# Decarbonize Ports & Manage Energies Efficiency

## Key findings of the study carried out by our Working Group dedicated to Ports

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NEW ENERGIES

The energies coalition for transport & logistics

# Preamble

As the global community confronts the urgent need to address climate change, nations and industries everywhere are scrambling to achieve environmental goals and take actions to ensure a sustainable future. The maritime transport sector holds particularly significant potential to make a difference.

Ports and terminals play a pivotal role in the race towards decarbonization. As strategic global transportation hubs, their proposal of solutions for decarbonization efforts have a ripple effect across the seas. Their onshore facilities may provide the space and potential to produce renewable energies to contribute to powering shipping and haulage lines around the world. Excess energy could be stored and used during peak times or sold. Today, ports would like to transition from carbonized logistics hubs to potentially independent cost-efficient green energy hubs that can hugely impact global carbon emissions.

Shipping operations are a valuable lever for improving energy efficiency, promoting sustainable practices, and contributing to research and development. This potential, coupled with an effective, harmonized regulatory landscape can help to achieve targets for net zero emissions in the future.

Low-carbon sustainable solutions exist but the price to pay for the energy transition is currently high and there are complexities to their implementations. Ports and terminals may be confronted with technological, financial, operational and regulatory barriers. Equally, all stakeholders involved at every level international, national and local must have a common vision and target. Cooperation between all parties involved is needed for a coherent, consolidated approach to tackling emissions on a global scale. How do those objectives translate to the real world?

This is what the Coalition set out to explore through one of its working groups, led by **Schneider Electric** with the contribution of **CMA CGM, Cluster Maritime Français, Engie, TotalEnergies** and **PSA**. This report presents the Coalition's findings on the decarbonization of port operations around the world and builds on a previous study on the electrification of ports. This new research focuses more specifically on the aspects of energy efficiency and decarbonization. Using 2022 data, we assess the current situation; consider the solutions available and the challenges faced; address the regulatory frameworks in place and analyse five container terminals across diverse global contexts to see what is actually happening on the ground. The findings of this study provide real world insights into current practices and strategies to achieve carbon neutrality at ports and terminals by 2050.

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***The NEW ENERGIES Coalition, initiated in 2019 by CMA CGM, is a consortium of key players in international supply chains, working across various sectors and industries.***

*Through a collaborative approach, they aim to develop innovative technologies and energy solutions to decarbonize maritime, air, and road activities worldwide.*

*Additionally, to address the need for a regulatory framework that encourages the recognition and development of new energies and low-carbon and renewable fuels, the members of the NEW ENERGIES Coalition produce studies and manifestos for public and private representatives in the transportation and logistics sector.*

*NEW ENERGIES thus operates on two levels: solutions and mobilization.*

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# Executive Summary

Ports are central to global trade and pivotal in decarbonizing transportation and logistics by their capacity to adopt more sustainable fuels, improve energy efficiency, and foster innovation. However, challenges like technological limitations, financial costs, regulatory barriers, and stakeholder coordination must be addressed. While regulations may require ports to be carbon neutral by 2050, the reality is that they often lack the infrastructure and funding to implement the solutions available.

In an endeavour to explore and understand the current situation, the New Energies Coalition working group asked:

- What regulations and targets are in place to encourage and enable a carbon neutral future?
- What are ports doing to meet these deadlines?
- What can be done to improve energy efficiency and reduce emissions?
- What does a carbon neutral future look like for shipping terminals and what can be done to accelerate the journey towards it?

Our study commenced by acknowledging the strategic importance of ports for global decarbonization. Their logistics and operational practices significantly impact greenhouse gas emissions, and sustainability initiatives carried out locally carry global influence.

Next, in response to the questions addressed, we identified the following:

## 1. A strong regulatory landscape:

Regulation is a powerful lever for decarbonization, and a multitude of frameworks apply to the maritime transport sector at different levels: international (IMO), regional (EU Green Deal, ETS) and national. Some of the main requirements applicable to the maritime transport sector include:

- The IMO's goal of achieving carbon neutrality by 2050.
- The EU AFIR (Alternative Fuels Infrastructure Regulator) for ports and Fuel EU for ships, regulations making shoreside electricity compulsory for ports by 2030.
- The Greenhouse Gas Protocol, a valuable tool to help ports and terminals identify where critical emissions are occurring in the supply chain and what to prioritize in their decarbonization strategies and initiatives.

On the positive side, by making sustainable energy mandatory, these targets and regulations incentivize the development of clean energy and infrastructure.

## 2. Sustainable solutions in place and in the pipeline:

Sustainable solutions exist and are already being rolled out to various extents in ports and terminals around the world. Additional actions can be considered: firstly, efforts to reduce or eliminate direct emissions – replacing diesel motors by electrical motors supplied by batteries or with cleaner fuels.

Secondly, investing in local assets to generate renewable sources of energy, while taking into account the space availability constraint that limits such investments. It is essential to complement this approach with the use of contractual agreements, particularly through green power purchase agreements (ideally PPAs), to ensure a sustainable and competitive supply of green energy to power the ports and reduce their energy costs."Electrifying equipment and vehicles to stop GHG Scope 1 direct emissions or transitioning from diesel engines to cleaner fuels.

- Being able to produce and store renewable energy on site (solar, wind). Excess energy could be reinjected into the local network and delivered as and when required using data-driven smart grids. This requires additional investments in local electrical infrastructures with data collection and analysis, at the port.
- Installing and providing shore-side electricity facilities so ships can connect to the port's electrical network and cut emissions from the generators on ships in call.

## 3. A need for data sharing and collaborative involvement across the board:

Coordinated efforts among shipping lines, port authorities, and energy providers will be crucial for harmonized decarbonization strategies. Data sharing and cybersecurity are paramount for facilitating efficient energy use and operational transparency for civil society. On the ground, this means introducing sensors and smart grids on site that can record, collate and process data to anticipate energy needs and deliver the right amount of power to the right place at the right time.

## 4. Case study – five terminals, five strategies

Having considered the elements outlined above, our working group then looked at real-world realities. We examined the annual energy consumption and emissions of five terminals in their specific context and the decarbonization strategies adopted at the ports in:

- **Martinique** : Grand Port Maritime de la Martinique (GPMDLM)
- **Malta:** Freeport in Birżebbuġa
- **USA**: Fenix Marine Services terminal (FMS POLA) in Los Angeles, California
- **France** : Terminal de France at the Grand Port Maritime du Havre (GMPH) in Le Havre
- **Singapore**: PSA, all terminals

These five distinct terminals around the world each have different geographical, energetic and strategic constraints and opportunities, demonstrating the impossibility of a one-size-fits-all approach and the importance of tailoring decarbonization efforts to each individual set of circumstances.

