EALING

Milestone 6

Final recommendations for a harmonised framework on OPS in EU ports

Co-financed by the Connecting Europe Facility of the European Union

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Abbreviat	Meaning
AFIR	Alternative Fuels Infrastructure Regulation
AFID	Alternative Fuels Infrastructure Directive
ASL	Azienda Sanitaria Locale
AFI	Alternative Fuels Insight
BS	Battery Swapping
BPO	Baltic Ports Organisation
CA	Competent Authority
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenses
CB	Circuit Breakers
CBA	Cost-Benefit Analysis
CCNR	Central Commission for the Navigation of the Rhine
CEF	Connecting Europe Facility
Class	Classification Society
CLIA	Cruise Lines International Association
CO_2	Carbon Dioxide
CSI	Clean Shipping Index
CNG	Compressed Natural Gas
CLIA	Cruise Lines International Association
CMS	Cable Management System
DSO	Distribution System Operator
DNV	Det Norske Veritas
DWT	DeadWeight Tonnage
EALING	European flagship Action for coLd ironING in ports
ECSA	European Community Shipowners´ Association
EEA	European Environment Agency
EEDI	Energy Efficiency Design Index
EES	Electrical Energy Storage
EFIP	European Federation of Inland Ports
ESPO	European Sea Ports Organisation
EMSA	European Maritime Safety Authority
EMTER	European Maritime Transport Environmental Report
EU	European Union
EC	European Commission
EU ETS	European Union Emissions Trading System
EU MRV	European Union Monitoring, Reporting and Verification system
EPF	European Ports Forum
ESI	Environmental Ship Index
ESOs	European Standardisation Organisations
ESR	Effort Sharing Regulation
ESSF	European Sustainable Shipping Forum
ETD	Energy Taxation Regulation
FEED	Front-End Engineering Design
FEPORT	Federation of European Private Port Companies and Terminals

Flag	Flag State
GHG	Greenhouse Gas
GT	Gross Tonnage
GW	Giga Watt
HVSC	High Voltage Shore Connection
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IMO	International Maritime Organisation
IMO DCS	International Maritime Organisation Data Collection System
ISO	International Standard Organization
IWT	Inland waterway transport
kV	Kilovolt
kW	Kilowatt
LVSC	Low Voltage Shore Connection
MARPOL	The International Convention for the Prevention of Pollution from Ships
MBA	Management Body of the Port
MG	MicroGeneration
MVA	Mega Volt Ampere
MW	Mega Watt
NOK	Norwegian Krone
NOx	Nitrogen Oxides
NT	Net Tonnage
OP	Intra-Port Operator
OPS	Onshore Power Supply
OPEX	Operational Expenses
PGO	Port Grid Operator
PLC	Programmable logic controller
PM	Particulate Matter
PAS	Publicly Available Specifications
PSC	Port State Control
RSO	Receiving Ship Operator
RTP	Real time pricing
Ro-Ro	Roll-on/roll-off
SBC	Shore-side Battery Charging
SCADA	Supervisory Control And Data Acquisition
SPB	Shore-side Power Banks
SO_2	Sulphure Dioxide
SOLAS	The International Convention for the Safety of Life at Sea
SSE	Shore-Side Electricity
SSE OP	Shore-Side Electricity Operator
SPTP	Shore Power Technology for Ports Program
SVG	Static Var Generators
SOx	Sulphur Oxides
STCW	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers
TEN-T	Trans-European Network of Transport
TO	Terminal Operator
TOU tariff	Time-Of-Use tariff
TSOs	Transmission System Operators

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USA	United States of America
USD	United States Dollar
UK	United Kingdom
UN	United Nations
VAT	Value Added Tax
WPCAP	World Ports Climate Action Program

EXECUTIVE SUMMARY

EALING (European flagship action for cold ironing in ports) is a 36-month Action co-funded by the CEF Programme that aims to develop the technical, environmental, financial, and legal studies necessary to implement onshore power facilities in at least 16 EU ports, and to work on a common EU harmonised and interoperable framework for their transition to electrification.

Within the project, the objective of the first activity is to implement a detailed analysis on the status of the technical, legal, and regulatory framework in the Member States concerned at national level, and on the status of the EU legislation as well as policy initiatives, standards and guidelines focusing on the implementation of Shore-side electricity (SSE) in the EU ports participating in the consortium of the Action. It also aims to report with recommendations on how to bring forward and implement a harmonised framework boosting the development of SSE in the ports of the TEN-T Network, considering the technical, legal, and regulatory framework in place and under development at EU level. The analysis will notably focus on the technical aspects that may derive in a difficult harmonisation for SSE implementation.

This report contains the compilation of the final recommendations gathered from the main EU port and shipping stakeholders and the partners of the EALING consortium to bring forward the deployment of SSE infrastructures in European ports. It constitutes the third deliverable of Activity 1 (the first being the *Detailed analysis on the existing national/port regulations directly or indirectly related to shore side electricity supply (Milestone 4)* and the second the *Executive Summary on Ports Questionnaire*), as well as the means of verification of ***Milestone 6: Final recommendations for a harmonised framework on OPS in EU ports.***

1 SCOPE OF THE REPORT

Maritime transport is essential for the EU as it contributes to around 75% of European Union external trade and 31% of EU internal trade volumes [1], making it of great strategic importance for the European economy. This translates into close to 4 billion tonnes of cargo handled in EU ports and 400 million passengers per year on average.

Although the maritime sector brings significant economic and social benefits to the EU by meeting ever-increasing demands, it also has a negative impact on the environment and contributes to global warming while affecting the health of EU citizens and the state of marine and coastal ecosystems. In total, ships calling at EU and European Economic Area ports generated around 140 million tonnes of CO_2 emissions in 2018 (approximately 18% of all CO_2 emissions generated by maritime transport worldwide that year). In relation to air pollution, sulphur dioxide (SO_2) emissions from ships calling in European ports amounted to around 1.63 million tonnes in 2019, approximately 16% of the global SO_2 emissions from international shipping. Despite a drop-in shipping activity in 2020 due to the effects of the COVID-19 pandemic, the sector is expected to grow strongly over the coming decades, fuelled by rising demand for primary resources and container shipping. Therefore, emissions from shipping will consequently continue to increase.

In September 2020, the Commission adopted a proposal to cut greenhouse gas emissions by at least 55% by 2030 and put the EU on a responsible path to becoming climate neutral by 2050. To achieve climate-neutrality, a 90% reduction in transport emissions is needed by 2050, and all transport modes, including maritime transport, will have to contribute to the reduction efforts.

Within the EU port and maritime sector, one of the solutions to reduce emissions in ports is the installation of shore-side electricity (SSE) solutions in ports. However, although the technology is available and fully mature, European ports currently face difficulties in implementing these facilities due to the lack of a harmonised framework on SSE in EU ports.

In order to contribute to bringing forward the deployment of SSE solutions in EU ports, the EALING consortium has intensively worked with the main shipping and port stakeholders to identify the main obstacles that ports and shipping companies face when implementing SSE as well as to propose recommendations for a harmonised framework. This report contains the final recommendations to accelerate the deployment of SSE infrastructures in European ports, gathered throughout the different activities of the project. The report has been divided into 5 areas of study (Policy and legal, Technical, Environmental, Economic and Social) around which the document is structured.

2 POLICY AND LEGAL SCOPES

2.1 Overview of current and forthcoming EU regulations

In December 2019, the European Commission (EC) presented its communication on the **European Green Deal** [2], the new growth strategy of the EU, aiming to set Europe on the path of transformation to a climate-neutral, fair, and prosperous society with a modern, resource-efficient, and competitive economy. It reaffirmed the EC's ambition to increase its climate targets and make Europe the first climate-neutral continent by 2050 while protecting the health and well-being of citizens from environment-related risks and impacts.

The communication stressed, inter alia, the need to accelerate the shift to sustainable and smart mobility, as transport accounts for a quarter of the EU's greenhouse gas emissions and still growing, being the maritime transport responsible for 3-4% [3] of the CO2 emissions in the EU. To achieve climate-neutrality, a 90% reduction of greenhouse gas emissions (GHG) in transport emissions is needed by 2050.

Since then, the EC has been working intensively on several strategies and regulations with the ultimate aim of reaching the European Green Deal's goal of climate neutrality by 2050, as shown in the following table:

Table 1 EU Strategies and Regulations related to SSE

Name	Brief description	Relation with SSE
2030 Climate Target Plan [4] (Date of publication: 09/2020)	Proposal to cut EU GHG emissions by at least 55% in 2030 to become climate neutral in 2050.	The Plan states that the use of sustainable alternative fuels needs to increase.
Sustainable and Smart Mobility Strategy [5] (Date of publication: 12/2020)	Action plan to transform the EU transport system to achieve its green and digital transformation and become resilient to future crises.	The Strategy includes many references to stress the relevance of the use of alternative fuels in the transport sector.

Fit for 55 Package [6] (Date of publication: 07/2021)	First set of legislative proposals to meet the targets set in the European Green Deal, 2030 Climate Target Plan and the Sustainable and Smart Mobility Strategy and reach the objective of reducing net greenhouse gas emissions by at least 55% by 2030. The proposals included in this legislative tool aim to deliver on the targets agreed in the **European Climate Law** [7] and fundamentally transform the EU economy and society for a fair, green and prosperous future.	The Fit for 55 Package consists of thirteen proposals covering a wide range of policy areas, including energy efficiency, renewables, land use, energy taxation, effort sharing and emissions trading. Some of these proposals affect directly or indirectly the implementation of SSE solutions, such as the **Revision of the Alternative Fuels Infrastructure Regulation** [8] (also called AFIR)**, Fuel EU Maritime** [9] and the **Revision of the EU Emission Trading System** [10] **.**
Efficient & Green Mobility Package [11] (Date of publication: 12/2021)	Second set of proposals to support a transition to cleaner and greener transport.	The **Revision of TEN-T Regulation** [12] is one of the four proposals that are included in this package. Following the references to SSE included in the Revision, it is expected that the EC, through the CEF Programme, will continue to support new SSE investments in EU ports.

In relation to the Fit for 55 Package, it is worth detailing the proposals that have the greatest impact on the implementation of SSE solutions in EU ports:

- **Revision of the Alternative Fuels Infrastructure Regulation** (revision of existing regulation *Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels infrastructur*e).

  On 14 July 2021, the EC published a proposal for the creation of a new Regulation for the deployment of alternative fuels infrastructure, which will repeal Directive 2014/94/EU. The proposed regulation sets mandatory national targets for the deployment of alternative fuels infrastructure in the EU for road vehicles, vessels, and stationary aircraft.

  For waterborne transport, this initiative delivers on the clear requirement of the European Green Deal to oblige docked ships to use shore-side electricity. The draft regulation sets targets for the deployment of SSE for certain seagoing container and passenger ships (including ro-ro passenger ships, high-speed passenger craft and cruise ships) in maritime ports and inland waterway vessels.

- **FuelEU Maritime** (*Regulation of the European Parliament and of the Council on using renewable and low-carbon fuels in maritime transport and amending Directive 2009/16/EC)* (new proposal). The new FuelEU Maritime proposal to promote sustainable maritime fuels will create new requirements for ships, regardless of their flag, arriving to or departing from EU ports, by imposing a maximum limit on the GHG content of the energy they use and making these limits more stringent over time.

  FuelEU Maritime introduces increasingly stringent limits on the carbon intensity of the energy used by vessels from 2025, which should oblige them to use alternative fuels. It applies to commercial vessels of 5,000 gross tonnage (GT) and above, regardless of the flag (fishing ships are exempted). It covers all energy used on board when the ship is at an EU port, all energy used by the ship on voyages between EU ports and 50% of the energy used on voyages departing from or arriving at an EU port.

  This proposal will certainly affect the implementation of SSE facilities in EU ports, as it is closely linked to the revision of the Alternative Fuels Infrastructure Directive, but from the demand side.

