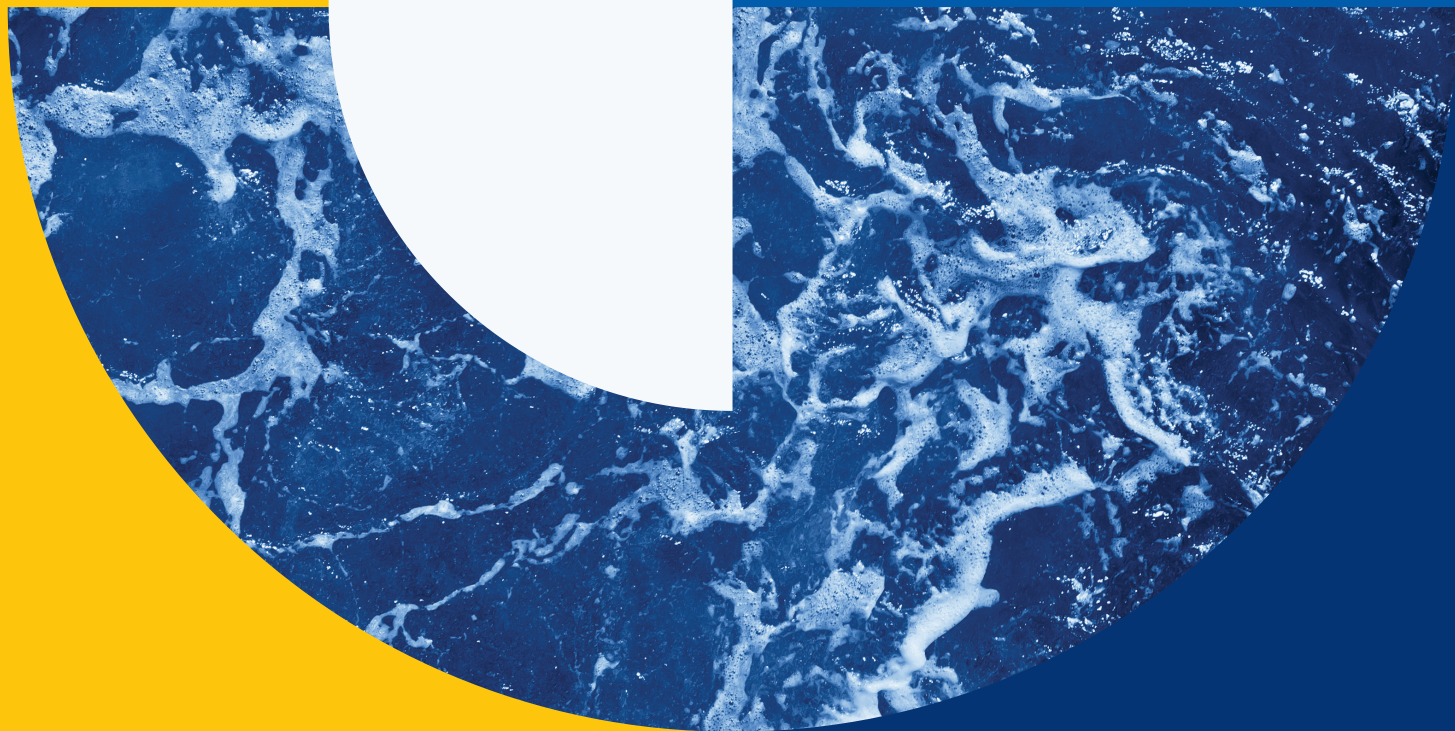
The Energy Transition

Challenges and opportunities



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PORT MONTRĒAL

As a driving force of the world economy, the port and shipping sector plays a pivotal role in tackling the issues surrounding a global energy transition. Maritime transport accounts for 940 Mt of CO_2 emissions (3.7% of global GHG emissions), with 55% to 77% of port GHG emissions coming from ships, followed by facilities and operations.

In 2018, International Maritime Organization (IMO) member states pledged to cut GHG emissions from maritime transport by at least **50% from 2008 levels by the year 2050.**

Meeting that target, and addressing the broader challenge of decarbonizing the port and shipping economy, calls for a variety of measures, such as:

1. Regulating emissions from commercial ships to IMO standards
2. Increasing energy efficiency
3. Reducing energy consumption
4. Increasing equipment and vehicle electrification
5. Implementing green pricing
6. Lowering GHG emissions
7. Introducing shore power supply
8. Establishing regulatory decarbonization KPIs
9. Sourcing sustainable energy alternatives to power port facilities and infrastructure
10. Structuring carrier and port activities with closed-loop practices in mind, such as carbon capture
11. Modernizing assets through automation

In short, sweeping structural changes to energy production, operation and consumption will require innovation, financial investment and political will.