Ultimately, our findings highlight the need for a coordinated and multifaceted approach based on the integration of data solutions and advanced technologies; compliance with aligned regulations; and strategic collaborations among stakeholders at all levels of governance and the supply chain.

They suggest that targets to achieve shore side electricity in Europe by 2030 and net zero emissions worldwide by 2050 can be attained, but are dependent on:

- The harmonization of regulatory frameworks, essential to ensure coherent and transparent objectives
- This harmonization is also crucial to maintaining the competitiveness of ports, which, while competing on a local, regional, or international scale, should not be penalized by regulatory obligations resulting in disproportionate costs.
- The ability of ports to become energy hubs, capable of producing, storing, and supplying renewable energy as needed, through smart data management within connected networks.
- Close collaboration and coordinated efforts between policymakers, maritime and land transport providers, and other stakeholders.
- A careful balance between local and global approaches, with strategies tailored to each port and terminal but integrated into a coherent framework.
- The capacity of ports to finance necessary investments and absorb induced additional costs, which implies mobilizing sufficient financial resources and being able to pass on these extra costs in service tariffs.
- Significant investments from both the public and private sectors to support innovation.

# Part 1: Regulation – a strategic lever for decarbonization

**Regulation plays a central role in the transition toward a sustainable maritime industry. By setting clear objectives and precise deadlines, it encourages ports, terminals, and shipping companies to reduce their carbon footprint while fostering technological innovations and the development of cleaner solutions. However, despite its undeniable potential, regulation also faces complex challenges that sometimes hinder its effectiveness.**

## A Tool to Transform the Maritime Industry

Environmental regulations, whether local, regional, or international, act as a catalyst to accelerate decarbonization. They encourage investments in sustainable infrastructure, strengthen collaboration among stakeholders, and establish a shared responsibility dynamic. Moreover, they stimulate innovation by imposing ambitious standards that push companies to explore new fuels, technologies, and practices.

Yet, despite their appeal and common goal—achieving carbon neutrality by 2050—regulations encounter obstacles. The maritime industry, by its global nature, is subject to diverse influences and requirements: reducing ship speeds, using alternative energies, shore power supply, safety, etc. This diversity of priorities, combined with the multiplicity of regulatory frameworks, can create tensions between local and global approaches.

**The regulatory landscape is complex, and compliance is individually challenging for ports and terminals.**

## A Complex and Demanding Regulatory Landscape

Navigating this fragmented regulatory environment is a challenge for ports and terminals. The gaps between imposed requirements and available resources (funding, infrastructure, technologies) complicate implementation. Yet, these frameworks are essential to guide the industry toward a sustainable energy transition.

**Figure 1: Regulatory targets and their practical application in major nations.**

| Regulations | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|
| International (IMO) | Cut 2008 CO2 levels by 20% | Cut 2008 CO2 levels by 70% | Net Zero | |
| European | Use shore power<br>Cut 1990 CO2 levels by 55% | | Net Zero | |
| National | Use shore power | Cut 1990 CO2 levels by 85% in California | Net Zero | Carbon Neutral |

## Key Regulations: The EU and IMO Leading the Way

### International Maritime Organization (IMO):

**The IMO, as the global maritime regulatory body, has adopted ambitious measures to reduce emissions in the sector.** These measures, while primarily targeting ships, have direct implications for ports, which must adapt to support these objectives.

- **MARPOL Annex VI:**

Strict limitations on SOx and NOx emissions from ships, requiring ports to develop suitable infrastructure, such as low-sulfur fuel bunkering facilities or emission management systems (scrubbers).

- **Initial Greenhouse Gas (GHG) Strategy:**

A goal of reducing GHG emissions by at least 20% by 2030 (compared to 2008 levels) and achieving carbon neutrality by 2050. Ports must prepare by developing infrastructure for alternative fuels such as LNG, hydrogen, and ammonia.

- **EEDI and EEXI (Energy Efficiency Design Index):**

Ports need to provide solutions to enable ships to comply with these indices, including the supply of clean fuels and reducing their own carbon footprint.

- **CII (Carbon Intensity Indicator):**

By measuring the carbon intensity of ships in operation, this indicator encourages ports to reduce ship waiting times and invest in solutions like shore-side electricity.

### European Union (EU):

**The EU, through its Green Deal, goes even further by imposing specific requirements for ports:**

- **Alternative Fuels Infrastructure Regulation (AFIR):**
  European ports are required to provide shore-side electricity by 2030, thereby reducing emissions from ships at berth, and to develop infrastructure for alternative fuels such as LNG, hydrogen, or ammonia.
- **FuelEU Maritime:**
  A gradual reduction in the carbon intensity of marine fuels. Ports must ensure the availability of these fuels to enable ships to comply with this regulation.
- **Emissions Trading System (ETS):**
  Inclusion of maritime transport in the ETS, monetizing GHG emissions from ships. Ports play a key role by offering solutions such as shore-side electricity and sustainable fuels.
- **Ambient Air Quality Directive:**
  Strict limitations on air pollutant emissions in port areas, encouraging ports to adopt clean technologies and electrify their equipment.
  Fuel EU

**Although these regulations primarily target ships, ports, as hubs of innovation and sustainability, hold a key responsibility in achieving global climate goals.**

## Regional and National Regulations: Concrete Examples

California stands out with pioneering regulations implemented by the California Air Resources Board (CARB). Since 2020, a law mandates ships at berth to connect to the onshore power grid, thereby reducing local pollutant and GHG emissions. This effort aligns with the overarching goal of carbon neutrality for the port sector by 2045. Simultaneously, the state invests in alternative fuel infrastructure and innovative technologies.

China has integrated strict environmental objectives into its port development strategy. Major ports are now equipped to enable 90% of public vessels to use shore power, reducing SOx and NOx emissions by up to 65% in key areas. These measures are accompanied by a stringent regulatory framework requiring new ports and ships to incorporate low-carbon technologies from their design phase.

As a global maritime hub, Singapore is actively promoting alternative fuels (ammonia, hydrogen) and the development of green shipping corridors. Financial and regulatory incentives have also been introduced to support the development of charging infrastructure for electric harbor vessel and research into autonomous shipping.

The EU mandates shore power connection for 90% of ferries, container ships, and cruise ships in its major ports by 2030. This transition is supported by massive investments in infrastructure and incentive policies.

### Challenges and Perspectives

Despite their relevance, these regulations pose major challenges:

- **Infrastructure adaptation :** Modernizing ports to accommodate low-carbon technologies requires massive investments.
- **Cost of clean technologies:** The innovations needed to achieve carbon neutrality remain expensive.
- **International coordination:** Harmonizing regulatory frameworks across different regions and stakeholders is a complex task.