- **Revision to the EU Emission Trading Scheme** (Revision of *Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a system for greenhouse gas emission allowance trading within the Union and amending Council Directive 96/61/EC*). The proposal would extend the EU ETS to cover CO_2 emissions from maritime transport, specifically from large ships above 5,000 GT. The extension applies to all emissions from intra-EU voyages and to 50% of emissions from extra-EU voyages and all emissions occurring when ships are at berth at an EU port. The same rules as for the other sectors would apply to maritime emissions. The requirement to surrender allowances would be gradually phased-in during 2023-2025 (20% of verified emissions for 2023, 45% for 2024, 70 % for 2025, and 100% from 2026 onwards). Non-compliance is fined and may eventually lead to a ban from EU waters.
  The forthcoming Directive [13] will incentivise the use of alternative fuels while at berth, which include electricity, thus increasing the need of the EU ports to have SSE installations.

Other existing and forthcoming regulations affecting directly or indirectly the deployment of SSE are:

- **Revision of the Energy Taxation Directive** [14] (forthcoming regulation). The revision will promote clean technologies and remove outdated exemptions and reduced rates that currently encourage the use of fossil fuels.

- **Revision to the Effort Sharing Regulation** [15] (forthcoming regulation). The revision will continue to include domestic shipping in national GHG reduction emissions targets. Therefore, the use of clean fuels while at berth will be incentivised, thus increasing the need of the EU ports to have SSE installations.

- **Amendment of the Renewable Energy Directive** [16] (forthcoming regulation). It sets a new target of 40% (up from 32%) of energy use from renewables by 2030 and strengthens bioenergy sustainability criteria. The forthcoming amendment will contribute to facilitating the use of renewable electricity for SSE facilities at EU berths.

- **EU Directive 2005/33/EC on the sulphur content of marine fuels** [17] (existing regulation). It regulates the sulphur content of heavy fuel oil and marine fuels to achieve this goal. The Directive encourages land-based electricity supply insofar as ships that switch off all engines and use shore-side electricity while at berth in ports are exempt from this sulphur restriction.

- **Commission Recommendation 2006/339/EC on the promotion of shoreside electricity for use by ships at berth in Community ports** [18] (existing regulation). The purpose of this non-binding recommendation is to encourage EU Member States to engage in activities that promote SSE and ultimately improve port air quality beyond existing international regulations set by the IMO. All the recommendations given by the EC to promote SSE installations in ports have been considered in the EALING Action.

- **Commission Communication (2007) 575 on an integrated maritime policy for the European Union** [19] (existing regulation). The Communication's primary purpose is to define a set of tools and five action areas for a future mainstreaming of EU maritime governance. The first action area, "Maximising the Sustainable Use of the Oceans and Seas" acknowledges the role of European seaports in determining the quality of their surrounding urban and natural environments. In this context, the Commission states that it will "make proposals to reduce the levels of air pollution from ships in ports namely by removing tax disadvantages for shore-side electricity", thus encouraging land-based electricity supply for ships in berth.

- **EU Directive 2008/50/EC on ambient air quality and cleaner air for Europe** [20] (existing regulation). The Directive aims to reduce air pollution levels and harmful impacts, particularly on sensitive populations and the environment. Article 24 requires that the Member States draw up short-term action plans in given zones or agglomerations where there is a risk that the levels of pollutants will exceed one or more of the alert thresholds. The action plans may include, inter alia, measures about ships at berth, SSE is an example of a measure that succeeds in reducing emissions.

Detailed descriptions of each of the existing and forthcoming regulations are included in **Milestone 4** of the project [21].

2.2 Outlook of relevant European organisations

The growing interest in shore-side electricity solutions and the need to respond to the regulations being proposed in Europe has led various associations in the sector to pronounce themselves on the deployment of SSE, mainly in relation to the expected obligation for shipping companies to be supplied with SSE when at berth, and for ports to offer SSE facilities. In this sense, the EU reference associations that have expressed their point of view as a voice representing the interests of the port and shipping sector, have been:

- From the point of view of ports and terminals:
  - ESPO – European Sea Ports Organisation
  - FEPORT – The Federation of European Private Port Companies and Terminals
- From the point of view of shipping companies:
  - ECSA – European Community Shipowners´ Association

The following pages include a summary of their views, drawn from the various position papers they have published in recent months and their interventions at the various EALING workshops and conferences in which they have participated.

ESPO views on SSE

ESPO points out the following aspects that must be assessed to understand the implications of the implementation of the forthcoming regulations affecting the implementation of SSE in EU ports:

- European ports are committed to helping greening shipping, including through the deployment and use of SSE, where it can effectively reduce greenhouse emissions.
- The legislative framework regulating the supply of clean energy and the requirements associated with ports must be considered from a long-term perspective. It needs to be reinforced with a future-proof legislative framework that provides legal and investment certainty for ports.
- Any requirement to provide shore-side electricity in ports must be in line with the forthcoming requirements for the vessels to use the infrastructure. FuelEU Maritime is therefore necessary to match supply and demand by requiring vessels to use SSE at berth.
- Shore side electricity should be implemented where it makes sense. Ports take into consideration that other existing and potential future technologies that tackle emissions at berth and during navigation could also be used instead of shore side electricity.
- European ports must be able to prioritise the deployment of SSE in terms of delivering cost-effective reductions of greenhouse gas emissions at berth. It is important to deeply analyse each port's demand to avoid stranded or underused facilities.
- To ensure the effective roll out of SSE in European ports, it is important to define the scope

based on a minimum traffic volume level per terminal (instead of per port) to prioritise busy terminals and avoid underused facilities.

- Shore-side electricity should be assessed against current and future alternative equivalent technologies provided in Annex II of FuelEU Maritime.
- It is important to determine the most potential ship segments in reducing emissions at berth to prioritise and rationalise the investments in SSE in the short/medium term.
- The definition of "ship at berth" should be clarified for this Regulation. Providing SSE while mooring or at anchorage is not feasible from a safety and efficiency perspective and should be excluded.
- It is essential to have a cooperation mechanism between ships and ports to ensure that ports know well in advance how much power the ships calling at their berths need, thus enabling and maximising the use of SSE.
- Once a port has decided to install SSE, the cost of the electric power should be competitive and come from the grid connection outside the port. The use of SSE by ships at the same time can even impact the power reserve in ports. Accurate information about the energy needs of a given ship at a given port is crucial.
- The energy production capacity in both islands and outermost regions of the EU might not always be enough to meet the demand for SSE due to not having a connection to the main grid or insufficient local capacity to generate renewable electricity.
- The promotion of the deployment and use of SSE based on the strict requirements in AFIR and FuelEU Maritime should be accompanied by the introduction of an EU-wide permanent tax exemption for SSE in Article 15 of the proposal for a reviewed Energy Taxation Directive.
- There is a need for a comprehensive financing plan as a part of the National Policy Framework and for dedicating sufficient public investments to deploying SSE.
- The contribution of the use of shore-side electricity or other alternative solutions as outlined in Article 5 of the FuelEU Maritime *(Additional zero-emission requirements of energy used at berth)* should be explicitly included, and accounted for, in Article 4 *(Greenhouse gas intensity limit of energy used on-board by a ship)*.
- It is necessary to engage all shipping segments towards lowering emissions at berth and in navigation by 2030 and beyond.
- It is suggested to limit the exception in Article 5(3)e of FuelEU Maritime for incompatibilities between the shore-side electricity installation at berth and the installation onboard vessels in the case of frequency conversion.
- It is proposed that European Commission and relevant EU agencies such as EMSA develop technical specifications for SSE installed onboard vessels, including, where applicable, frequency standardisation, plug specifications, and standard areas for plugs and flexible cable management system locations onboard.

FEPORT views on SSE

A set of recommendations have been stated by the association in relation to SSE:

- Focus both on the demand and the supply side if the EU wants to avoid the so called "chicken and egg" problem.
- Mention in AFIR specifically that the managing body of the port is the party responsible for the financing of refuelling and recharging infrastructure, in accordance with the *Port Services Regulation and the 2017 amendment to the General Block Exemption Regulation (GBER)*, which both stipulate that infrastructure management and maintenance is the responsibility of the port authorities. Legislation must be clear as to who is responsible for what.
- Ensure the availability of sufficient public funding to support the roll-out of alternative fuels infrastructures. FEPORT also believes that part of the revenues raised via the implementation of FuelEU Maritime, and EU ETS should be used to fund the deployment of SSE facilities. The establishment of a dedicated fund based on FuelEU and EU ETS revenues reduces the need for direct or indirect tax revenues to finance the deployment of SSE and clean bunkering facilities in ports.
- Align AFIR with existing EU legislation that clearly specifies that the managing body of the ports is responsible for the provision of alternative fuel infrastructures.
- Provide public support to bridge the current price gap. CAPEX expenditures must be paid by shipping lines to adapt their ships to be able to plug in to SSE. The OPEX expenditures are the responsibility of the terminal operator or another service provider. It should indeed be possible for terminal operators to engage in this model and offer SSE as a service, but this can only be possible and profitable if Member States or port authorities invest to ensure that electricity can be provided to ships in the long term, at a profitable rate.
- Include an EU-wide systematic tax exemption for electricity provided to vessels at berth in the revised Energy Taxation Directive, as this could incentivise ships to already plug in before 2030. Once shipping demand increases, more private operators will be inclined to offer SSE as a commercial service.
- Maintain the 5,000 GT limit throughout the Fit for 55 Package to ensure that SSE is primarily installed in ports where it makes the most environmental and economic sense.
- Allow flexibility to port stakeholders to decide between the business model to be applied. FEPORT opposes amendments to the AFIR that would entail those terminal operators are obliged to provide shore-side electricity to vessels at berth. If a terminal operator voluntarily chooses the service provider model, it will be essential to provide more financial incentives, such as via tax exemptions.

ECSA views on SSE

ECSA supports the objective of the FuelEU Maritime proposal to foster the uptake of cleaner fuels in shipping. However, in the Position Paper on the FuelEU Maritime proposal published in October 2021, they highlighted the following point of concern regarding shore-side electricity: *"The proposal* *introduces a requirement for passenger ships and containerships to use Shore-side electricity (SSE) when at berth at a European port for more than two hours. The requirement does not apply when the port infrastructure is not available or not compatible with the ships' equipment. However, this exemption effectively expires at the end of 2034, making ships responsible when the infrastructure is not available at the port. Such a financial penalty on ships when the SSE infrastructure is unavailable in a port does not address the right entity. Rather than the FuelEU Maritime proposal, the Alternative Fuels Infrastructure Regulation (AFIR) proposal would be a better instrument to incentivise the installation of SSE in ports and, consequently, the use of SSE by vessels. At the very least, the exemption from the mandatory use of SSE when infrastructure is not available in the port and when ship's on-board onshore power equipment is incompatible with the port's installation should not expire in 2035."*

In addition, during the EALING Mid-Term conference, organised on 29 April 2022, the representative ECSA pointed out that:

- There is a need for standardisation regarding connection, cables, voltage, and frequency.
- The focus must be put on the target (decarbonised shipping) and not at the expense of one technology or another.
- SSE will be challenging to be applied for deep sea transhipping that does not operate on fixed schedules.

Other EU organisations views on SSE

During the internal workshop organised in the framework of the EALING project on 25 February 2021, the following EU organisations expressed their views on the existing challenges for the SSE deployment.

- Baltic Ports Organisation (BPO)
  BPO highlighted during the event the need for public funds for ports and shipping lines to support the implementation of SSE facilities.

  Regarding the technologies to be used to abate emissions, they consider that the EC should be neutral and not only focus on SSE, as they consider that SSE is probably not the technology to be implemented in all the ports. This would be the case, for instance, in small ports or underused berths.

- MEDPORTS Association
  In their opinion, it is important that these SSE installations are being carried out where it makes sense. It is also crucial to foster cooperation for the successful deployment of SSE, with interoperability and harmonisation being two of the critical issues.

- European Federation of Inland Ports (EFIP). The recommendations provided by EFIP during the EALING workshop were to:
  - Revise the Energy Taxation Directive.
  - Have the corridor approach for AFIR, including all inland waterways actors.
  - Further fund and designate inland waterways funding sources to support both infrastructure and demand.
  - Monitor and implement recommendations of the ongoing Central Commission for the Navigation of the Rhine (CCNR) study "*Financing the energy transition towards a zero-emission European IWT sector*": adapting payment schemes, facilitating pay-per-use, etc.

