accompanying comments on Japan's CNP certification system, one of the first steps in port and terminal decarbonization is to ensure adequate electric power supply. Experience in Northern California shows that port decarbonization efforts can face long delays unless expanded electric power supply, transmission and distribution infrastructure is planned in parallel with planned electrification of cargo handling equipment, shore power and drayage truck charging equipment. Staging of this infrastructure may require investment in microgrids, onsite renewable generation and stationary battery storage to fill power supply gaps arising during planning, permitting and construction of grid upgrades. The Yokohama plan does not address this aspect of port decarbonization in detail. This may be because other planning systems, external to the Port of Yokohama, are fully adequate to meet power delivery needs. But this should not be assumed, since other near port power demands from data centers, industrial processes and hydrogen production can quickly outstrip existing electric system reserves.

Hydrogen pipeline:

We visited the Port of Yokohama in September 2023 and were grateful to receive excellent briefings by the city of Yokohama and Port officials and staff. The city and port's extensive outreach, consultation and research associated with plans to connect the port and nearby chemical, refining, steel, wastewater and power plant facilities with a hydrogen pipeline system were impressive. The city of Yokohama has conducted outreach on this vision using maps of existing and extended hydrogen and carbon dioxide pipelines.[50]



A hydrogen distribution and storage system will be key to domestic production, import and distribution of renewable hydrogen (RH2) as needed to introduce:

- New low- and zero-carbon maritime fuels.
- Zero-carbon road transport and cargo handling equipment.
- Decarbonization of nearby industrial production associated with Japan's export markets.

The plan includes a detailed forecast of port and city hydrogen demand.[51] However, RH2 and CO_2 distribution systems and parallel pipelines and supply chains for ammonia,

[50] See decarbonization plan Page 12, https://www.city.yokohama.lg.jp/lang/overseas/port/kankyo/cnp/initiatives.files/0057_20250520.pdf

[51] See discussion in Decarbonization Plan at Page 33. See also Pages 38-39.

synthetic methane and liquid synthetic fuels are discussed only briefly in the March 2025 decarbonization plan.[52]

Undoubtedly, planning for any pipeline system is extremely complex, very long-term and involves many different players engaged in often sensitive financial, technical and security research. It is not a surprise that the decarbonization plan was not able to go deeper on this part of the infrastructure planning. Nevertheless, Yokohama has shown important leadership in these matters. Other jurisdictions facing similar needs would benefit from periodic updates on this ambitious and world-class endeavor.

Other jurisdictions facing similar needs would benefit from periodic updates on this ambitious and world-class endeavor.

- **Alternative fuel for ocean-going and intercoastal vessels:**

Yokohama's decarbonization plan frequently acknowledges the importance of work to commercialize low- and zero-carbon liquid fuels for ocean-going vessels and opportunities to reduce emissions from intercoastal shipping through electrification of short-haul cargo voyages. For example, the plan notes that:[53]

> "In December 2023, Maersk AS and Mitsubishi Gas Chemical Company, Inc. signed a memorandum of understanding to promote the use of green methanol as a marine fuel. In September 2024, a methanol bunkering simulation was conducted with Idemitsu Kosan Co., Ltd. Efforts are underway to realize methanol bunkering in collaboration with private companies."

Mitsubishi is also studying the feasibility of using domestic woody biomass and waste to produce green methanol commercially in Japan.[54] Similarly, regarding ammonia fuels, the Port of Yokohama was part of a consortium in July 2024 (led by Nippon Yusen Kabushiki Kaisha — NYK Line) that carried out the world's first truck-to-ship method of ammonia bunkering (Honmoku Pier in the Port of Yokohama). The city of Yokohama's Port and Harbor Bureau coordinated the use of the pier, the Fire Bureau and other related departments to support the consortium's efforts.

Regarding short-haul cargo vessel electrification, the city of Yokohama joined (July 2023) the "Zero Emission Charger Promotion Council for Ships," which aims to promote general-purpose onshore power supply facilities and unified standards for onshore power supply facilities for domestic vessels.[55]

Undoubtedly, Yokohama will be part of Japan's ¥60 billion national project to create a zero-emission coastal shipping industry, likely with leadership on ship battery charging

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[52] See discussion in Decarbonization Plan at Pages 7, 12.

[53] See discussion in Decarbonization Plan at Pages 62-63.