However, these challenges should not overshadow the opportunities offered by this transition:

- **Job creation** in renewable energy and clean technology sectors.
- **Increased attractiveness** of ports for investors and shipping companies.
- **Environmental leadership** for ports that adopt innovative solutions, enhancing their competitiveness on the global stage.

**The decarbonization of ports is not only a response to climate imperatives but also an opportunity for profound transformation in the maritime sector.**

**By adapting to regulations and investing in innovative solutions, ports can become key players in the global energy transition. for**

# The GHG Protocol – better understanding emissions to better manage them

The Greenhouse Gas (GHG) Protocol is a supportive rather than restrictive global standards framework for measuring, managing and reporting greenhouse gas emissions. By classing emissions into three scopes, it can help ports to understand and mitigate their carbon footprint. Reporting is mandatory for Scope 1 and 2.

- **Scope 1: Direct Emissions**

Emissions under the port's remit, from sources that are owned or controlled by the port:

- **Port equipment** and vehicles: diesel-powered cranes, forklifts, and machinery.
- **Stationary sources**: on-site generators, boilers, and other stationary combustion sources.

- **Scope 2: Indirect Emissions from Purchased Electricity**

Emissions resulting from port operations powered by purchased electricity:

- **Electricity use**: emissions from port facilities, lighting, and equipment.
- **Heating and cooling**: emissions from purchased steam, heating, and cooling services.

Scope 2 emissions are transferred to the CO2 emissions generated by the country's energy mix.

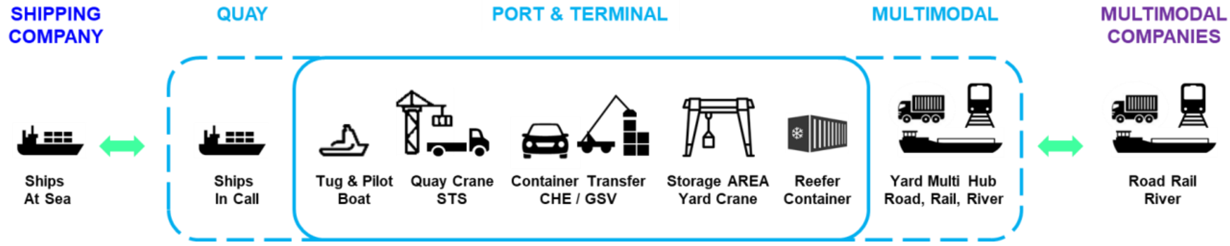
- **Scope 3: Other Indirect Emissions**

This is the hardest scope to quantify and covers all other indirect emissions in the port's value chain:

- Production and transportation of goods and services purchased by the port, employee commuting, treatment and disposal of waste, emissions generated by port tenants and customers, and emissions from transporting goods: ships, trucks, and trains.

# How GHG standards apply to ports

**Figure 2 : the supply chain**




This section looks at the GHG protocol applied to ports and terminals [1]to understand how to organize and classify consumers based on source of energy used. The GHG protocol allow ports and terminals to have a clear vision and be able to make the right decision to provide simple and comprehensive proposals to be shared and understood by all port stakeholders.

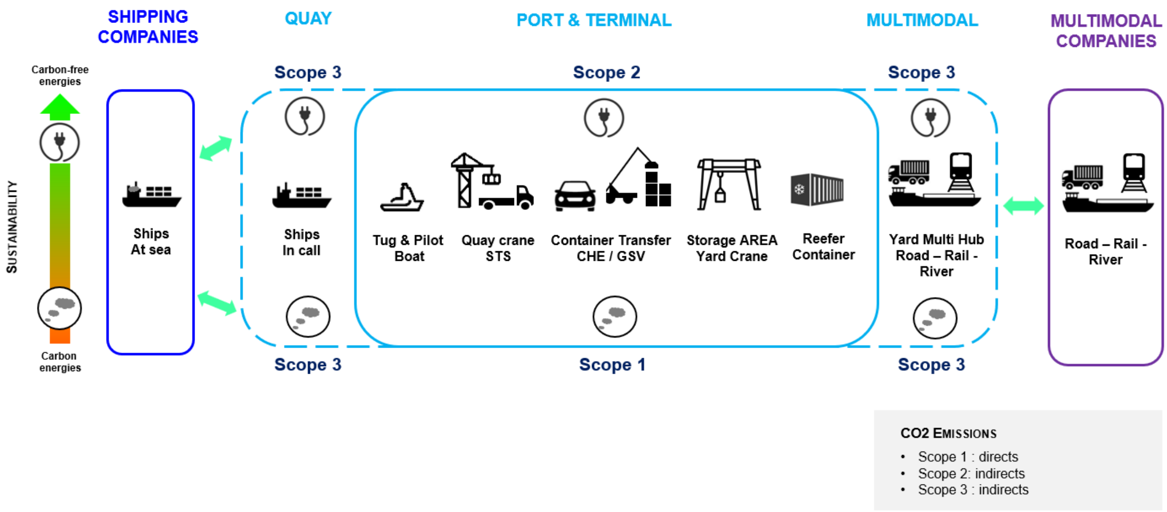
- **Identify and quantify** emissions across all scopes.
- **Reduce** emissions through electrification, renewables, and efficiency improvements.
- **Monitor and report** emissions per GHG Protocol standards.
- **Collaborate** with stakeholders to reduce value chain emissions.
- **Continuously review** and refine reduction strategies.
- **Implement** high-impact measures.

## Where are Scope 1 and 2 emissions generated in the supply chain?

The figure below illustrates Scope 1 and Scope 2 emission sources across the supply chain: at sea, in port, and on the road.

- **Scope 2 emissions** (top): low-carbon energies like electricity (e.g., ships using SSE).
- **Scope 1 emissions** (bottom): carbon fuels like diesel (e.g., ships' diesel generators).