Challenges

The port and shipping sector faces four main challenges in meeting the 2050 target:

GROWING ENERGY NEEDS

Driven by demand in North America, Europe and the emerging markets of China and India, annual global energy consumption was estimated at 557.1 exajoules in 2020—for an average year-on-year growth rate of 1.6% since 2000. While oil is still the world's leading fuel at 31.3% of global consumption, coal (27.2%) and natural gas (24.7%) are close behind, along with nuclear power (4.3%). Hydropower and renewables account for 6.8% and 5.7%, respectively (BP, 2021). Somewhat ironically, hydrocarbon use has risen in part due to the shuttering of thermal and nuclear power plants in several countries with no green energy production in place to offset the closures.

CURRENT CO_2 LEVELS

While roughly 70% of global carbon emissions are locked into GHG reduction agreements, net global CO_2 levels have contributed to increased atmospheric concentrations of CO_2, measured at 414 ppm in 2020.

THE EFFICIENCY TRAP

Investments in renewable energies, such as wind and solar, have exceeded $5 trillion worldwide since the 2000s. But when we consider the resources needed to build hydroelectric facilities and wind turbines, manufacture solar panels—and transmit this power—it becomes clear that the renewables boom has actually added to GHG emissions. Wind and solar, for their part, have limitations when it comes to continuous energy production, with well-documented reliability issues.

What do energy efficiency gains mean for shipping companies? Larger vessels and longer distances. For ports, they mean reinvesting energy savings in new growth areas. But increased energy usage can cancel out those initial efficiency gains; efficiency is not enough to reduce consumption.

THE LIMITATIONS OF CLOSED-LOOP

Energy efficiency and climate change resiliency measures have many economic benefits, but are not sufficient to curb consumption. Shifting from a production economy to a circular economy is the only way to achieve meaningful results.

For the port and shipping sector, this entails minimizing resource supply costs and maximizing waste and by-product recovery. In this scenario, vessels would be designed with recyclability in mind. A circular port economy would include advanced manufacturing that generates negligible waste to improve synergy and efficiency with residual heat, optimize the water cycle and recover CO_2, all with a view to meet zero waste targets.

But the circular economy has its limits. Not all materials are recyclable or useful to other industries, and the recycling process itself is energy-intensive. Finally, efficiency gains don't necessarily translate into significant emission reductions.

Measures

The key to meeting the port and shipping sector's decarbonization goals could simply be using the best available technologies to their full potential.

One promising option is the electrification of lifting and handling equipment, infrastructure and vehicles in terminals, resulting in a reduction of carbon emissions. And shore power, which supplies ships with renewable fuels, can decrease a vessel's carbon footprint.

Technical and operational measures are another angle. Although 100% electric engines are neither compact nor powerful enough to be a viable option right now, vessel owners are moving towards hybrid engines that combine alternative fuels, heat recovery systems and high-performance batteries for auxiliary engines.

On the engineering side, carriers want engines with peak propulsive efficiency, as well as optimized hull configurations and more efficient thrusters. Meanwhile, ports are implementing heat recovery systems and improving the performance of vehicles and motorized industrial equipment.

Then there is the matter of fuel. Altering fuel properties or switching to clean fuels are quick and effective ways to reduce emissions.

But there's no magic bullet, and there are still many unknowns.

Alternative fuels

The IMO regulation on fuel sulphur content is an incentive to use alternative fuels for maritime transport.

BIOFUELS

Biofuels include methanol, ethanol, biodiesel and renewable natural gas.

They work well in shipboard machinery and internal diesel engines used in port equipment. Maersk plans to take delivery of 12 container ships running on green methanol in 2024. These fuels can be used in their pure state or mixed with conventional petroleum-based fuels.

But biofuels do have issues, such as limited production capacity. The industry can't rely on international markets to supply resources, as this would entail longer transport distances and a consequent increase in GHG emissions. The second reason is the low calorific value of biofuels relative to conventional fuels, meaning that it takes more fuel to generate one unit of production or to cover a given distance. Lastly, biofuels are more expensive than fossil fuels, which can cost up to 5 times more than natural gas.