2.3 Main findings from the detailed analysis of existing national/regional/local regulation in EALING ports

The legislative framework analysis related to SSE development at the local, regional, and national level of each Member State participating in EALING Action, submitted to the European Commission as means of verification of Milestone 4, was mainly focused on the following aspects: i) the transposition of the EU Directive 2014/94/EU on Alternative Fuels Infrastructure into their national legislations, ii) the adoption of the international electro-technical standards for shore-side electricity infrastructure in ports, iii) the organisation of the environmental impact assessment and safety requirements for electrical installations, and iv) the adoption of national climate and energy plans with incentives for promoting shore-side electricity supply to vessels as port services.

In addition, aspects such as the framework for the public procurement processes for SSE facilities development, the organisation and operation of the electricity grid, electric power plants and networks, the generation of electricity, and the formulation mechanisms for electricity prices were considered.

In relation to local and regional regulations, urban development plans for the realisation of SSE installations in ports, and City Council regulations (for either the approval of construction works for SSE to vessels calling at ports or the environmental impact assessment approval for the installations and technical norms of the local Distribution System Operators for the ports' shore-side electricity infrastructure) were studied.

From the results of the comparative analysis of the regulations in the countries of the EALING consortium (Spain, Italy, Portugal, Greece, Slovenia, Romania and Bulgaria), it is possible to highlight the diversity in terms of complexity of the different scenarios in relation to the applicable regulation at national, regional, or local level. In this sense, the centralised nature of port management at the State level simplifies this complexity and makes regulation more intuitive.

National level

The analysis of regulation at the national level in the EALING countries led to the following results:

- 87.5% of the EALING Member States (all except Portugal) have national regulations in place related to port structure and administrative issues, such as contracting power supply and infrastructure works. All must respect the existing regulations related to the power supply and electricity distribution and those related to environmental impact, noise pollution, etc.
- 75% of the EALING Member States (all except Bulgaria and Portugal) must comply with national regulations related to industrial installations, especially electricity transmission and distribution facilities.
- 75% of the EALING Member States (all except Portugal and Ireland) have national regulations on safety and security measures, including occupational risk prevention.
- 62.5% (all except for Spain, Greece, and Italy) of the EALING Member States have not issued national regulations, including provisions for tax incentives (tax exemptions or reduced rates).
- 37.5% of the EALING Member States (Italy, Greece, and Spain) have issued national regulations for developing electricity production facilities based on renewable energy sources or microgrids development.
- 50% of the participating Member States (Spain, Italy, Greece, and Romania) already have national regulations that include technical rules for SSE facilities development in full compliance with international electrotechnical standards.
- 50% of the EALING Member States (Spain, Italy, Slovenia, and Bulgaria) have issued national regulations that include safety and security protocols for SSE facilities' works and operations.
- 75% of the EALING Member States (all except for Bulgaria and Portugal) have issued national regulations that include technical norms and requirements for developing industrial installations in ports dedicated to SSE.
- 87.5% of the EALING countries (all except Ireland) have issued National Energy & Climate Plans that include provisions for the promotion of shore-side electricity as a port service.

Regional level

The analysis of regulation at the regional level in the EALING countries led to the following results:

- 50% of the EALING Member States (Greece, Romania, and Bulgaria) have in place regional regulations related to port structure and administrative issues, such as contracting power supply and infrastructure works.
- 50% of the EALING Member States (Italy, Spain, Romania, and Portugal) have power supply and electricity distribution regulations.
- 37.5% of the EALING Member States (Italy, Spain, and Greece) have regulations related to environmental impact, noise pollution, etc.
- 25% of the EALING Member States (Spain and Romania) have issued regulations related to industrial installations.
- 50% of the EALING Member States (Italy, Spain, Romania, and Portugal) have regulations on

safety and security measures, including occupational risk prevention.

Local level

The analysis of regulation at the local level in the EALING countries led to the following results:

- 62.5% of the EALING Member States (Italy, Spain, Greece, Romania, and Portugal) have in effect Local Development Plans & City Regulations that must be considered when implementing SSE installations. On the contrary, Bulgaria, Slovenia and Ireland are not affected by them.
- Only 25 % of the EALING Member States (Italy and Spain) are affected by technical specifications related to electrical installations. On the contrary, Greece, Romania, Bulgaria, Portugal, Slovenia, and Ireland do not have to follow any local regulations on technical specifications related to electrical installations.

In addition to the quantitative analysis, a qualitative study was done concerning the main characteristics of national regulations related to SSE. The following table shows its results.

Table 2. Qualitative analysis of the main characteristics of national regulations related to SSE

MAIN CHARACTERISTICS OF NATIONAL REGULATIONS RELATED TO SSE	SPAIN	GREECE	ITALY	ROMANIA	BULGARIA	SLOVENIA	IRELAND	PORTUGAL
Maturity Level (By covering all regulation aspects)	High	Medium	Medium	Medium	Medium	Medium	Low	Medium
Complexity Level (also including Regional & Local Regulations)	Medium	Low	Medium	Medium	Low	Low	Low	High
Deployment of measures carried out in relation to the EU Directives transposed	High	Medium	Medium	Medium	Medium	Medium	Low	Medium
Compliance with International Electro-technical Standards	High	High	High	Low	Low	High	Low	Low
Articulacy Level (ease of understanding and level of clarity)	High	High	High	Medium	High	High	Medium	Medium
Readiness Level (concerning regulations that have not been issued and are planned to be legislated)	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium

In conclusion, the comparative and qualitative analysis results revealed that the Member States of Spain and Greece seem to have a more mature regulatory framework at a national level. These Member States have successfully transposed a plethora of EU Directives concerning the Alternative Fuels Infrastructure and the Environmental Impact Assessment procedures into their national legislations, have issued national regulations related to the majority of under-study regulatory fields and present minor gaps in their legislative framework.

Italy, Bulgaria, Romania, Slovenia, and Portugal are characterised as Member States with an adequate level of maturity as they have also transposed the main EU Directives on Alternative Fuels Infrastructure and the Environmental Impact Assessment procedures for electrical installations development into their national legislation. They have also prioritised national policy frameworks including shore-side electricity in ports. Still, they present gaps in the fields of electricity production by renewable energy sources, microgrids development, the existence of safety and security protocols for shore-side electricity infrastructure in ports, the application of international technical standards for electrical installations and the presence of financial incentives such as tax exemptions or tax reductions to the electricity supplied to vessels.

Similarly, Ireland, which presents several gaps in most of the fields above-mentioned in relation to national regulations, seems to be at a lower level of maturity even though it has already transposed into its national legislation the EU Directives on Alternative Fuels Infrastructure and Environmental Impact Assessment procedures for electrical facilities development.

2.4 Recommendations focused on the policy and legal scope

Based on the previous sections, the following table shows a summary of recommendations focused on policy and legal scope:

Table 3 Summary of recommendations – policy and legal scope

Recommendations – policy and legal scope
• Simplify and harmonise administrative burden at the national, regional, and local levels (resulting from the application of regulation) to build and operate SSE infrastructures.
• Facilitate the involvement of port authorities in the development and operation of their electricity distribution system to provide the necessary quantities of electricity to their end-users. This could be done by ensuring through Member States' legislation that this possibility exists and/or by allowing/promoting ports to become energy hubs and/or renewable energy communities, capable of injecting excess renewable energy production into the grid and trading it on the different electricity markets.

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- Clarify in the forthcoming EU regulations, i.e., who will be responsible for what: construction, operation, and maintenance of SSE facilities.
- Increase the intensity of public funding. In this sense, the revenues raised via EU ETS could be used to fund SSE installations.
- Include tax exemption for electricity provided to vessels at berth in the revised Energy Taxation Directive.

3 TECHNICAL SCOPE

3.1 Overview of the technical work performed by European and International bodies and the main challenges highlighted

International Maritime Organization (IMO)

The International Maritime Organization (IMO), through one of its sub-committees, the Ship Systems and Equipment (SSE) Group, is developing the *Interim Guidelines on Safe Operation of On-Shore Power Supply (SSE) service in Port for Ships Engaged on International Voyages* [22] to provide an international operational standard for the safe operation of SSE service in port on ships.

The Guidelines will apply to alternating current of the SSE service for ships in port (except for liquid cargo) engaged on international voyages. They will not apply to the electrical power supply during docking periods, e.g., dry docking and other out-of-service maintenance and repair.

The structure of the Interim SSE guidelines will, in summary, be as follows:

1. General: Application, terms and definitions, and communication.
2. Verification and testing: Tests on the first port of calls and repeated calls.
3. Operation: Personal protective equipment (national legislation for Shore/Safety Management System (SMS) for the ship; high-voltage and low-voltage operational procedures; disconnection.
4. Safety precautions before maintenance: "Lock out/tag out" and equipment grounding procedures.
5. Documentation: SSE procedures in SMS, plans, diagrams and instructions.
6. Personnel, training, and familiarisation: Minimum competency requirements for the Person In Charge (PIC).

The draft recommends revisiting fully automatic and semi-automatic processes as indicated by the standard and the IEC/IEEE 80005-3 PAS (Publicly Available Specifications) regarding the low voltage supply. Finally, the Guidelines will also pay special attention to both ship and shore **safety checklists and flow charts**.

European Maritime Safety Agency (EMSA)

The European Maritime Safety Agency (EMSA) published in July 2022 the Guidance document called "*Shore-Side Electricity. Guidance to Port Authorities and Administrations*". The Guidance is structured in two parts. The first part, called "*Equipment and Technology*" is an exhaustive review of the current technological solutions and components available for the shore side infrastructure. The second part, called "*Planning, Operations and Safety*" describes different configurations of an SSE infrastructure, from the energy source to the connection to the ship. This Guidance includes **not only SSE, but also Shore-side Battery Charging (SBC), Shore-side Power Banks (SPB) and Battery Swapping (BS) installations**. The final sections of the Guidance describe safety procedures for connection and disconnection.

The EMSA highlights the following technical challenges in its Guidance document - Part 1:

- GHG Impact. In countries with **high CO2 emission factors for the electricity supply**, the use of SSE from the national electricity grid would lead to more emissions than using the standard diesel generator on-board.
- Frequency. The **incompatibility between 50 and 60Hz** will have to be solved by installing a frequency converter. This will immediately lead to an increase in the investment cost associated to shore side electricity infrastructure.
- Connectors. **Standardization of SSE equipment** can be a challenge, globally. Through Directive 2014/94 the standard enforced is IEC/IEEE 80051/1 (2019) – High Voltage Shore Connection (HVSC).
- Black-out. Some onboard shore-power arrangements in the main switchboard may lead to **black-out during the transfer of the energy** from the ship to the shore supply. Gradually, with the introduction of synchronization capability, this challenge has been overcome.

Specific challenges are also mentioned regarding Low Voltage (LV) installations:

- The **number of cables** needs to be considered for each connection and ship type. Up to five cables may be needed in some cases.
- **Coordination between LV feeder Circuit Breakers (CB)**. The opening of one CB will lead to an overload on the other CBs. There may be a need to consider selectivity in an adequate design to ensure the reliability of LVSC systems.
- **Safety**. With a higher number of cables, it is important to consider the difficulties associated with handling them, increasing potential risks.
- **Operation**. A higher number of cables implies higher connection and disconnection times.

Besides, other challenges are highlighted throughout the two documents, being the following:

- **Power demand estimation**. The daily variation of the demand introduces a high uncertainty in SSE, not only for planning but also for operation.
- **Variable power factor**. Since different vessels might be connected, the power factor may not be a fixed value, that could be compensated with a capacitor bank. Given the case that the reactive component of the demand starts to be an issue, the solution may involve installing active compensation components, such as Static Var Generators (SVG).
- **Metering**. It is important to study how to measure, what variables to measure (e.g., voltage, current, harmonics, etc.), where to measure and when, not only for billing purposes, but regarding power quality and the registration of electrical events. A large amount of data might

be measured, which will require a specific big data infrastructure and appropriate curation and mining algorithms.

- **Combination with Shore Battery Charging (SBC)**, or how to provide charging and demand coverage at the same time. The Guidance describes different configurations and options, however, there are technical challenges in these configurations since including battery charging implies measuring and controlling the charge. Besides, there are currently no standards available for SBC.
- **Types of ships**. It will be necessary to implement SSE on other types of ships, such as chemical tankers, oil tankers and LNG carriers.
- **Cable Management System (CMS).** CMS is identified in the EMSA guidelines as one of the most important and challenging elements of shore side electricity installations. These components are tailored to the specific needs of each port and, although compliant with the standard IEC 80005, different configurations may be found.