**Figure 3: Scope 1 and Scope 2 emission sources across the supply chain: at sea, in port, and on the road**



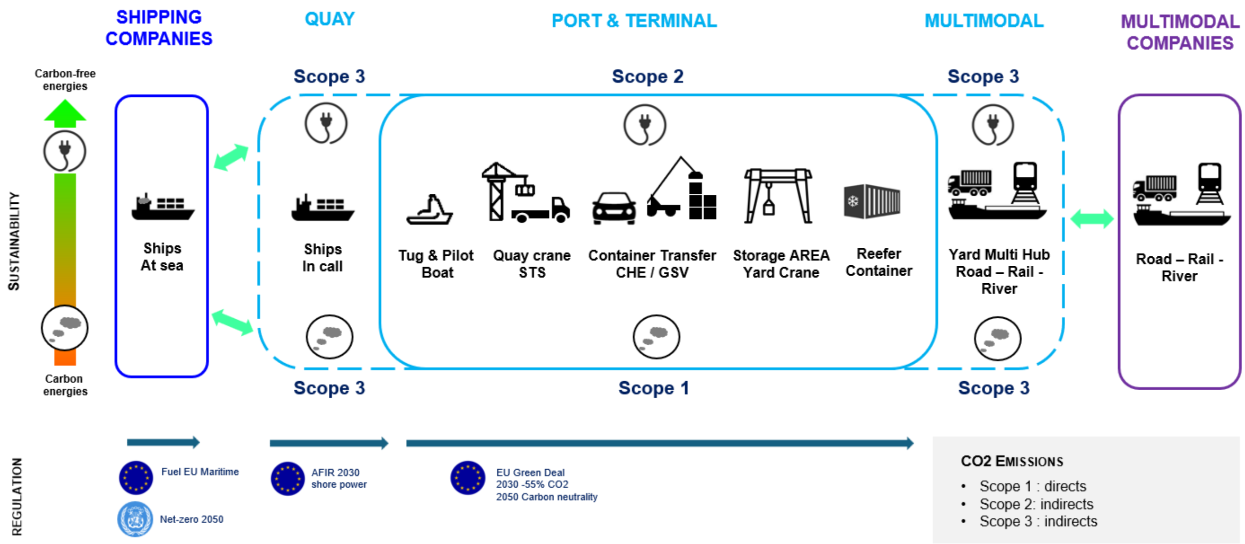

[1] *Note that terminals are generally not responsible for tugboats and pilots.*

## Where do regulations apply to GHG Scope 1 and 2 emissions?

The second figure outlines how regulations affect container terminals, shipping, and multi-hub companies:

- **Shore side electricity in Europe**: We can see that the Fuel EU directive requires ships at berth to be equipped for shore side electrical connection, while AFIR 2030 requires ports to provide shore side electricity infrastructure for at least 90% of ships in call.
- **Scope 2 users**: Reenewable electricity-powered yard equipment is considered zero-emission.
- **Scope 1 users**: Diesel engines still in use must reduce CO2 emissions by 55% by 2030 (versus 1990 levels) and achieve carbon neutrality by 2050 under the EU Green Deal.

**Figure 4: Impacts of regulations on container terminals, shipping, and multi-hub companies**[2]




[2] *Note that terminals are generally not responsible for tugboats and pilots.*

## Examples of how can ports use the GHG protocol to identify and implement decarbonization solutions

Ports can use the GHG scopes to identify where emissions can be cut, consider the pro's and con's, and calculate efficiency gains. For example:

### Ports can identify Scope 1 direct emissions and reduce them by:

- **Improving fuel efficiency: switch to fuel-efficient vehicles or retrofit existing ones.**
  +: Maximize use of existing diesel engines
  -: Complex distribution and availability. Low volume. Price
  Reminder: Average efficiency of diesel engine: around 40%.

- **Going electric: replace diesel-powered equipment with electric alternatives.**
  +: Technology available and Zero Emission, Zero Vibration, Zero Noise solutions in ports
  -: High investment costs & the global benefice for emissions depend on each country Energy mix CO2 footprint.
  Reminder : Average efficiency of electric motor : around 90%.

Container handling equipment (CHE) diesel engines can be replaced with electric motors. Batteries can provide full yard autonomy, recharged via smart grids or electrical infrastructure with charging units. However, this transition requires tailored infrastructure designed to meet the specific needs of each terminal.

- **Switching to renewable energies: using solar or wind power for port operations.**

### Ports can identify Scope 2 indirect emissions and reduce them by:

- **Implementing energy-efficient practices and technologies** in buildings and operations.
- **Green power:** purchasing renewable electricity or investing in on-site energy production.
  + : Reduces dependence on an energy provider and results in energy cost savings
  - : Requires substantial financial investment and space

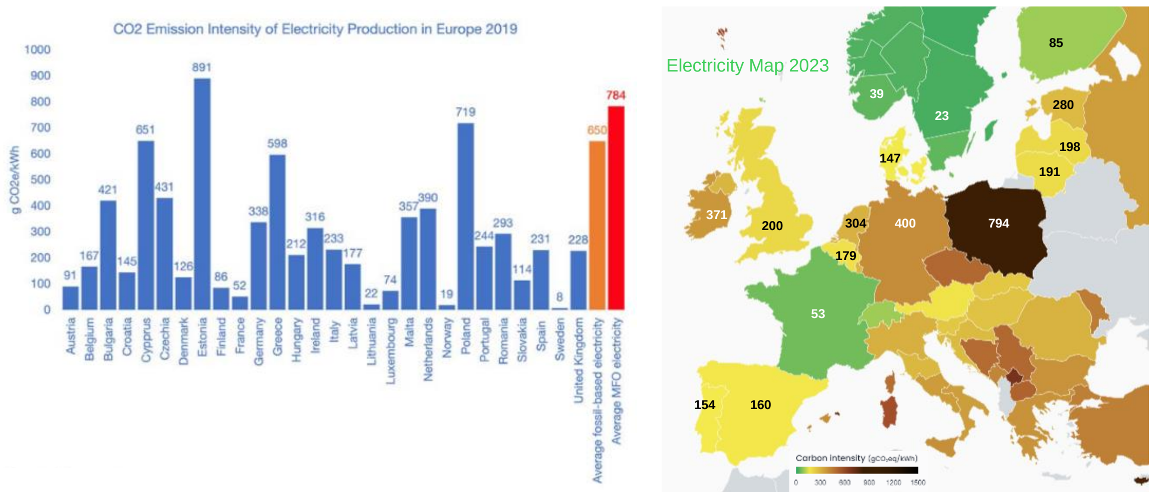
Producing renewable energy helps ports reduce reliance on suppliers and gain energy independence. While success depends on factors like location, initial costs, and government support, the long-term benefits can be substantial. Ports can use the energy they produce to power their operations and sell any surplus, cutting costs and generating extra income. To maximize these benefits, efficient infrastructure and smart energy management are key.

## Energy mix of EU countries

Scope 2 emissions from electric-powered activities are integrated into the country's energy mix emissions. Indirect emissions generated by main consumers can be calculated based on the power consumed, using "Eurostat" data for 2019 and "Electricity Map" 2023 which details the annual average of $CO_2$ emissions (in grams) generated by all European Countries to produce 1kWh.