[54] *TRE HOLDINGS and Mitsubishi Gas Chemical to Study Feasibility of Using Woody Biomass and Waste to Produce and Sell Green Methanol Commercially in Japan,* May 2025, https://www.mgc.co.jp/eng/corporate/news/2025/202522e.html.

[55] See Discussion in Decarbonization Plan at Page 66. For additional information regarding alternative fuels for ocean-going vessels, see UC Berkeley Goldman School and Energy & Environmental Research Associates, *Policy Options to Decarbonize Ocean Going Vessels, and Technology Assessment,* May 2024, https://gspp.berkeley.edu/research-and-impact/centers/cepp/projects/ocean-going-vessel-decarbonization.

infrastructure and ship design/construction of zero-emission vessels.[56] Domestic cargo vessels are responsible for a large percentage of carbon dioxide emissions from ships at-berth in Yokohama — an indicator of the importance of work to electrify intercoastal vessels that move cargo between Japanese ports and short sea cargo voyages between Japan, Korea and other nearby nations.[57] In 2024, 18,800 coastal vessels called at the port of Yokohama.[58]

Our recommendation is that the next iteration of Yokohama's port decarbonization plan should include more detail on its role in intercoastal fleet electrification and development of supply chains for zero-carbon maritime liquid fuels. This relates in part to our earlier recommendation regarding additional detail on electric power planning to ensure the Yokohama port can meet growing needs for electric power infrastructure and intercoastal ship battery-charging capacity.

- **Sustainable biomass:**

  It is possible that Japan is not making optimal use of sustainable biomass produced by agriculture, forestry, wastewater treatment, food processing and food service. This deserves research, particularly in a period when it may be that electric generation is shifting more heavily toward nuclear power and road transport more heavily toward batteries. These trends may reduce the need to burn biomass to make electricity and may reduce the need for hydrogen in light-duty road transport.[59] If this is correct, there may be an emerging opportunity to redirect some of these feedstocks toward production of low- or zero-carbon liquid fuels for maritime transport, such as e-methanol (methanol made from renewable hydrogen and captured carbon) and bio-methanol. For a fuller discussion on this topic, see the discussion on biomass in the first part of these comments that addresses the CNP.

  We also note that the plan exclusively references e-methanol. E-methanol is currently more expensive to make than biomethanol derived from sustainable biomass. Feed stocks suitable for bio-methanol are currently burned and disposed of in landfills. **We recommend that the plan be expanded to research opportunities to produce bio-methanol from urban and rural sustainable biomass as a bridge to a future in which renewable hydrogen is lower cost and more available for e-methanol production.**

- **Air pollution inventory, impact and target boundaries:**

  The plan seems unclear whether it excludes emissions from ocean-going vessels sailing in or through the Port of Yokohama area. In some ways, the plan appears designed to reduce these

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[56] Hae Jeong Cho, et al, *Economic benefits of building zero-emission capable vessels in East Asia,* September 2024, https://theicct.org/wp-content/uploads/2024/09/ID-205-%E2%80%93-ZE-vessels-working-paper-A4-60047-v4.pdf

> "We estimate that, if all newbuild bulk carriers, chemical tankers, container ships, oil tankers, and liquefied gas tankers produced in 2030 were to be zero-emission capable instead of running on conventional fossil fuels, the additional revenues would range from $6.9 billion to $36.0 billion globally. Building ZECVs could thus increase shipbuilder revenue from propulsion systems by 86% to 452%. … Japan would gain an additional $2.1–$12.5 billion (97% to 583% above the Baseline)."

The analysis suggests there is strategic value to align port decarbonization initiatives with shipbuilding policy.

[57] See Discussion in Decarbonization Plan at Pages 21-23.

[58] See Discussion in Decarbonization Plan at Pages 1, 3.

[59] Bio-methane made from sustainable feedstocks is likely to be less expensive than e-methanol in the near term. Biomass feedstocks are not likely to be sufficient to fully build out alternative fuels for maritime and aviation but can get us started while the cost of e-fuels gradually comes down. This is a good time to optimize use of sustainable biomass feed stocks.

emissions via projects to introduce low- or zero-emission fuels, the use of battery electric propulsion for intercoastal vessels and other measures. But other parts of the plan appear to exclude those emissions from pollution and GHG inventories and planning. Planners in California faced a similar issue regarding boundaries within which to measure emissions and credit reductions in port-related emission. For example, the Port of Oakland recently decided to expand the geographic boundaries for measuring emissions in order to give the public a more complete picture of the air pollution and GHG associated with port operations. The emissions reduction targets set out under the "Port and Harbor Decarbonization Plan for the Port of Yokohama" geographically cover only the waterfront area and adjacent areas of the Port of Yokohama, including the energy conversion sector, the industrial sector, the transportation sector (coastal shipping included) and ocean-going vessels at anchor. This means that the targets in this plan exclude ocean-going vessels sailing in or through the Port of Yokohama area and hinterland trucking mileage.