Finally, it is worth noting that EMSA includes a quick-reference guide for developing shore-side electricity in ports in which, among other pointers, the Agency includes the life cycle steps for SSE (Figure 1). Overall, the process is divided into four main stages:

1. Preparedness,
2. Planning and Design,
3. Engineering/ Procurement/ Contracting/ Construction and
4. Operation.

Within these four main stages, the structure presented below follows the typical engineering development process, with 1) identification of initial requisites, 2) Study of options followed 3) Feasibility Analysis and Project Evaluation. Following the identification of a preferred option, the deployment of the project takes place with all detailed engineering drawings, procurement, contracting and construction and finally, the system's operation.

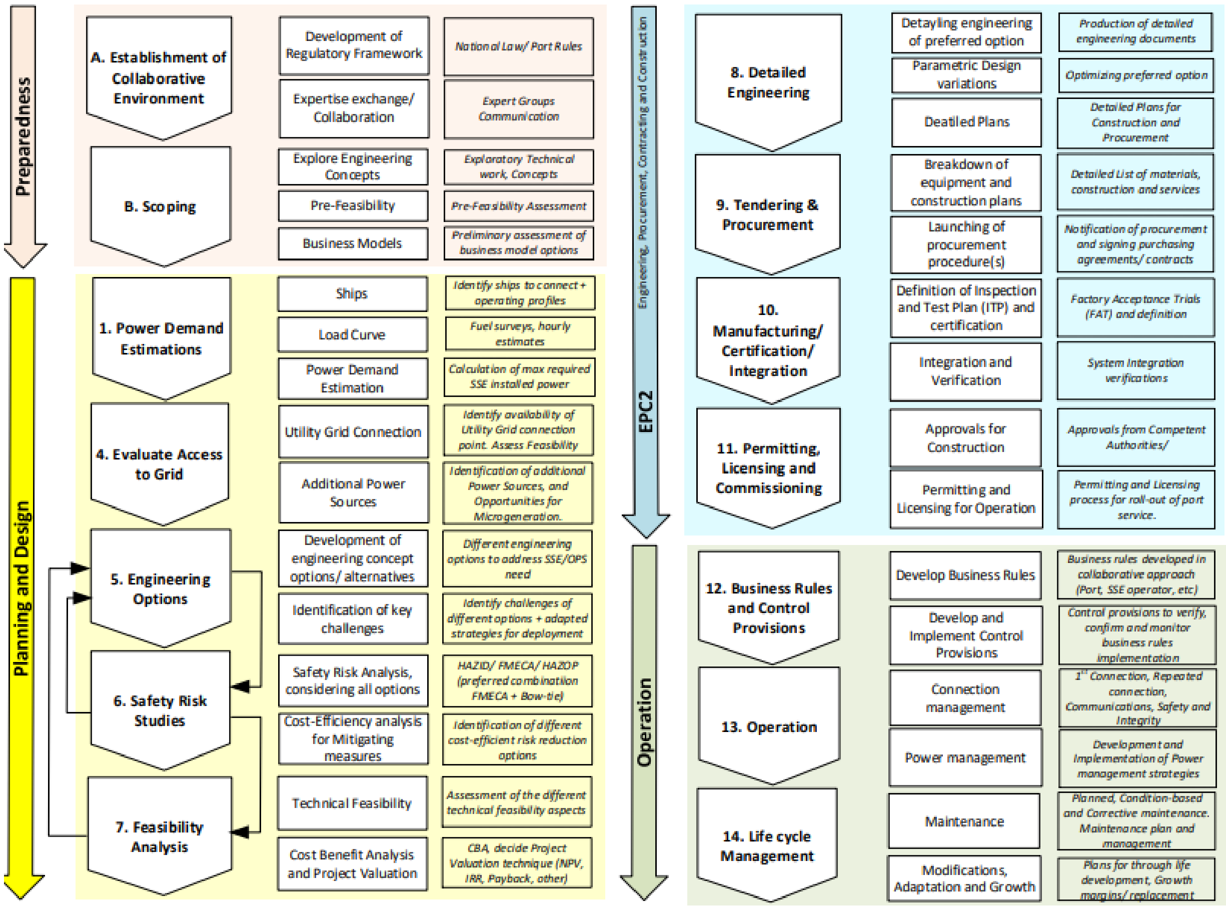

Figure 1. Life cycle of SSE projects
Source: EMSA

3.2 Outlook of the energy suppliers and main challenges highlighted

Description and roles of energy suppliers

The unbundling of the energy sector in the European Union started in 1996 with the publication of the so-called "First Energy Package" Directive [23] on 19 December 1996. To foster liberalisation of the electricity and gas sectors and the free concurrence of competence to energy markets, companies are separated into four segments:

- Generation, or companies that produce and sell the energy in the wholesale market.
- Transmission, or companies that transport the energy at high voltage level, from production plants to final customers or distributors.
- Distribution, or companies that distribute the electricity at medium and low voltage levels to the final customers.

- Retailers or companies that buy the energy and sign energy supply contracts with final customers to charge them for the energy delivered.

From this initial classification, the roles that energy suppliers can provide to ports regarding shore-side electricity can be one or all of the following:

- A **Retailer** who will sign a contract with the port or the terminal for energy supply, usually to cover all the electricity demand of the terminal, not only SSE. There is a challenge in the definition of electricity tariffs that would best suit the fluctuating SSE demand.
- A **Distribution System Operator (DSO)**, who has the challenge of assuring the supply of energy and power that the aggregated SSE will demand. The DSO will have to deploy the necessary electrical infrastructure for this.
- Finally, an energy supplier can also be a **Service Provider**. Given their experience in electricity distribution, they could offer the complete SSE infrastructure (and operation) at the terminal or quay. The main challenges, in this case, are, on the one hand, the limited availability of space at the terminal, and, on the other hand, the installation of new connections to the distribution grid outside the terminal or the port land.

Challenges highlighted by energy suppliers

The following challenges have been extracted from the main conclusions of the EALING Energy Suppliers Workshop held on 5 July 2022:

- **Deeper studies are needed to assess the demand at Ports.** These studies should include the analysis of historical records of calls, of at least one year (although more than one is recommended). Daily fluctuation of energy and power values and the high peak/valley ratio are the biggest challenges.
- An interesting option might be that the ports become **energy communities**, with smart management and balancing local renewable production and energy consumption, including the aggregated demand from SSE.
- **The current tariffs scheme does not allow tailored electricity SSE tariffs**, with their huge fluctuations in energy and power. Tariffs have a lot of fixed costs that do not contribute to reducing the payback period. Flexible tariffs should be allowed. Power charges in the tariff are also an obstacle to SSE deployment.
- **Private investment in SSE infrastructure has a high risk** because the investment needed is very high and difficult to recover unless financial aid is obtained.

3.3 Outlook of the solution providers and main challenges highlighted

Description and roles of solution providers

Regarding the SSE infrastructure, solution providers are experts in different segments or components, from the very specific technology manufacturers and suppliers to the complete SSE solution turnkey providers. The following diagram gives an overview of the typical components that may be deployed for a shore connection infrastructure, starting from a supply medium voltage line from the distribution grid, until reaching the physical connector to the vessel at the quay:

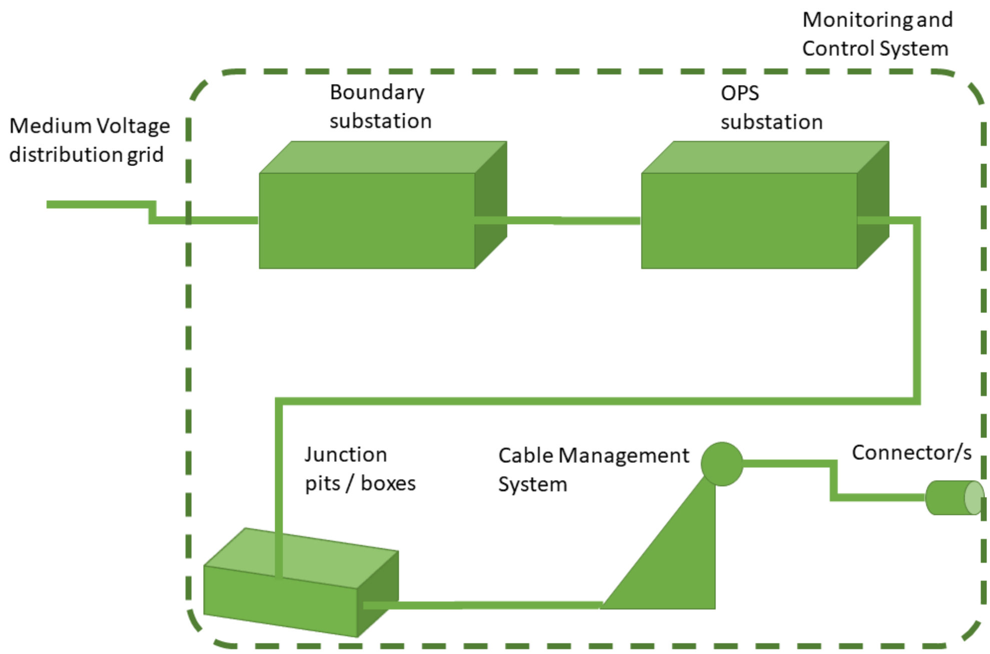

Figure 2 Overview of components needed to deploy an SSE infrastructure
Source: Own elaboration

Based on this diagram, the following main components or blocks in an SSE infrastructure can be found:

- A **boundary substation**. These are typical constructions in the electricity grid used to direct a supply line from the distribution grid to a specific client or group of clients. They usually delimit the boundary between the DSO grid and the client premises. Since these are common and well-known installations, specific providers for the complete substation can be found, including all the necessary components inside, mainly a derivation supply line with switches and protection devices, which may include remote control and communication capabilities. In most cases, a billing meter is placed in this substation to account for all the energy delivered to the client.
- The **SSE substation**. The components usually found inside this substation include switchgears and protection devices, circuit breakers, power transformers to adapt the voltage to the needed

levels, and frequency converters. In this case, usually, a single provider will supply the complete substation, however integrating technology from other suppliers for specific components such as the transformers and the frequency converters. The SSE substation also includes a PLC and SCADA monitoring and control system. Again, these systems can be supplied by different manufacturers in some cases, integrated seamlessly in the system.

- The **junction pits or boxes** are needed at the quay. They have the role of interfacing between the cables that come from the SSE substation and the Cable Management System. These connections are specifically designed for SSE solutions, and specialized suppliers can be found for them.
- The **Cable Management System** is very specific equipment used for SSE solutions. There are different types, fixed or mobile, and they must be different for each type of vessel (e.g., containerships, ferries, cruise ships, etc.). In most cases, customised CMS solutions might be needed. There are different suppliers specialized in CMS solutions.
- Finally, the **connector** is also very specific and must meet the requirements of IEC standards. There are also different types of connectors for each type of vessel. Different suppliers and manufacturers have these connectors in their portfolio of products.

As indicated previously, the providers usually specialise in one or more of these main components or blocks; however, some providers integrate all the different components and provide the complete turnkey SSE solution.

Challenges highlighted by solution providers

The following challenges have been extracted from the main conclusions of the EALING OPS solution providers workshop that was held on 12 July 2022:

- The **power grid** is not currently ready to provide all the estimated energy that SSE will demand in the future. Adequate grid development and financing of the investments needed to build new electricity infrastructure are necessary. Besides, all this energy will have to be carbon-free produced electricity, so more renewable generation will be needed, that could be installed inside port premises.
- The **evolution of vessels** must be considered: the trend of hybridisation or battery-powered vessels will demand more power while at berth, which may exceed the power rates currently defined in the IEC 80005 standard.
- The approach when dealing with SSE infrastructure is also a challenge. **It should not be considered a product but a system**. Each port or terminal needs a tailored solution, even though the concept might be the same. SSE systems are not just a list of components put together. SSE systems are complex, and underestimating their complexity is a challenge that providers usually face.
- When installing SSE in an existing vessel, no vessel can be compared with another one, so specific **"out of the box" solutions** are needed for each case.
- Both **technical and operational requirements** (I.e., how you want to operate SSE in your

terminal) **should be defined in an early stage** before the tendering process. A review of these requirements should be made by experienced players to validate their feasibility. This practice would **improve the specifications in the tender processes**, where sometimes unrealistic specifications in terms of execution or operation are found. In other cases, the specifications in these calls for tenders are too specific. The requirements should not be too detailed, allowing the providers to innovate and present the best technological solutions when applying to the calls.