According to Californian Air Resources Board data, ships in call generate 645g of $CO_2$/ kWh. For ships to be efficient, a country's energy mix must not exceed 645g of $CO_2$/kWh. Above this, ships in call connected to electrical network generate more $CO_2$ than their diesel engines. Countries are striving to reduce their emissions through their energy mix, but for some carbon-intensive islands, Shore Side Electricity makes no sense. Hence AFIR regulations allow exemptions for islands. Once an island achieves a low carbon energy mix, SSE must be considered.

**Figure 5: Energy mix of European countries**




*Sources: Eurostat & Electricity map*

*The graphs highlight the disparities in $CO_2$ emission intensity related to electricity production in Europe. In 2019, countries like France and Sweden displayed very low levels thanks to an energy mix dominated by nuclear power and renewables, while Poland showed very high emissions due to its heavy reliance on coal. The 2023 map confirms these trends, emphasizing the critical impact of the energy mix on $CO_2$ emissions and the need to accelerate the transition to low-carbon energy sources.*

### Ports can identify Scope 3 other indirect emissions and reduce them by:

- **Working with supply chain partners to reduce emissions.**
- **Optimizing transportation and logistics (ships, trucks, and rail)**
  - Low-sulphur fuel bunkering
  - Shore power at berth – already compulsory in some countries
  - Hydrogen or biogas for trucks
  - On-board carbon capture system (OCCS) in the absence of shore-side electrification or during maneuvering operations
- **Waste management:** reduction, recycling, and composting to minimize emissions.

# Part 2: Evolution of Ports to Multi-Energy Hubs and Central Platforms for Real-Time Data Exchange

**Decarbonization solutions exist and are already being rolled out to various extents in different locations. The transition to sustainable energies encourages ports to move beyond their traditional role as energy-intensive logistics centers with high carbon footprints. Depending on local conditions, they can become multi-energy hubs that produce and store part of their own carbon-free energy, or rely on renewable electricity sourced from elsewhere if it is more sustainable and cost-effective.**

## How can ports become sustainable energy-producing power hubs?

New technologies and initiatives to cut CO2 emissions are already in use, with more being developed. They include:

- Using low carbon fuels and biogas to power yard vehicles
- Electrification of equipment and vehicles
- Solar panels and wind turbines to produce as much as possible renewable energy on site
- Battery energy storage systems (BESS) to store electricity produced on site
- Hydrogen fuel cells
- Connecting ships in call to shore-side electricity (SSE)
- Leveraging Energy as a Service (EaaS) and Power Purchase Agreements (PPA).

**What is a PPA?**

**A PPA (Purchasing Power Agreement) is an electticty supply contract that ensures a port purchases green energy, delivered & distributed through the nationalpower grid**

## Challenges that stand in the way

Not all ports can implement all available solutions due to various obstacles (technological, financial, regulatory, etc.) and a lack of coordination among stakeholders. Ports, terminals, and shipping companies have different priorities: some focus on local issues (impact on communities and the regional environment), while others take a global approach (meeting international emission reduction targets).

Transparent and aligned cooperation among all stakeholders is essential to overcome these differences and accelerate the transition to sustainable practices.

# Real-time data-driven multi-energy hubs: a fully integrated solution for decarbonization

Ports possess strategic infrastructures and land that can be utilized to produce and store renewable energy, thereby contributing to the local generation of part of the clean energy required.

Potential solutions include:

- **Solar panels**: installed on the roofs of warehouses, hangars, or parking lots.
- **Wind turbines**: deployed on-site, taking advantage of windy conditions.
- **Tidal energy**: harnessing the power of tides to generate electricity.
- **Biomass**: converting organic waste into energy.
- **Small Modular Reactors (SMRs)**: providing localized, stable & tailored nuclear energy.
- **Electricity generation through osmosis**: a promising process that harnesses the salinity gradient in terminals located near suitable environments."

The energy produced could power:

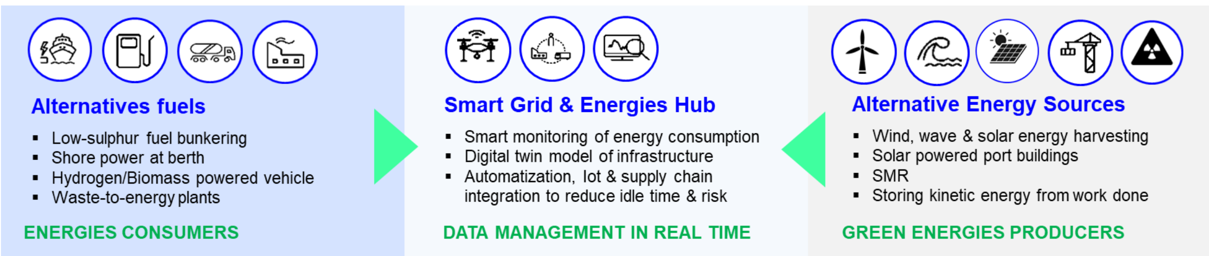
- **Docked ships**, reducing their fossil fuel consumption.
- **Port equipment and infrastructure**, such as cranes and warehouses.
- **Land transportation**, including trucks and trains.

Excess energy would be stored in batteries or other advanced systems and redistributed through **smart grids** to meet peak demand.

Transforming ports into sustainable energy hubs offers numerous advantages:

- **Increased efficiency** through optimized resource management.
- **Cost savings** by reducing reliance on external energy sources.
- **Lower environmental impact** with a significant reduction in carbon emissions.

The key to this transformation lies in the use of **real-time data**. By collecting and analyzing this information, it becomes possible to efficiently coordinate energy production, distribution, and consumption, making the entire system smarter, more responsive, and more efficient.