An alternative approach is to include emissions from ocean-going vessels traveling through and beyond the port area, potentially to include the first 100 miles of travel or some portion of emissions from docks in Yokohama to first port-of-call. Similarly, trucking and rail operations moving cargo to and from the port could include the miles traveled in the broader metropolitan area. This approach would provide a more accurate picture of the impact of ships, trucks, rail and cargo moving into and out of the Yokohama port areas. People living in the broader metropolitan area of Yokohama would then have a better understanding of the emissions associated with hinterland trucking as well as emissions from the port and ships in-transit to and from the port. We recommend this be done in addition to the current method to measure emission inventories and impacts, so that the narrower boundary data is retained and can be compared with similar approaches at other ports and to historic data.[60]

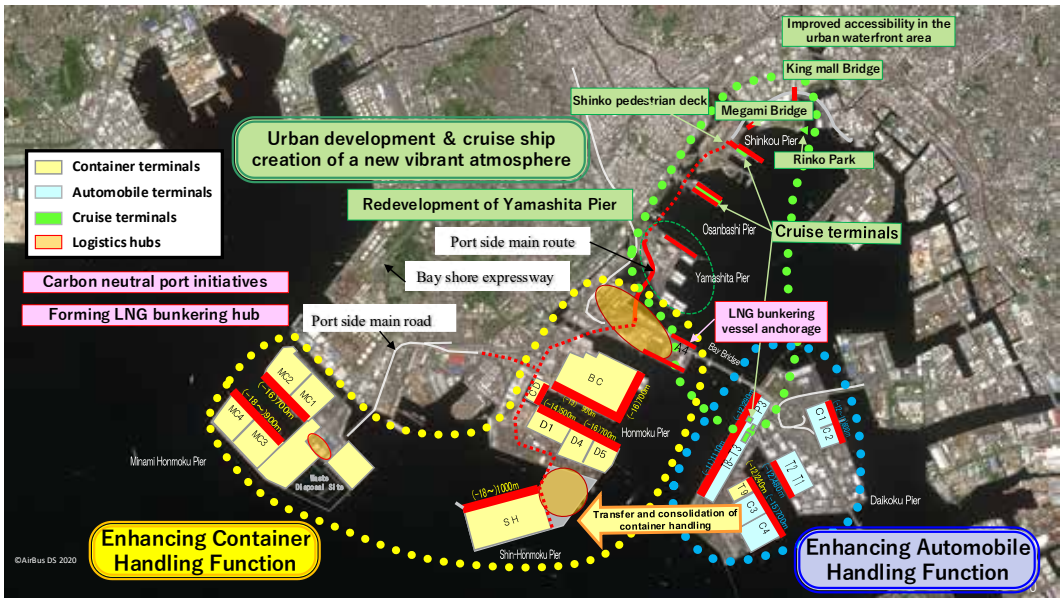

Image reference: Port of Yokohama Decarbonization Plan, page 2

[60] The Port of Oakland in California recently decided to expand the boundary of its emission inventory to include emissions from trucking and vessels that occur beyond the perimeter of the port.

- **LNG ship propulsion, LNG infrastructure:**

  Liquefied natural gas (LNG) is a controversial maritime fuel. Many countries, including Japan, only access the fuel through long distance and expensive international imports. GHG emissions associated with upstream fossil gas production and transport, gasification at the point of LNG export, leaks during voyage ("methane slip"), re-gasification at point of import, and pre- and post-voyage cryogenic storage losses add up to a very large GHG burden. Methane losses also occur after delivery in the form of methane leaks from fossil gas transmission and distribution lines and end-use appliances. While better than coal regarding particulate and metals emissions, GHG emissions associated with LNG are very large.