- The variety in vessels lengths and locations of the SSE sockets results in the obligation to design systems that **must cover a wide length of the quay** to guarantee supply to as many vessels as possible. The connection point at the vessel is not defined.
- The **availability of space at berth** is one of the main technical challenges. For brownfield container terminals, for instance, there was no provision for SSE, and sometimes a compromise solution must be reached. In other cases, the challenge is not the lack of space but where this available space is and how to bring the cables there.
- **Integrating Shore Battery Charging (SBC) with SSE** is a technical challenge. On the one hand, they do not serve the same purpose, and no standard covers fast charging. On the other hand, battery charging is designed to be done many times a day, whereas an SSE connection is made only a few times a day.
- There are challenges to bringing SSE for tankers as they must operate at berth, and therefore they must switch loads on and off. Besides, tankers have hazardous areas that limit the space available for SSE implementation.

3.4 Main challenges highlighted by Port Authorities

Port Authorities must deal with the supply of the expected demand in SSE. To do so, ports are going through different phases of assessment:

- The first one is assessing **power demand** that will be needed at a port level, considering different scenarios of maritime traffic and SSE coverage at the quays.
- The second one is **how to procure the estimated energy** in the form of electricity to the terminals and quays. These works will probably cover not only the port premises but also the provision of new connections from the medium voltage distribution electricity grid outside the port or terminal.
- Finally, with a more detailed level of granularity, **specific engineering or Front-End Engineering Design (FEED) projects** will be needed to assess the deployment of SSE at each quay case by case.

In this process, ports face different challenges, some of them being the following:

- The lack of **common methodologies to assess the demand estimation**, especially how to

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address average and peak demand values from the vessels that will be calling at the port. The deployment of SSE infrastructure at the port will probably mean a complete renovation of the electricity grid at port premises and the installation of dedicated substations. For this reason, evaluating the maximum peak of power that could be demanded is key.

- Another difficulty is the lack of a common method or guide to compute **simultaneity coefficients**. Most of the distribution electricity grids are designed assuming that not all the possible demand from the loads will be required at the same time; otherwise, oversizing the infrastructure would be too expensive (and inefficient).
- Another big challenge is the lack of **space at the quay for the SSE infrastructure**. The needed infrastructure, especially the SSE substation, requires considerable space as close to the quay as possible and must be installed somewhere between the electrical infrastructure and the quay. This can be a hard constraint. Besides, underground cables to the quay are needed, with a considerable section since the power to be transported also considerable.
- Another big issue comes from the fact that the **socket placement at the ship** is not standardized. Therefore, it can be anywhere. This is a challenge for ports because the infrastructure needs to cover all the quay where the ships call.

3.5 Results of the EALING Port and Shipping Questionnaires: main technical challenges highlighted

As part of the tasks developed in the EALING Action, two questionnaires were carried out and analysed, one to collect the views of SSE from the port side (Activity 1) and another to gather information on SSE implementation from the ship side (Activity 2). Followingly the main findings related to technical challenges and barriers are described.

Ports Questionnaire

54 ports from 15 different EU countries participated in the questionnaire. The results indicate that most of the existing SSE infrastructure in the ports are low-voltage installations that do not comply with the IEC/IEEE/ISO 80005 standard. Therefore, **shifting to high-voltage infrastructure** (and higher power levels) is a technical challenge for the ports because they are not familiarized with these systems.

Another challenge is the need to **prepare the electricity distribution grid** to be able to provide the estimated amount of power and energy demand in the different scenarios of SSE coverage. Most ports answered that their electricity grid is not prepared for this; therefore, future works will be needed, not only within each port land but also upstream and outside the port boundaries. Coordinated reinforcements of the electricity grid will be needed with Distribution System Operators (DSOs) and maybe even Transmission System Operators (TSOs). Each port will have to guarantee electricity supply to its quays, either from the medium voltage distribution grid or from their own energy generation sources.

This situation presents a new challenge: **balancing the energy supply and demand at the port level and finding** the most suitable tariff. Ports will have to cope with a variable demand throughout the day, which may fluctuate rather quickly, and present peaks of high-power consumption for a few short periods. To achieve the highest efficiency and avoid losses, ports may become **active consumption nodes, integrating local renewable energy production and energy storage**. Smart grid management systems and digitisation will help them to be more carbon-neutral and efficient. Even though the technology is mature enough and commercial systems are already available, this path will bring new technical challenges to overcome.

Shipping Questionnaire

The questionnaire, which involved 18 shipping companies, 4 classification societies and 2 flagships, revealed the following main challenges:

- The **cost of retrofitting** for the vessels. It is costly and takes time to install SSE in an existing ship. The cost varies depending on the type of vessel, from around EUR 50,000 for tugboats up to around EUR 1,000,000 (on each side) for containerships. The **lack of regulation** regarding how this retrofit should be made is also a barrier. The age of the ship also affects the viability of the SSE implementation. There is no generic procedure, and each vessel needs to be addressed case by case.
- Most of the vessels **operate on low voltage**, specifically 440 V or below. The IEC/ISO/IEEE 80005 standard recommends high voltage shore connection for vessels with a power demand higher than 1 MVA. In this case, the vessels will need to install an additional transformer to step down the voltage coming from the shore.
- The **lack of technical understanding** of SSE systems from the stakeholders is also a challenge slowing down its implementation.
- There are some technical challenges when **implementing SSE connection** at the vessel regarding interfacing voltage, frequency, connection type, load requirements and short circuit contribution. The synchronization process and the protection systems also present some challenges.

3.6 Recommendations focused on the technical scope

Recommendations from EMSA

In its Guidance documents, the following recommendations are stated by EMSA:

- As a general recommendation, to overcome and harmonise technical challenges.

- Keep working on the international standard for Shore Connection (IEC/IEEE 80005). More specifically, to finalise Part 3 (LVSC systems) and issues related to communications (Part 2). It also proposes that IEC 80005 broadens the scope to include Shore side Battery Charging and Shore Power Banking.

It also includes a list of specific measures to reduce power demand unpredictability:

- Apply **energy survey-based power demand estimation**, including a representative set of port calls in advance to the shore side electricity design phase.
- Confirm with representative ships their **operating profile** at berth, using questionnaires and considering the approved electric load balance of the different ships, with reference to a **maximum electrical power demand at berth**.
- Build **power demand curves and load duration curves** for the different representative ships.
- Decide on design factors (diversity/**simultaneity factor**), based on documented exchange with operators.
- Apply **power allocation** to specific ships, with maximum power allocation associated with the compatibility assessment file.

Recommendations from the port sector

The following recommendations can be mentioned, extracted from the EALING Ports Questionnaire:

- Define proper **power values** to size the SSE infrastructure.
- Define a methodology to obtain **simultaneity coefficients**.
- Develop standards for **socket placement per ship type** to narrow infrastructure deployment (such as the number of connection pits).
- Produce and give access to a **public repository of SSE-ready vessels** and their characteristics. This repository could be linked to (or included within) the THETIS-MRW Repository by EMSA to report CO2 emissions from ships according to the EU Regulation 2015/757 [24].

Recommendations from the shipping sector

Following, some recommendations have been extracted from the EALING Shipping Questionnaire:

- An **early engagement** with all the various stakeholders across the supply chain is key.
- Appropriate **training** is needed, especially on safety aspects regarding shore-ship compatibility. Operation **manuals** should be produced that could help to speed up the process onboard.
- There is a need for **technical and regulatory harmonisation** when implementing SSE connection on board.

Recommendations from energy suppliers

The following recommendations have been extracted from the main conclusions of the EALING Energy suppliers' workshop, which was held on 5 July 2022:

- Promote **regulatory sandboxes** that allow designing and testing new, more flexible tariffs specifically for SSE service, which may facilitate recovering the investment.
- **Load forecasting models** will be needed to reduce uncertainty in energy supply, balance supply with demand in advance and (maybe) reduce energy price volatility.

Recommendations from SSE solution providers

The following recommendations have been derived from the main conclusions of the EALING SSE solution providers workshop that was held on 12 July 2022:

- There should be some standardisation or guidelines regarding the **position of the SSE connection at the vessel** for each type of vessel. This would probably allow for narrowing the coverage of the CMS at the quay in some cases, making the installed system more efficient and probably cheaper.
- Mandating **joint ventures** in the tender processes may not be a good approach because it limits the participation of companies. In order to ensure the technical feasibility of a project, the supplier or tendering company may sign specific agreements with suppliers.
- Experts should review the **SSE project specifications** to validate their feasibility prior to be included in tender calls.
- The **requirements of the tender processes** do not need to be very detailed because they will limit and exclude other possible and viable solutions. The recommendation is to define good requirements, let the providers innovate, and provide the best technical solutions to the tender calls.

Summary of recommendations from the technical scope

It is interesting to note that the different agents (ports, energy suppliers, technology providers) coincide in some key recommendations, such as the need to harmonise or standardise the SSE connection at vessels. There are also specific recommendations concerning each sector, such as assessing power demand in the case of ports or appropriate training for SSE operation, both at the shore and on board. The recommendations previously proposed are grouped by theme and summarised in the table below.

Table 4. Summary of recommendations – technical scope

Topic	Recommendations – technical scope
SSE connection at vessels	• There should be some standardisation or guidelines regarding the position of the SSE connection for each type of vessel. • Appropriate training is needed, especially on safety aspects regarding shore-ship compatibility. Operation manuals should be produced to help speed up the process onboard. • There is a need for technical and regulatory harmonisation when implementing SSE connection on board. IMO guidelines under preparation are expected to provide support on these issues.
Tender processes	• Mandating joint ventures in the tender processes may not be a good approach because it will limit the participation of companies. To secure the feasibility of a project, the provider or company that will apply to the tender process may sign specific arrangements with the suppliers. • Experts should review the SSE project specifications to validate their feasibility before being included in tender terms of reference. • Requirements at the tender processes do not need to be very detailed because this will limit and exclude other possible and viable solutions. The recommendation is to define good requirements, let the providers innovate, and provide the best technical solutions to the tender calls.
Regulations and standards	• Promoting regulatory sandboxes that allow designing and testing new, more flexible tariffs specifically for SSE service may facilitate recovering the investment. • Keep working on and improving the international standard for Shore Connection (IEC/IEEE 80005). • Broaden the scope of IEC 80005 to include Shore side Battery Charging and Shore Power Banking.
Assessment of power demand	• Load forecasting models will be needed to reduce uncertainty in energy supply, balance supply with demand in advance and (maybe) reduce energy price volatility. • Define proper power demand values to size the SSE infrastructure. Apply energy survey-based power demand estimation, including a representative set of port calls before the design phase. Confirm with representative ships their operating profile at berth, using questionnaires and considering the approved electric load balance of the different vessels to reference a maximum electrical power demand at berth.

- Define a methodology to obtain simultaneity coefficients and decide on design factors (diversity/simultaneity factor) based on documented exchange with operators.
- Produce and give access to a public repository of SSE-ready vessels and their characteristics.
- Build power demand curves and load duration curves for the different representative ships.
- Apply power allocation to specific ships, with maximum power allocation associated with the compatibility assessment file.

4 ECONOMIC SCOPE

4.1 Overview of the SSE European market

Introduction – SSE in Europe

The first SSE systems in Europe for the merchant marine sector date back to 1985, with the first low-voltage system installed in Stockholm, Sweden. Other facilities would follow, having the first high-voltage systems deployed in the year 2000. Figure 3 indicates the rapid growth of shore power technology deployment in ports across Europe in recent years. The decline in 2020 is due to COVID, which has affected all maritime sectors.