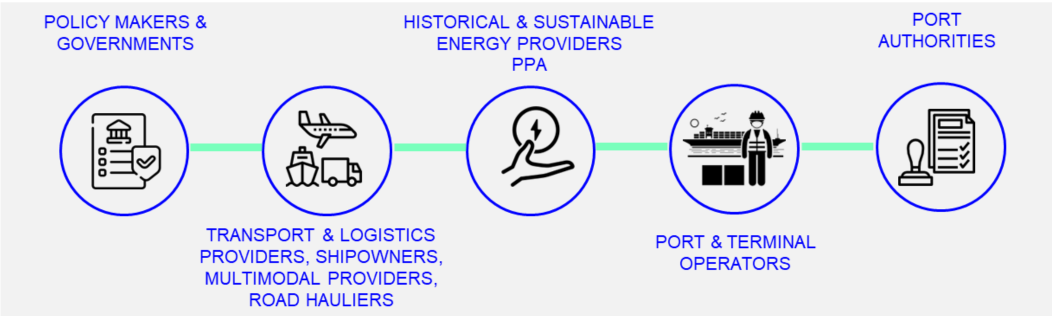


# The key role of data for decarbonizing ports

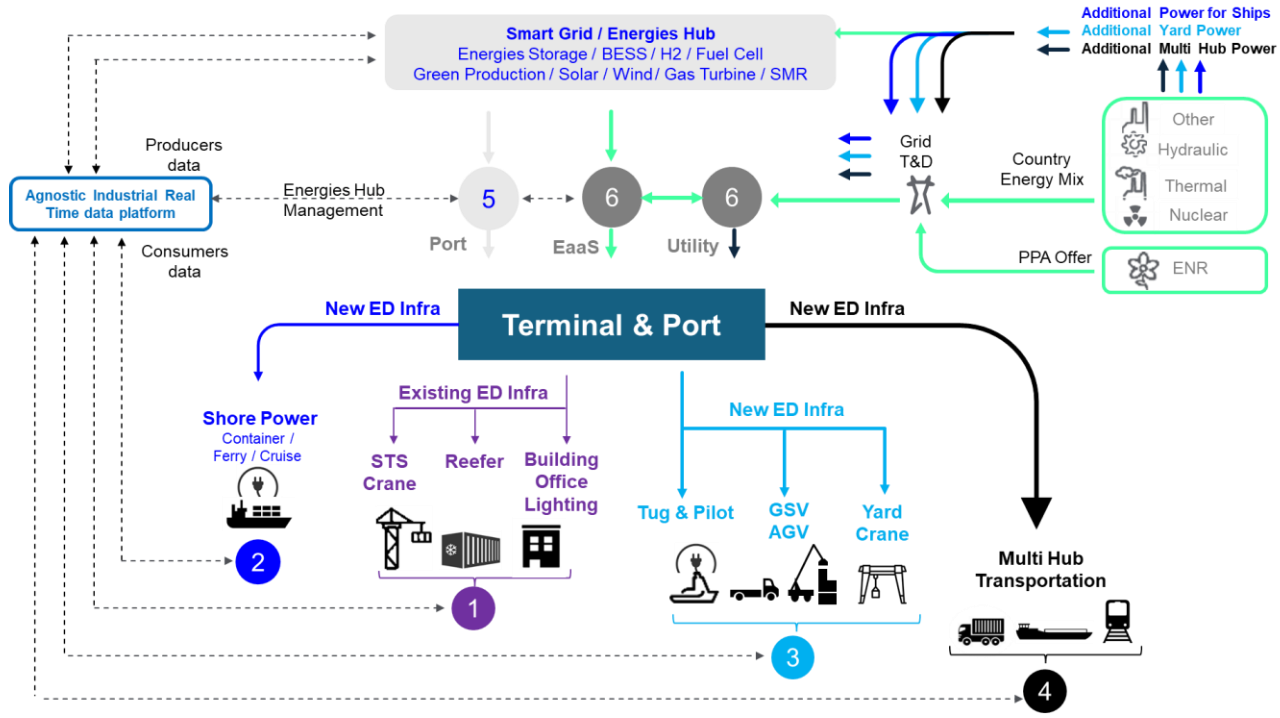
The data collected and analysed can be used for:

- **Real-time energy monitoring and forecasting**. Data collected is used to optimize operations, minimize losses and predict future needs.
- **Powering docked ships.** Data helps to optimize energy distribution and dock connections, reduce costs and increase efficiency.

**Powering port handling equipment, including trucks:** Locally powered electric charging stations can anticipate supply needs and optimize scheduling, thereby maximizing operational efficiency while minimizing costs.**This can only succeed if all stakeholders agree to a global exchange of real-time and cyber-secure data**



# Future new energy demands at ports and terminals




*T&D : Transport and Distribution, ED : Electrical Distribution, EaaS: Energy as a Service, ENR: Renewable Energy*

**1** **Existing Electrical Network (Scope 2), Indirect emissions**
Existing electrified consumers: STS, RMG & RTG crane, reefer containers, building offices and lightings.
Emissions are linked to the carbon intensity of the country’s energy mix.

**2** **Shoreside Electricity Mandatory in EU 2030 for TEN-T central**
AFIR and Fuel EU require SSE facilities to supply at least 90% of calls for the TEN-T central network by 2030. Electrical infrastructure to be increased accordingly.

**3** **Yard Power**
All direct-emission yard engines: cranes, CHE, GSV, tractors must be carbon neutral by 2050. Solutions: switch to low carbon fuels or Scope 2 solutions such as battery-powered electric motors. Electrical infrastructure to be increased accordingly.

**4** **Multi Hub**
All external energy consumers arriving at the multi-hub: trucks, trains, barges etc.
Solutions: switch from diesel to **new low carbon fuel or hydrogen,** electrify vehicles with battery charging units. Electrical infrastructure to be increased accordingly. Not analysed in our study.

5 **Smart Grid & Energies Hub**

To minimize their carbon footprint, ports can leverage a combination of local green energy sources, including **wind turbines, solar panels, biogas turbines, green hydrogen, and small modular reactors (SMRs).** Additionally, **e-fuel generators** enable the production of synthetic fuels from renewable electricity, specifically designed to meet the energy demands of ships and port infrastructure.

**Thanks to smart grids, r**eal-time intelligent energy management optimizes production and distribution based on demand, while integrating traditional suppliers and reducing the infrastructure costs required to strengthen the terminal's electrical grid. Additionally, robust cybersecurity measures ensure the protection of these critical systems.

6 **Upstream ED Infrastructure**

Electric grid operators must adapt and modernize their infrastructures to meet the growing energy demands of ports. A range of strategies can be employed to address these needs:

- **Investments by grid operators:** Distribution System Operators (DSOs) upgrade and expand their networks to support the increasing energy requirements of ports.
- **Long-term Power Purchase Agreements (PPAs):** Ports enter into contracts with renewable energy producers to secure a stable and sustainable energy supply over the long term.
- **Energy-as-a-Service (EaaS) providers:** Ports collaborate with providers who finance, implement, and operate decarbonized energy solutions tailored to their specific needs.
- **Development of smart grids:** Ports establish advanced systems to locally produce, store, and manage sustainable energy, optimizing distribution and reducing reliance on traditional suppliers

## The need for industry-wide alignment and investment to establish energy hubs powered by real-time shared data platforms

Global decarbonization goals can only be achieved by:

- Harmonization of regulations for global consistency.
- Following the GHG Protocol to prioritize emissions reduction.
- Aligning stakeholders' visions, investments, and efforts.
- Turning ports into sustainable energy hubs that produce; store and distribute energy on site.
- Sharing and leveraging real-time data to optimize energy delivery via smart grids.