  Between 2019 and 2024, LNG transaction volume at the Port of Yokohama declined by about 20%.[61] The Yokohama decarbonization plan references efforts by the energy company JERA[62] to convert an LNG-fired power plant to hydrogen.[63] Nevertheless, the plan describes incentives for LNG bunkering and LNG bunkering vessels "in order to promote LNG-fueled vessels and encourage them to call at [ports][64]

  LNG-propelled ships currently tend to achieve better GHG emission profiles relative to older conventional ships due to higher efficiency of new ship designs, engines, hulls and equipment. But over time that advantage is expected to significantly decline. This is reflected in FuelEU Maritime and Draft IMO rules that award gradually declining emission credits for LNG propelled ships, but vessel operations on LNG will begin to generate emission deficits in about eight years. Some believe renewable natural gas feedstocks[65] and improved methane-slip controls will slightly lengthen LNG's run as a maritime fuel, but this is uncertain. For these reasons, over time, LNG is expected to decline as a maritime fuel.

  LNG poses several dilemmas for port and terminal operators. Many ship operators want access to LNG and a port's competitiveness may depend on LNG availability. But the infrastructure to deliver LNG to ships is expensive, poses risks to port communities and the lifecycle CO2e emissions (including methane) are high.

  The infrastructure to deliver LNG to ships is expensive, poses risks to port communities and the lifecycle CO_2e emissions are high.

  There are several things hat the city and Port of Yokohama could do to address the emissions and economic burden of LNG imports:

  - Clarify whether the port's emission inventory (and forecast) includes port and upstream methane emissions from the LNG fuel used at and bunkered at the port. If it does not, add

[61] See Discussion in Decarbonization Plan at Page 4, "Efforts at the Wharf."

[62] JERA is a 50-50 joint venture between TEPCO Fuel & Power, a wholly-owned subsidiary of Tokyo Electric Power Company and Chubu Electric Power founded in April 2015. https://www.jera.co.jp/en/corporate/.

[63] See Discussion in Decarbonization Plan at Pages 40-41.

[64] See Discussion in Decarbonization Plan at Pages 46-47, 48-49, 50-51, 63-64.

[65] The Yokohama port decarbonization plan references intent to promote activities to create new decarbonization innovations in hydrogen, ammonia, *synthetic methane*, liquid synthetic fuels.(Emphasis added). *Decarbonization Plan* at Pages 6, 11.

methane emissions to the inventory as soon as possible.[66]

- Phase out clean ship port-call incentives for LNG propelled ships. Incentives should be reserved for ships propelled by very low or zero-carbon emission fuels. This would be consistent with the city of Yokohama's recently launched incentive programs for alternative fuels, such as green methanol and advanced biofuels.[67] The following figure is from Page 2 of the plan.

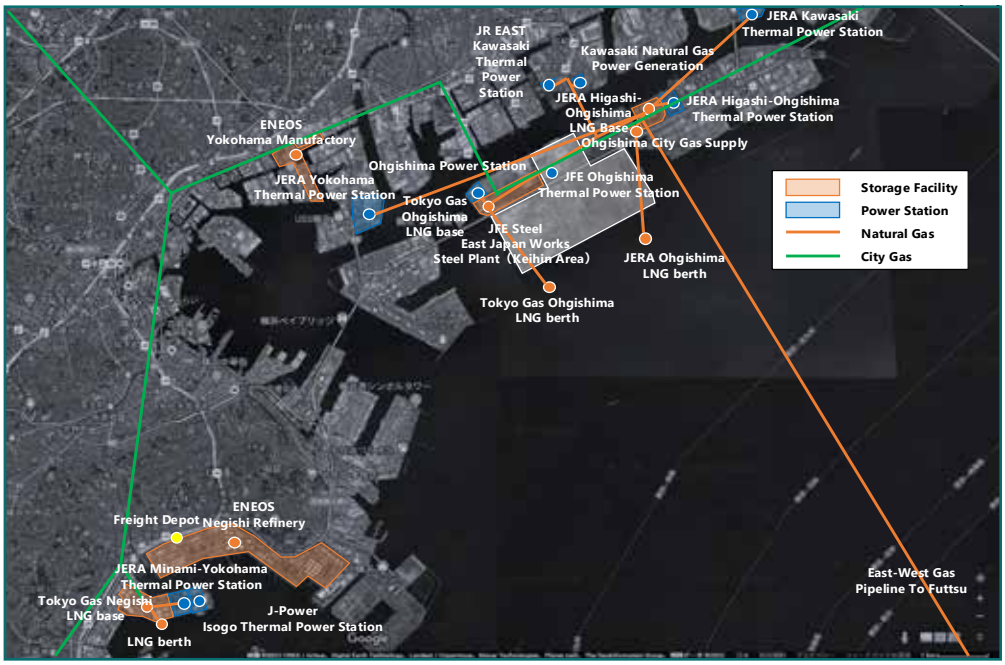

Image reference: https://www.city.yokohama.lg.jp/lang/overseas/port/kankyo/cnp/initiatives.files/0057_20250520.pdf