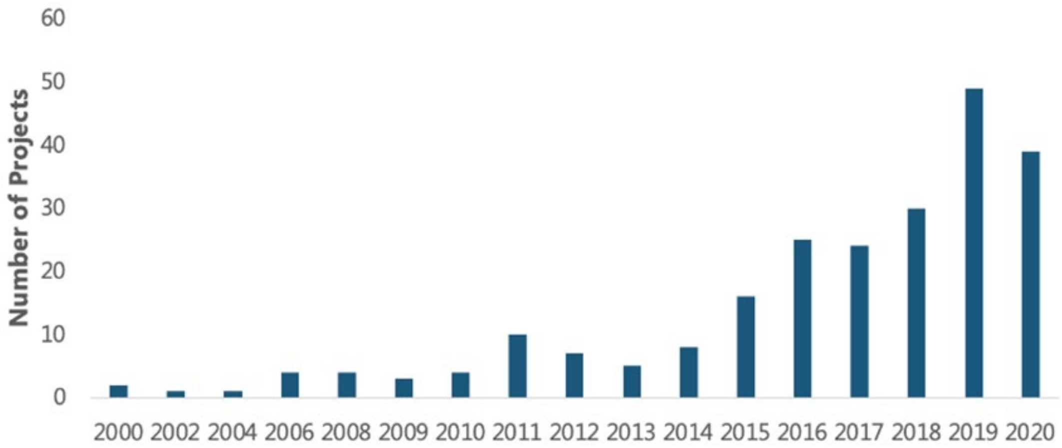

Figure 3. Deployment of Shore Power in Europe
Source: Onshore Power Supply in Europe (July 16, 2021) by Power Technology Research [25]

Europe has invested heavily in the implementation of SSE systems in major European ports in recent years. Figures 4 and 5 depict, according to EEA and EMSA, the location of high voltage SSE facilities in the European Economic Area, by December 2020. According to data from Power Technology Research [26], however, most of the SSE installations are low voltage (72%) and are used by container ships, ro-ro vessels, and ferries. As for high-voltage installations, they are mainly used by cruise ships and are installed in cruise ports. Both types of SSE systems, Low Voltage Shore Connection (LVSC) and High Voltage Shore Connection (HVSC) are mainly chosen based on the type of vessel they will connect to and the amount of power that the ship will demand (the IEC/ISO/IEEE standard 80005 on general requirements for shore connection recommends high voltage systems for a power demand above 1 MVA).

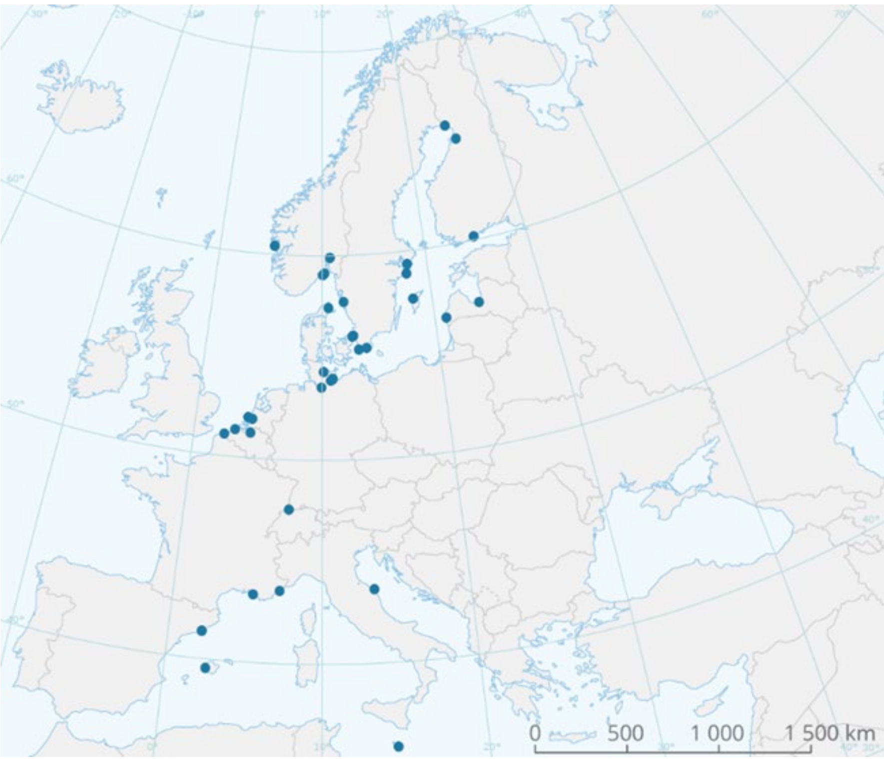

Figure 4. Location of ports with high voltage SSE facilities in the European Economic Area by December 2020

Source: EMTER 2021 by EEA and EMSA

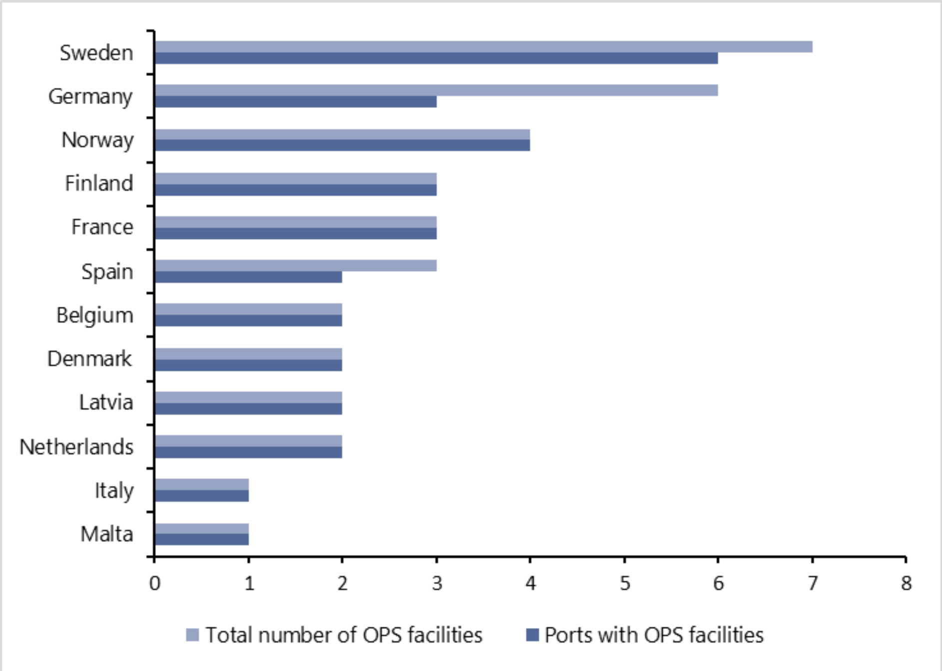

Figure 5 Number of ports and SSE facilities in the European Economic Area

Source: EMTER 2021 by EEA and EMSA

Regarding the type of vessel, and focusing only on passenger and container vessels, most of the current SSE facilities deployed in Europe until 2022 are for passenger vessels, being 70% of the facilities for Ro-ro/Ro-pax vessels, as can be seen in Figure 6. However, in terms of total power capacity installed, the highest amount of aggregated installed power is for cruise ships, which represent around 20% of the systems installed, but account for about 70% of the total power, as shown in Figure 7.

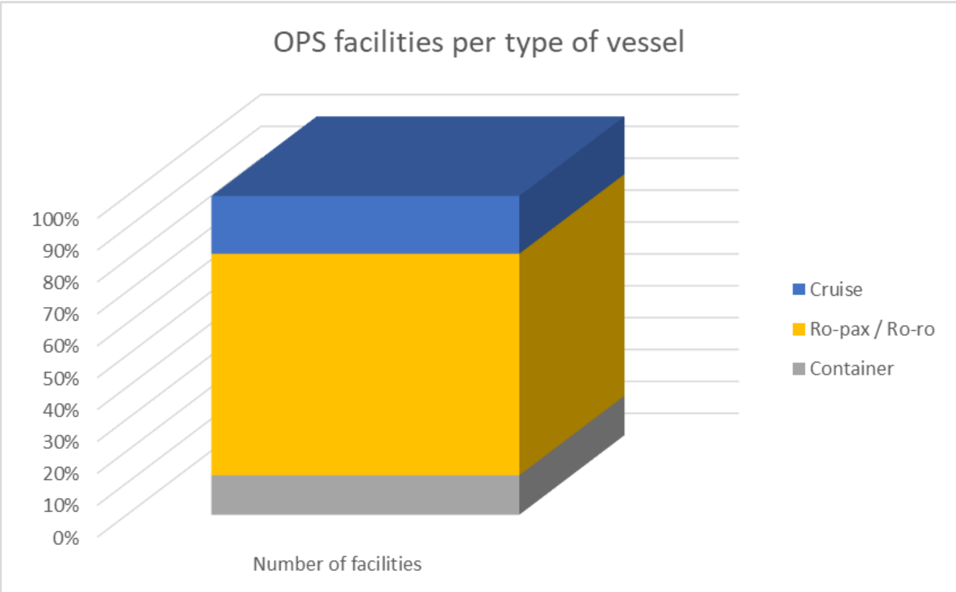

Figure 6. SSE systems deployed in Europe per type of vessel
Source: Own elaboration. Data extracted from WPCAP, EAFO, AFI platform DNV and additional internal EALING research

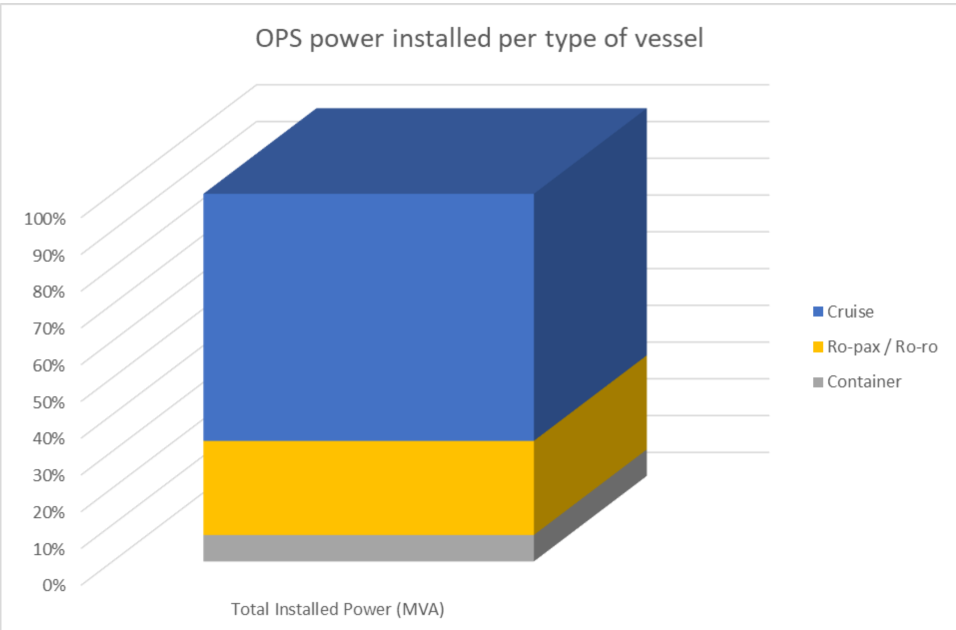

Figure 7. SSE systems total capacity installed in Europe per type of vessel
Source: Own elaboration. Data extracted from WPCAP, EAFO, AFI platform DNV and additional internal EALING research

An insight into SSE facilities installed per country in Europe for passenger and container vessels indicates that, regarding low voltage systems, The Netherlands, Norway and Sweden are at the top three positions in the list of installed power, with around 70% of the total, as can be seen in Figure 8.