NATURAL GAS

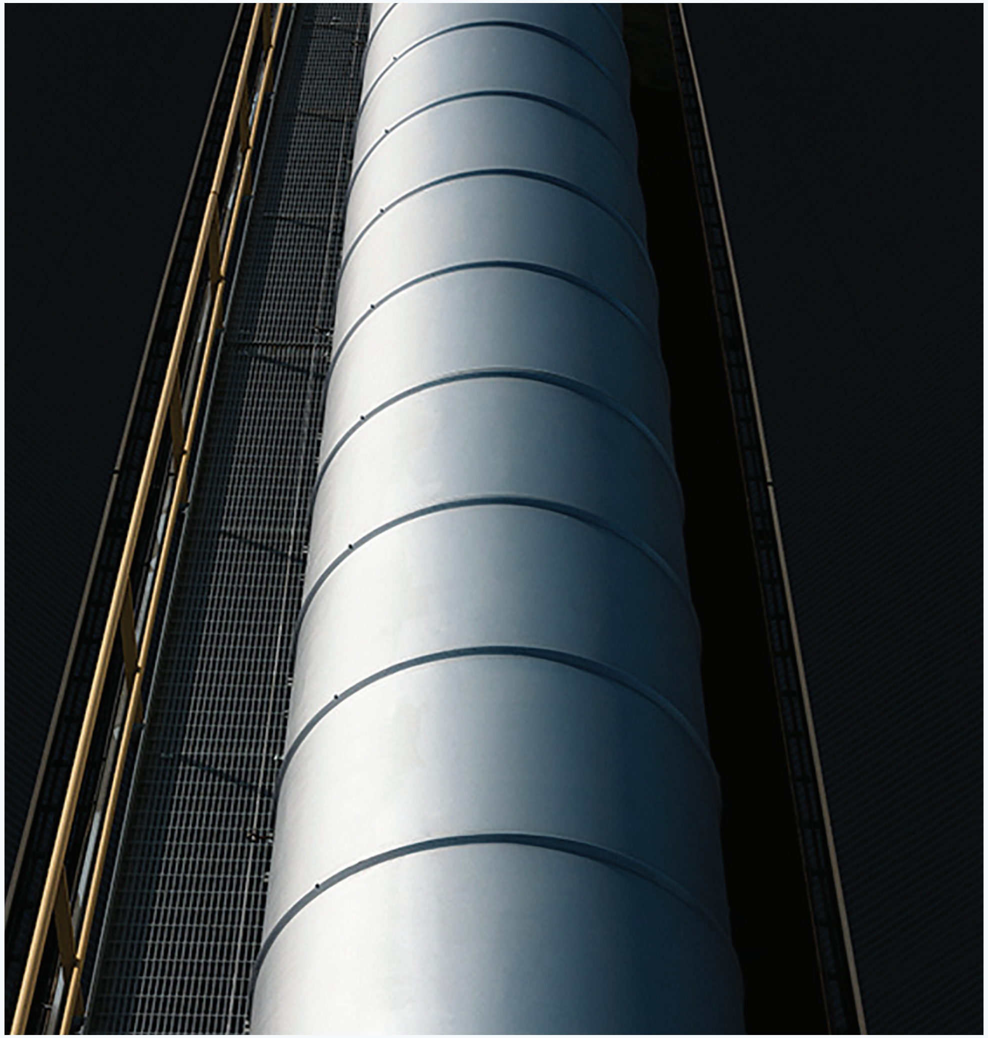
Natural gas has several benefits. Not only are global reserves big enough to meet demand, but it also contains less carbon than other fossil fuels and burns cleaner, without residue. Its higher octane levels make it burn more efficiently as well. Liquefied natural gas (LNG) is touted as the fuel of tomorrow for the port and shipping sector; replacing fuel oil and heavy fuel oil with LNG could cut ships' CO_2 emissions by 5% to 30% (ITF, 2018). CMA-CGM has 22 LNG-fuelled container ships in 2022.

But there are also serious concerns surrounding LNG. Onboard storage requires a lot of space, and LNG combustion emits more methane than oil (ITF, 2018). Methane is a significantly more potent greenhouse gas than CO_2. There is also controversy with respect to energy requirements for the production, pressurization and distribution of LNG. On top of this, GHG emissions during ship bunkering may undermine the mitigation potential of LNG.

HYDROGEN

Hydrogen could be the most environmentally friendly energy source, as it releases mainly steam, along with a negligible amount of chemical pollutants—and no CO_2. It can be used in a variety of ways by the port and shipping sector, like powering equipment and vessels. Hydrogen engines are 3 to 6 times more efficient than conventional fossil fuel or biofuel engines. Using a mixture of hydrogen and heavy fuel oil can cut CO_2 emissions by 43% per tonne-kilometre (tkm) a ship travels (ITF, 2018). Hydrogen can also be used to store surplus electrical energy for emergencies or to meet peak electricity demand. Liquefied hydrogen can be transported by train, truck or ship.

However, problems arise when considering hydrogen as a substitute for conventional fuels. Hydrogen does not generate additional energy, as the production process triggers a chemical reaction involving water or hydrocarbons. Roughly 95% of the world's hydrogen is produced from hydrocarbons—a method that releases 8.9 tonnes of carbon dioxide (CO_2) for every tonne of hydrogen generated. Electrolysis hydrogen production costs 3 times as much as natural gas reforming and incurs energy losses of up to 40% (IFPEN, 2020; Whitmore & Pineau, 2022). And because of hydrogen's low density, it must be compressed for storage, which raises both energy consumption and expense (hydrogen costs twice as much as fossil fuels). Storing hydrogen via fuel cells is one possible solution, but requires rare earth oxides for the manufacturing and refining processes, resulting in negative environmental externalities. Production limitations, cell costs per unit of energy, loss of cargo space on ships and vehicles, and safety issues associated with high operating temperatures, are all factors inhibiting large-scale deployment of hydrogen fuel cell technology in the port and shipping sector.