Public health benefits:

The Port of Yokohama, like the Port of Oakland in California, is located near residential, commercial and tourism sites. Many people live and work at or near the port. The port's plan appears quite likely to, over time, greatly reduce overall ("average") exposure to air pollution. However, there may be air pollution "hot spots" where certain neighborhoods, workplaces and business districts are exposed to differentially high levels of air pollution. One way to address this is to use short-range dispersion modeling techniques to identify air pollution hot spots in and around the port. Source-receptor modeling can then help identify the most important pollution sources affecting those places. Those locations and sources can then be

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[66] We are somewhat tentative on this recommendation, as the plan is ambiguous about methane emissions. Our review of the plan suggests that methane emissions are not included in the inventory.

> "Although the Zero Carbon and GREEN×EXPO Promotion Bureau includes CH4 and N2O emissions in its GHG estimates, the estimates for the harbor area for these gases are subject to future improvement, so only CO2 emissions were estimated in this study."

But we are unsure about this as some elements of the plan clearly express interest and concern regarding methane emissions and the impact on overall city GHG emissions. See figure at Page 16 and text at Page 18 of the plan that primarily discusses CO2 emission, but references CH4 emissions in relation to the *Rightship* tool. https://www.city.yokohama.lg.jp/lang/overseas/port/kankyo/cnp/initiatives.files/0057_20250520.pdf.

[67] On Dec. 25, 2025, the Port and Harbor Bureau of the city of Yokohama announced new incentive programs that fully waive port entry fees for: (1) methanol-fueled vessels; and (2) vessels that have received at least 300 tons of biofuel (with a blending ratio of 24% or higher) at the Port of Yokohama, effective Jan. 1, 2026. *Launching of a Port Fee Reduction Program for Methanol-Fueled Vessels and Biofuel-using Vessels*, https://www.city.yokohama.lg.jp/lang/overseas/port/kankyo/20240618.files/0006_20251224.pdf; The city of Yokohama, *Incentive Programs for Environmentally Friendly Vessels*, https://www.city.yokohama.lg.jp/lang/overseas/port/kankyo/20240618.html.

assigned priority for early emission control action. The Bay Area Air District in San Francisco has pioneered these techniques.[68]

- **Methane reduction target:**
  The decarbonization plan includes several references to production and use of synthetic methane.[69] We recommend that future revisions of the plan complement synthetic methane measures with a target to reduce methane emissions from operations at and near the port. Methane is a powerful greenhouse gas emission, some 86 times the global warming potential of carbon dioxide (20-year global warming potential). Hence, it is often a priority for government policy. The city and Port of Yokohama likely have several opportunities to achieve substantial reductions in methane emissions from city services, port operations and industrial production. Some of these opportunities may enable production of low- or zero-carbon fuels from capture and use of methane emissions.

Conclusion

While there are some policy tensions within the Yokohama port decarbonization plan, overall, it is a comprehensive and effective blueprint to reduce greenhouse gas emissions. Like any plan, it will evolve over time, and we hope that these comments will be helpful during implementation and in the next iteration of the plan.

[68] Formerly the Bay Area Air Quality Management District. See, https://www.baaqmd.gov/. See also, air quality guidelines Appendix E: *Recommended methods for Screening and Modeling local Risks and Hazards*, https://www.baaqmd.gov/~/media/files/planning-and-research/ceqa/ceqa-guidelines-2022/appendix-e-recommended-methods-for-screening-and-modeling-local-risks-and-hazards_final-pdf.pdf?rev=b8917a27345a4a629fc18fc8650951e4&sc_lang=en; *Research*, *Models and Modeling tools.* https://www.baaqmd.gov/en/about-air-quality/research-and-data/research-and-modeling.

[69] Decarbonization plan at Pages 38-39, https://www.city.yokohama.lg.jp/lang/overseas/port/kankyo/cnp/initiatives.files/0057_20250520.pdf.

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