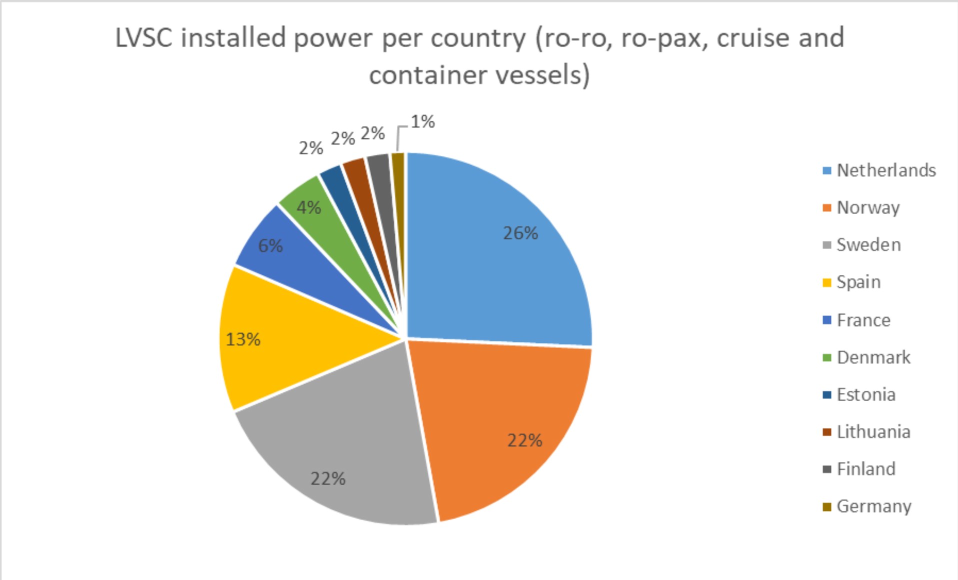

Figure 8. LVSC systems total capacity installed in Europe per country
Source: Own elaboration. Data extracted from WPCAP, EAFO, AFI platform DNV and additional internal EALING research

Regarding high voltage systems, as seen in Figure 9, Norway is in the first position, followed by Germany in terms of total power installed, with Sweden in the third position and Italy in the fourth.

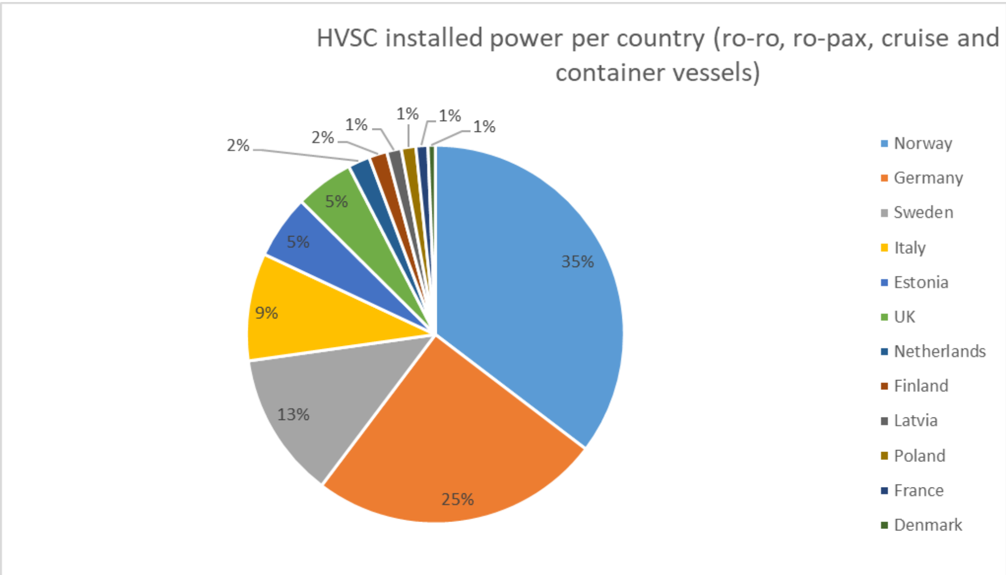

Figure 9. HVSC systems total capacity installed in Europe per country
Source: Own elaboration. Data extracted from WPCAP, EAFO, AFI platform DNV and additional internal EALING research

Market segments and main stakeholders

According to the Market Research Report published in April 2022 by MarketsandMarkets [27], the global shore power market is estimated at USD 1.6 billion in 2022 and is expected to reach USD 2.8 billion by 2027, at a Compound Annual Growth Rate (CAGR) of 11.2% during the forecast period. In this regard, the shore power demand is driven in the market due to increasing investments in SSE in ports. This is the case of the ports of Antwerp, Bremerhaven, Hamburg, Haropa and Rotterdam, when in June 2021, made a joint zero-emission shipping declaration in line with their green port strategy, emphasizing the strong business case for retrofitting or equipping large container vessels with shore power and noted the level of readiness of these vessels to use cold ironing. In this regard, more and more shipping companies are incorporating marine energy in new vessels and retrofitting existing ones due to the growing number of terminals equipped with this power and regulatory developments.

However, market growth is held back by this technology's high installation and maintenance costs. In particular, the high installation costs are due to the cost of on-board frequency conversion and the cost of supplying high-voltage electricity to the jetty. Maintenance costs are also increased by the weight of the equipment, which makes it bulky to transport and limits overall flexibility. On the other hand, the market has been affected by the uncertainty caused by the global pandemic and the coronavirus outbreak, which has posed a major challenge to the maritime market, negatively impacting the shipping sector.

The SSE industry is divided into two main stakeholder groups: the turnkey solution providers and the manufacturers. Turnkey solution providers are engineering companies, like Wärtsilä and PSW Power, that provide the complete SSE solution by the integration of products either manufactured by them or by third parties. Companies such as ABB, Siemens and PowerCon are both solution providers and component manufacturers.

Regarding manufacturers, further classification can be made among them in two main groups: the ones that provide electrical components for the SSE substation (transformers, frequency converters, etc.), with companies like Schneider Electric, General Electric, or Danfoss, and manufacturers of the shore-to-ship interfaces (i.e. Cable Management Systems, physical connectors, connection or junction boxes, etc.), with companies like Cavotec, igus, Stemmann-Technik, ShoreLink or ESL Power. The following table summarizes the overview of companies per type and country of origin.

Table 5. List of companies by type and country of origin

Turnkey solution providers	Turnkey solution providers and manufacturers	Manufacturers
• Wärtsilä (Finland) • PSW Power & Automation (Norway)	• ABB (Sweden-Switzerland) • Siemens (Germany) • PowerCon (Denmark)	• Schneider Electric (France) • General Electric (USA) • Danfoss (Denmark) • Cavotec (Sweden-Switzerland) • Igus (Germany) • Stemmann-Technik (Germany) • ESL Power (USA) • ShoreLink (Estonia)

Source: Own elaboration.

Two of the main components for SSE are transformers and cable management systems. According to Mordor Intelligence (*Transformer Market-Growth, Trends, Covid-19 impact, and Forecasts 2022-2027* [28]), the main companies supplying transformers in the European market are Siemens AG, ABB Ltd, General Electric Company, Mitsubishi Electric Company and Schneider Electric. Mordor Intelligence forecasts transformer market growth greater than 6.5% (CAGR) between 2019 and 2027. The largest market is the United States, while the fastest-growing market is Asia. The transformer market was valued at 40 billion USD in 2019 and is expected to be valued at 65 billion USD in 2027.

4.2 Main findings related to the economic scope

From the different activities carried out throughout the EALING project, different findings have been made, which have been grouped into the following points:

- Demand assessment
- Price of electricity
- Introduction of incentives
- Funding
- Sale mechanisms

Demand assessment

A lack of consistent demand has been identified as a relevant barrier for some EU ports in providing shore power. In this regard, ESPO has identified several cumulative criteria that are important in evaluating where and when SSE makes sense in European ports, which should be considered together as part of a holistic evaluation:

- *Ship type and SSE readiness of vessels.* Certain vessel types and segments are more SSE-ready than others and are already using SSE to some degree. These vessel types and segments should be prioritised, together with vessel types most suited for SSE. At first, passenger vessels, cruise vessels, and certain container segments could be considered. There is an added value for vessel types that use SSE for cargo operations at berths, such as containers and ro-ro.

- *Vessel minimum time at berth*. For SSE to be viable, vessels must spend a minimum amount of time at a particular berth. The time spent by the vessel at berth versus the time required to connect and disconnect SSE is an important factor. The time to connect varies greatly between ship types. It can take between 1-2 hours for a container vessel to connect or disconnect, whereas inland vessels and ro-ro vessels need less time but spend often spend limited time at berth.
- *Frequent and repeated calls by the same vessels:* SSE is more viable for berths serving regular calls and connections by the same ship.
- *Minimum occupancy rate of the berth:* to be worth the investment, a berth should be regularly used over an extended time. Temporary berths should be excluded.
- *New built berths:* new berths could be especially appropriate since the SSE infrastructure can be integrated into the berth planning and construction from the start, thereby limiting the costs.

All the above criteria must be considered to evaluate the expanded demand for electricity from the ships calling at a port. For this, close cooperation between shipping lines and ports is crucial.

The results of this demand assessment will also be used to develop the cost-benefit analysis (CBA), whose purpose of CBA is to facilitate a more efficient allocation of resources, demonstrating the convenience for society of a particular intervention rather than possible alternatives. Every port and possible operator should make a cost-benefit analysis of where to best deploy SSE and where and when to go for alternative solutions. This would avoid the misallocation of limited resources and ensure the feasibility of the investment.

Funding

The construction of SSE infrastructures is capital-intensive and has a long pay-back period. As described in the Port Investment Study 2018 published by ESPO [29], conceptually, a distinction can be made between the ‘business case’ of investment in port infrastructure for the port managing body and the “value case” of the investment for society at large. The business case only includes the value created for users and captured by the port managing body through charges and lease fees. At the same time, the “value case” also includes the value creation and the costs for society, including its positive and negative externalities. The figure below shows a framework to classify investment projects according to business potential and societal value.

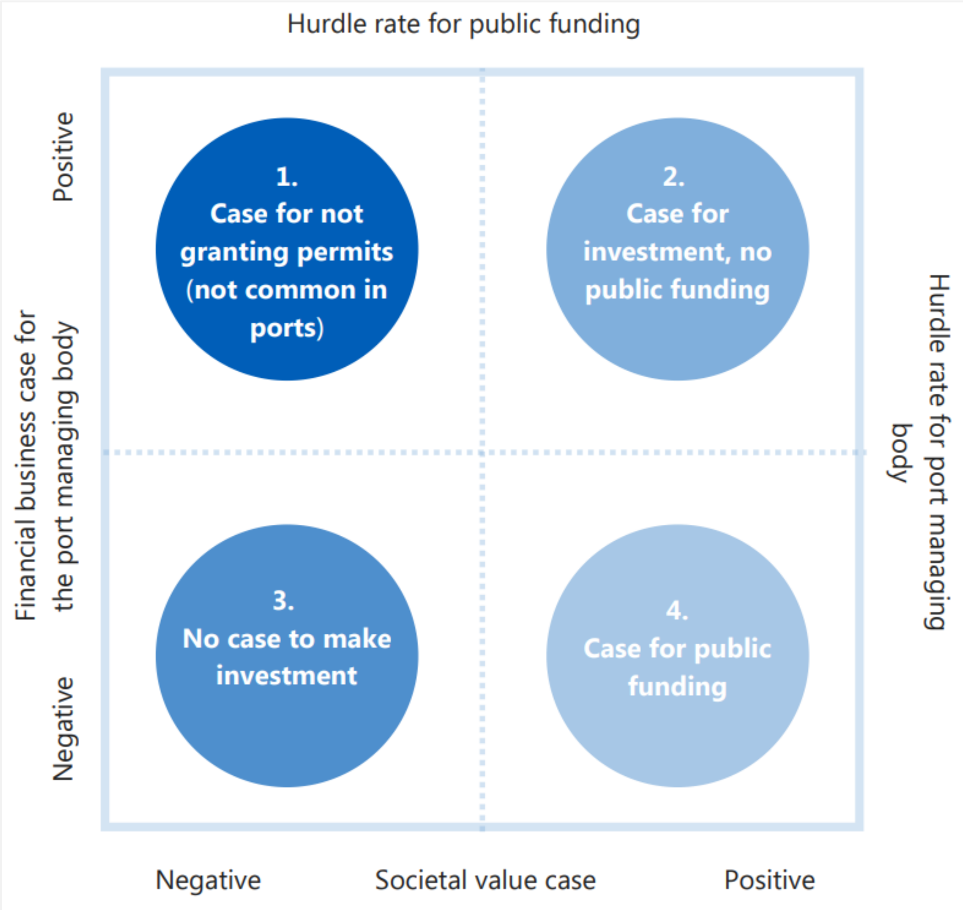

Figure 10. Investment projects framework
Source: Port Investment Study 2018 (ESPO) [29]

Public funding - that may be granted by regional, national and/or European public bodies - is legitimate for 'type 4' projects, which show a positive value case, but a negative business case.