In short, ports are mainly looking for direct power from renewable non-fossil energy sources. For shipping companies, it can cost up to 25% more to build greener vessels compared to diesel-powered ships. The low energy densities of alternative fuels also require a shift to decentralized low-carbon energy, which means refuelling more often. With that in mind, the order of priority for maritime fuel adoption will start with inland and coastal shipping, followed by short-range sea shipping, and then ocean shipping. Government incentives would certainly stimulate port and shipping sector buy-in when it comes to alternative fuels.

Opportunities

Ports play a key role in facilitating sustainable maritime transport. Decarbonization demands significant investments in infrastructure, equipment and facilities, but ports must also reshape the operational landscape—a process with significant, industry-wide financial and operational implications. While the sector acknowledges the need to replace infrastructure and equipment, efficiency and cost-effectiveness must be factored into the implementation timeline. The port and shipping sector will need to audit its carbon footprint and determine the cost and effort required to adjust each of its activities to meet target GHG reduction percentages.

But for all the challenges and issues raised by decarbonization, the path to a sustainable port and shipping economy holds considerable opportunities.

BUILDING CONNECTIONS

Ports must ensure that goods arriving and departing by sea and land are transported on a carbon-neutral basis.

On the supply side, over 200 shipping companies have committed to bringing carbon neutral ships to market and fast-tracking their production by 2030. From a demand standpoint, companies like Amazon, Ikea, Michelin, Unilever, Patagonia, Costco and Canadian Tire have announced their ocean freight activities will rely exclusively on carbon neutral carriers.

At the 26th Conference of the Parties (COP26) in Glasgow, 22 countries, including Canada, signed the "Clydebank Declaration for Green Shipping Corridors" (2021), committing to establish at least six international zero-emission maritime routes by 2025. The Port Authorities of Montreal and Antwerp also signed an agreement to develop the first transatlantic green shipping corridor. The partnership will support green fuel trade, develop infrastructure to power ships with renewable fuels and introduce innovative decarbonization technologies.

REHABILITATING INDUSTRIAL SPACE

Decarbonization means a wider selection of alternative fuels, as well as liquid biofuel production from biomass, agricultural waste and forestry by-products. Biorefining and a new energy chain are central to this shift, with biomass compensating for the loss of hydrocarbon tonnage. But transforming the refining industry is no easy task; collecting and processing industrial, commercial and municipal waste will be crucial. Ports can benefit from industrial use of biomass thanks to the import of by-products and the export of biofuels. Transporters are also vital for these new industries to succeed, most notably in their ability to supply and dispose of large quantities of cargo. The Société du parc industriel et portuaire de Bécancour, in Quebec, is already running the province's most advanced circular economy project to manage and recover by-products from the companies using its industrial park.

Another option is to capture, cleanse and compress carbon dioxide to create a carbon lifecycle. Given how close ports are to CO_2-intensive industrial parks and potential sites for low-cost CO_2 processing, there is the potential to 1) reduce GHG emissions; 2) generate carbon-neutral fuels like hydrogen and methanol; and 3) manufacture the coolants used in port and ship heat absorption systems. More importantly, CO_2 recovery helps substantiate the carbon credit market and increase the production value of shared port and industrial space.

LEVERAGING NEW SKILLSETS

Beyond the investments in physical capital (vessels, infrastructure, equipment, technology, etc.), a successful energy transition process will require new talent and skillsets to source and interpret information, develop and refine technologies, and build new bodies of knowledge. This includes specialists in the STEM fields—such as industrial engineering, civil engineering, IT, operational research and statistics—but also in the social sciences (management, economics, geography, ecology, political science and law).

It becomes clear that global decarbonization efforts hinge on comprehensive, cross-disciplinary collaboration and research. The process is long, multi-faceted, and something of a "contact sport": meeting industry stakeholders, circulating new ideas, forging partnerships, bridging fields, and so on.

Conclusion

The port and shipping sector's decarbonization strategy takes shape through several institutional and corporate initiatives, nurturing ongoing innovation and technological breakthroughs that could go a long way in reducing the sector's environmental footprint. More importantly, carbon neutrality opens up large-scale business opportunities by helping ports stay competitive.

Decarbonization efforts in Quebec and Canada are already positioning the port and shipping sector as a global market leader by setting the standard for best practices—and this is only the beginning.

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