# Part 3: Case Studies of decarbonization at ports

**Our New Energies Coalition working group studied five container terminals to understand their annual energy consumption and emissions in their specific context.**

The terminals are located at the following ports:

- **Martinique** : Grand Port Maritime de la Martinique (GPMDLM)
- **Malta:** Freeport in Birżebbuġa
- **USA**: Fenix Marine Services terminal (FMS POLA) in Los Angeles, California
- **France** : Terminal de France at the Grand Port Maritime du Havre (GMPH) in Le Havre
- **Singapore**: PSA, all terminals

The ports were considered regarding the regulatory requirements below:

- **2022** – Energies used, and related emissions
- **2030** – First stage of decarbonization in EU
- **2050** – Carbon neutrality in USA, Europe & Singapore
- **2060** – Carbon neutrality in China

### Starting point – Analysis of the terminals' energy use today

The group began by looking at the percentage breakdown of energies used in terminals, focusing on three areas:

Current electrification rate (as at 2022), a forecast for electrical connection of ships at the quayside (OPS) and a forecast for the other consumers of the terminal if they were entirely electric.

| | Martinique | Malta | Los Angeles | Le Havre | Singapore |
|---|---|---|---|---|---|
| Current electrification rate | 39% | 31% | 43% OPS | 45% | 43% |
| Forecast OPS | 50% | 47% | OPS Ready | 34% | OPS NA |
| Forecast other Terminal consumers | 11% | 22% | 57% | 21% | 57% |
| TOTAL | 100% | 100% | 100% | 100% | 100% |

## Energy use and emissions at ports: SSE requirements and infrastructure

The data collected on electrical energy consumed by ships in call, supplied by their own diesel engine and generating their own $CO_2$ emissions or supplied locally by the electrical network enabled us to produce a preliminary estimate of the impact of a move to Shore Side Electricity on terminal electrical infrastructures.

Elements calculated include:

- $CO_2$ emissions by ships in call
- Power demand from ships in call
- Quantity of marine gas oil (MGO) burned by ships in call
- Extension of the port's electrical infrastructure required to accommodate shore power

**Figure 8: Current and forecast data on energy use, emissions and electrical networks at ports**

| Terminal | Calls per year | Time at Berth (H) per call | Ship power at berth (kVA) (Estimated) | Annual ship energy (kWh) if shore power (Calculated) | Ship CO2emissions (kg) if diesel engine (Calculated) | MGO consumed at berth (L) (Calculated) | Power to be installed for OPS (MVA) | Current Yard Electrical Energy (kWh) | Total Energy with OPS (kWh) | Extension of port electrical network if shore power (Estimated) |
|---|---|---|---|---|---|---|---|---|---|---|
| Martinique GPMDLM | 276 | 14 | 1 500 | 5 796 000 | 3 738 420 | 1 811 250 | 8 | 4 500 000 | 10 296 000 | 2.28 |
| Malta Free Port | 1 631 | 23 | 1 500 | 56 269 000 | 36 293 828 | 17 584 219 | 24 | 37 000 000 | 93 269 000 | 2.52 |
| Los Angeles FMS | 164 | 120 | 1 500 | 29 520 000 | OPS Ready | 9 225 000 | OPS Ready | 28 000 000 | NA | OPS Ready |
| Le Havre T. de France | 498 | 27 | 1 500 | 20 169 000 | 13 009 000 | 6 302 813 | 16 | 27 000 000 | 47 169 000 | **1.75** |
| PSA Singapore | 14 497 | 20 | 1 500 | 434 910 000 | 280 516 950 | 135 909 375 | 159 | 549,584,000 | 984,494,000 | 1.79* |

** Example only as no shore power*

*Annual Ship Energy Demand = Number of calls x Average time at berth x Average ship power*
*Data from the Californian Air Resources Board environment agency*

# Five terminals, five strategies

### Grand Port Maritime de la Martinique (GPMDLM) in Martinique

France

#### Current situation:

- The Caribbean Island of Martinique is 90% powered by carbon energies.
- The island's energy mix could become 95% powered by renewable energies by 2033.
- Shore Side Electricity and CHE solutions are considered here on that basis.
- No Power Purchase Agreement in place.
- Limited space and high land prices are a barrier to solar panels.

#### What's being done:

The focus is on Scope 1, direct emissions. Due to insufficient market supply of batteries to fully power CHE, the terminal is in progress to analyse if it could be possible to replace yard diesel engines with a low carbon fuel like HVO100 as a temporary solution. Scenario comparison studies are underway to analyse the costs and the global supply chain for delivering this new fuel to the terminal.

> **Advantage:** existing motors can be maintained and optimized without having to modify or retrofit existing motors.
>
> **Limits :** The high cost associated with the supply chain and reliance on external sources limit the economic and environmental viability of this solution.

Simultaneously, the Grand Port Maritime is undertaking ambitious initiatives to significantly increase renewable energy production to power its infrastructure and users. These efforts are expected to reduce indirect emissions (Scope 2) associated with electricity consumption."

#### Future outlook:

E-Low carbon fuel can reduce emissions in the short term but will not suffice to achieve carbon neutrality by 2050.

**Shore Side Electricity simulation multiplied the existing electrical network by a factor of 2 to 3.**

## Terminal de France, Grand Port Maritime du Havre (GMPH) in Le Havre

France

Current situation:

- Le Havre is subject to EU requirements, with SSE becoming mandatory in 2030.
- France has a low-carbon energy mix (80% nuclear). Connecting a ship anywhere on the French electrical network helps to reduce CO2 emissions by 92%.
- There is also a high-potential PPA in place.

What's being done:

The transition of diesel shunting locomotives to new biofuels such as HVO100 could serve as a temporary solution to meet emission targets, as the refinery's proximity to the port makes this an attractive opportunity due to low logistical costs. In this context, optimizing the use of existing diesel engines is a clear opportunity. Additionally, 54 hybrid straddle carriers (SC) have recently been acquired, and tests using HVO100 are underway. A pilot test on an electric straddle carrier is also being considered.

Future outlook:

EU regulations require ships to be connected to the grid by the end of 2029 at the latest. Based on current maritime traffic data, this would necessitate a 1.75-fold increase in existing electrical infrastructure. Furthermore, the terminal's photovoltaic (PV) production potential is estimated at around 3 MW, which could help reduce energy dependency and enhance the sustainability of operations

## Malta Freeport

Malta

Current situation :

- The island of Malta is currently 90% powered by carbon energies.
- No Power Purchase Agreement in place.
- Limited space and high land prices are a barrier to solar panels.
- The terminal has an onshore power connection with 4 plugs for one ship.

What's being done:

Alongside the SSE already in place, tests are being carried out with four electrical tractors and one CHE to reduce the yard's emissions.

In addition, other pilot tests are being deployed, including two additional electric tractors, a reach stacker (RS), and an opportunity charging system, to assess their efficiency and contribution to reducing the terminal's carbon footprint.

Future outlook:

**SSE simulation multiplied the existing electrical network by a factor of 2 to 3**

## Fenix Marine Services (FMS) terminal in Los Angeles, California

USA

### Current situation:

- Los Angeles' energy mix is 50% decarbonized. SSE in place as required by California regulations.
- California has a PPA offer in place to ensure decarbonized electricity.
- Power outages are frequent – peak power times present a challenge.

### What's being done:

With shore power already in place, the terminal is exploring transitional solutions to reduce emissions, including the use of a new biofuel such as HVO100, known as RD99 in the United States. Since 2022, this fuel has been used at FMS for all port vehicles, achieving a nearly 80% reduction in Scope 1 emissions.

At the same time, in-depth studies are being conducted to evaluate the use of green hydrogen as fuel for CHE and tractors, leveraging suitable technologies such as fuel cells. These studies also include analyzing potential hydrogen supply sources, with a focus on local and sustainable options."

To counter frequent power outages, green hydrogen is being considered for CHE and yard tractors. The port is seeking to adapt its infrastructure to seamlessly accommodate a mix of solutions: biodiesel, solar power, H2, and four 1MW fuel cells. New surveys are in progress to test carbon-free CHE on the yard, a H2 top loader, a H2 tractor, an e-tractor with fast charging robot, and H2 CHE.

### Challenges:

Managing peak power demands for lifting engines remains complex with hydrogen solutions, which could slow their adoption. In the meantime, the renewable diesel RD99, already in use, provides a viable alternative to reduce emissions while optimizing the use of existing diesel engines. However, the main decarbonization challenges for this terminal remain the reduction of Scope 2 emissions, notably through the use of a green power purchase agreement (PPA), strengthening the electrical grid, and/or establishing competitive and sustainable hydrogen logistics."

### Future outlook:

**SSE is already implemented. Research into hydrogen-powered solutions is underway**

## PSA Singapore

Singapore

Current situation:

- Singapore's decarbonization strategy: 50% reduction by 2030 and carbon neutrality by 2050.
- SSE is not being considered as a potential solution.
- PPA offers are available.

What's being done:

If SSE had been adopted as a decarbonization strategy, ships would account for over 44% of energy consumption at PSA. PSA aims to achieve carbon neutrality by 2050, , with a strong focus on abating Scope 1 direct emissions from yard operations, with the adoption of renewable electricity to abate Scope 2 emissions. To support the implementation of shore power, this would require the doubling of existing electrical infrastructure capacity

The terminal is also exploring smart grids, solar power, and battery energy storage systems to enhance its electrical infrastructure. Electrification solutions for yard equipment, such as eRTG/eRMG and AGVs, are also being studied and implemented to reduce emissions from existing diesel engines. Additionally, 90% of quay cranes are now electrified.

Future outlook:

PSA aims to support the shipping industry in complying with **IMO regulations, which mandates global shipping to be carbon neutral** by 2050 (20% reduction by 2030, 70% reduction by 2040, Net-zero emissions by 2050).

**Shore power has not been implemented yet. Simulations indicate that a full electrification of PSA Terminals would require upgrading the existing electrical network by 1.79.**

**There is no one-size-fits-all solution:
each terminal needs a tailor-made infrastructure**

# Key takeaways & Recommendations

1. **Regulations to accelerate change**
   Clear and ambitious regulations, such as reducing emissions by 50% by 2030 and achieving carbon neutrality by 2050, are essential. Harmonized global standards, supported by governments and international organizations, will ensure consistency, compliance, and incentivize green innovation.

2. **Ports as clean energy hubs**
   Ports can lead the energy transition by integrating smart grids, renewable energy, and storage solutions, while expanding shore-side electricity (SSE) to reduce emissions from docked vessels. Significant investments are needed to position ports as key players in decarbonization.

3. **Real-time data for smarter operations**
   Real-time data collection and sharing enable optimized operations and reduced emissions. Interoperable digital platforms and robust cybersecurity measures are critical to foster collaboration and ensure secure data exchange among stakeholders.

4. **Tailored strategies for unique challenges**
   Each port faces unique challenges, requiring customized decarbonization strategies. Detailed assessments and roadmaps with clear milestones and timelines can guide effective and practical implementation.

5. **Collaboration for a shared vision**
   Decarbonization demands unified efforts from governments, shipping companies, ports, and energy providers. Multi-stakeholder partnerships and public-private collaborations are crucial to align goals and drive coordinated action at all levels.

6. **Shared accountability for impact**
   Achieving carbon neutrality by 2050 requires shared responsibility across the industry. Defining clear roles, establishing accountability frameworks, and tracking progress are essential to ensure collective impact.

7. **Global ambition, local execution**
   Global goals set the direction, but local implementation drives change. Ports should aim for zero-emission, energy self-sufficiency, while terminal operators adopt interim low-carbon solutions to bridge the gap between ambition and action.

8. **Investment to turn vision into reality**
   Significant public and private investments are needed to fund carbon-neutral technologies and modernize infrastructure. Financial mechanisms should de-risk green investments, while fostering leadership and shared ownership to ensure resources are strategically directed.

Decarbonizing ports is a multifaceted challenge requiring localized strategies, stakeholder cooperation, and substantial investments. Achieving carbon neutrality by 2050 hinges on harmonized regulations, technological advancements, and robust financial frameworks.

**Ports are not just gateways for goods**
**They can lead the way to a sustainable future.**

# Vocabulary and abbreviations used

| | |
|---|---|
| AFIR | Alternative Fuel Infrastructure Regulation |
| AGV | Automated guided vehicles |
| BESS | Battery energy storage systems |
| CARB | Californian Air Resources Board |
| CHE | Container handling equipment |
| EaaS | Energy as a Service |
| eRTG/eRMG | Electric Rubber tyred gantry crane / Rail mounted gantry crane |
| ETS | Emissions Trading System |
| GHG | Greenhouse gases |
| GSV | Ground support vehicles |
| IMO | International Maritime Organization |
| PPA | Power purchase agreements |
| SMR | Small & Medium Reactor |
| SOx | Sulfut Oxides |
| SSE | Shore-side electricity. Also known as shore connection, cold ironing, onshore power supply (OPS), shore power or alternative marine power (AMP). |
| STG | Ship-To-Shore crane |
| OCCS | On-board carbon capture system |

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