There may also be a case for public involvement and even funding for 'type 2' projects. The combination of considerable development costs, lengthy and uncertain approval processes and high risks (societal risks associated with stakeholder acceptance of port development, political risks associated with certainty of political support and infrastructure policies and commercial risks because of long pay-back period and associated uncertainty) may lead to a very low private investor 'appetite' in port projects, even in those with a positive financial business case.

As stated by ESPO in their position paper on SSE, many European port authorities are willing to deploy SSE to facilitate the greening of shipping. The cost of developing SSE in ports varies from port to port and from location to location in the port, but overall, the cost is high, with almost no return on investment for the investing party. So far, there are no cases known where SSE has been deployed on a commercial basis, not even in countries where renewable electricity is cheaper than the fuel used on board. So far, every SSE facility has been supported by up to 50% of public financing. Substantial amounts of public funding must accompany an ambitious SSE development plan in ports to enable the deployment of SSE in ports. Next to the already existing funding mechanisms, such as the Connecting Europe Facility and the Recovery and Resilience Facility, dedicated funds for SSE investment in ports should be provided in future funding mechanisms, such as a maritime fund under the EU ETS.

When preparing the financial plan for SSE deployment, it is important to take the following aspects into account:

- High investment cost for infrastructure.
- High investment cost onboard vessels.
- High operational costs: the electricity grid tariff structure is based on a peak capacity only reached a few days per year, but the cost is based on use 24/7, 365 days per year. This creates a high fixed cost for grid connectivity, which is difficult to pass on to users.
- High energy demand peaks: depending on the segment equipped and the number of plugs installed in the port, necessary electrical power reserves could reach peaks that will be difficult for ports to plan for in terms of energy storage and adequate supply. Depending on the types of ships, electrical power reserves can reach very high levels of up to 16 MVA.
- Unlevel playing field for taxation of electricity: there are only temporary tax exemptions for SSE on a national basis, which must compete with permanently tax-exempt oil-based products.
- Split responsibilities: it is necessary to consider the need for grid connectivity investments outside the port area and to define who is responsible for these.
- High risk: as a result of the previous points listed above, private and public investments are made less likely by the high degree of uncertainty and financial risk associated with SSE.

Some examples of funding mechanisms used in some non-EU countries are:

- **Canada**: Transport Canada – the federal institution responsible for transportation policies – launched the *Shore Power Technology for Ports Program (SPTP)* in 2012. This provided C$19.5m in funding to shore power projects. Funding was usually matched with regional funding or investment from other public sources. For example, the SPTP program contributed C$5m to the Port of Montreal's Alexandra Pier Shore Power Project in 2015. The Government of Quebec provided C$5.1m, with Quebec Port Authority contributing the final 25% - C$3.4m. The fund closed in 2015. Other projects have been funded by federal and other public sources in earlier guises of this programme, including the Prince Rupert Port Authority, which received approximately 70% of the project cost from public sources for the Fairview Terminal shore power project for container ships in 2010 [30] .
- **Norway**. Norway has several grant schemes for emissions reductions. Concerning SSE, there are two main support schemes. The first one, called Enova, has provided significant support to shore power projects. Enova is a Norwegian state funding body established in 2001 to accelerate Norway's energy transition. Enova's support scheme can contribute up to 50% of the costs of such a facility. Since 2016, this grant scheme has provided support for a total of 119 shore power projects with more than NOK 842 million.

The following figure shows the top four projects funded in 2021 [30]:

Major Fundings in 2021	Funding USD (Million)
Port of Oslo- Shore Power for cruise ships on Revierkaia	3
Port of Oslo-Shore Power for container ships at Sydhavna	0.5
Fjuel Tromsø-development of Shore Power plant Troms Freezing Terminal, Tromsdalen	0.2
Fjord Base-Kai D	0.3

Figure 11. Top four projects funded in 2021 by the Enova fund
Source: Power Technology Research

SSE projects can also be funded by the NOx fund, owned by 15 business organizations to reduce NOx in Norway, which allows businesses to pay into the fund at a lower rate than the tax imposed in 2008 in Norway. Payments to the fund are returned to the industry as investment support, and those that invest pay less after the measure is implemented.

In the case of EU countries, a clear example of a funding mechanism is the Climate Leap initiative (Kimatklivet) of the Environmental Protection Agency of **Sweden**, which aims to reduce the emissions that affect the climate. Two examples of ports that have benefited from the Kimatklivet funding are 1) Port of Gothenburg, which is expanding its shoreside power network to the Energy Port and will connect tankers to shore power in 2023, and 2) Port of Stockholm, which is equipping two city quays with SSE connection for cruises. It is worth noting that the Climate Leap initiative is also available for shipping lines committed to reducing their emissions. An example is DFDS, which has received funds to retrofit their ships to shore-side electricity.

Port incentives

In relation to incentives, they play an important role in encouraging ship owners to invest in SSE. One relevant initiative that is used by ports to reward cleaner vessels by offering, for example, discounts on their port fees is the Environmental Ship Index (ESI), already described in the environmental scope section. However, ESI is completely voluntary, and only a few ports in the European Union participate as incentive providers, as shown in the following figure.

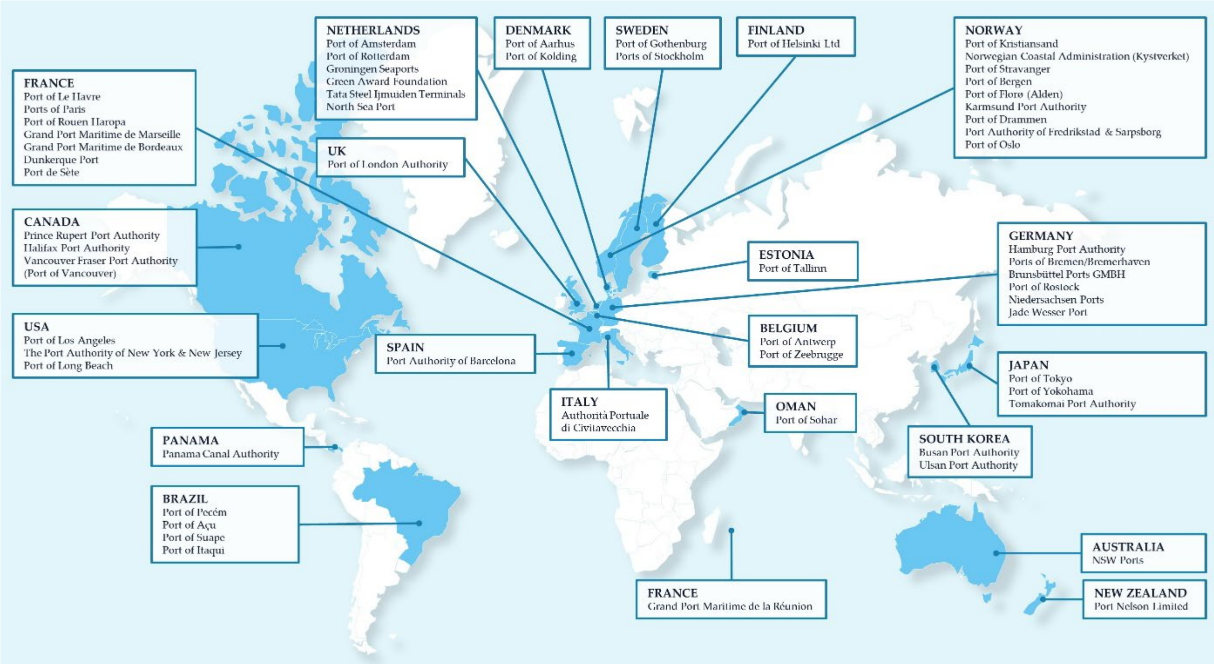

Figure 12. Ports participating in the ESI
Source: Environmental Ship Index

Apart from this kind of initiative, another important way to support the SSE deployment is the reduction of port fees at the port level to those ships that connect to the electricity grid when docked, as it is the case, for instance, in Spain, where ports can apply a 50% rebate on port fees. However, as analysed in the EALING project, most of the ports of the consortium have not issued any national regulation, including provisions for tax incentives (for more information, please refer to Milestone 4 of the project).

<u>Price of electricity</u>

The price of electricity compared to marine diesel is consistently raised as a barrier to the take-up of shore power. Currently, electricity produced from the combustion of marine fuel on board ships is tax-exempt. However, when ships at berth are plugging into the shore-side electricity system, they must pay taxes applied to electricity. When building a business case, a port must be confident that the electricity will be able to compete against marine fuel and any potential alternatives that might appear in the longer term. Ports will usually also need to add their margins to the electricity to recover their investment costs.

As stated in the report *Examining the Barriers to Shore Power* [31], published by the British Ports Organisation, both the prices of electricity and the price of marine diesel fluctuate, and different shipping owners and operators (and indeed ports) will have differing buying power when negotiating prices. This makes direct comparisons more difficult. Shipping is a highly competitive industry, and it is clear to ports that shipowners – like most commercial organisations – will, in most cases, take the cheapest viable option on energy. Therefore, whilst using auxiliary engines is the more affordable option, and with no regulation in place to prevent it (notwithstanding IMO and emissions control area rules), it will be difficult for shore power to compete. Consumer-facing sections of the shipping industry, such as cruise, may opt for shore power for their reputation or because customers demand it. Pressure may also begin to fall on carriers from investors, which may change behaviour. Still, for most shipping, the cost will remain the primary driver of choice between using auxiliary engines and plugging in, where available.

Regarding the taxation of energy products and electricity in the European Union (Energy Taxation Directive), the European Parliament's Transport Committee has supported the removal of tax barriers for the uptake of shore-side electricity supply SSE in ports for ships at berth. Accordingly, Sweden, Italy, Germany, Spain, and Denmark have been provided under the Energy Taxation Directive with a permit to temporarily apply a reduced rate of taxation to shore-side electricity for ships.

Energy sale mechanisms

Nowadays, authorised market agents can purchase electricity at wholesale power exchange markets in the European Union. At present, the direct stakeholders of SSE include power grid utilities, port authorities, and shipping companies [32].

In general, shipping companies bear the costs of modifying ships to use SSE and pay the shore-side electricity fee to the port authorities. Shipping companies may achieve economic benefits by using onshore electric power to save fuel costs. Port authorities are responsible for the investment and operation of SSE equipment and pay electric power supply charges to energy retailers. Port authorities achieve economic benefits and recover investment costs from the price difference between onshore electric power and electric power supply charges. Power grid utilities provide the electrical infrastructure to supply the energy needed to the port, whereas retailers will charge the port authorities for the energy delivered, obtaining their margin of benefit in the tariff applied. The energy supply fee charged by retailers should be subject to the electricity price specified in the state tariff. Besides, port authorities can charge the service fee from ships for using onshore electric power [33]. This fee can be determined by port authorities independently.

The investment in SSE infrastructure implies enormous costs. To recover this cost, port authorities may opt to increase the onshore electric power price, increasing shipping companies' cost in energy consumption.

However, higher energy prices than fuel prices, coupled with huge investment costs, have seriously weakened the enthusiasm of shipping companies to adopt shore-side electricity and reduced the willingness of port authorities to invest in shore-side electricity infrastructure. Therefore, the price of shore-side electricity is crucial for promoting and implementing SSE.

Some options to be considered that may have a positive impact on the electricity price are the following:

- Port Authorities purchase electricity in power exchange markets: The voltage of electricity offered by the electric power grid to the shore-side electricity system might vary between 10 and 20 kV, which meets the voltage requirement of power exchange markets for electric power user access. Port enterprises can enter these electricity markets as electric power users. They can directly participate in market transactions to purchase electricity or entrust specialized market agents as intermediaries. Furthermore, the annual electricity consumption of the shore-side electricity is generally above a million kilowatt-hours. Port authorities may have strong bargaining power as big users in the wholesale power exchange market. They can obtain preferential electricity price contracts through bilateral negotiations with power producers in the form of Power Purchase Agreements (PPA). As a result, port enterprises may significantly reduce electricity prices if a good power purchase strategy is applied. This action has its associated risks, price fluctuation one of them, in case the port opts to buy energy in the spot market. However, purchasing power directly in the market comes with several requirements, such as being an authorized market agent or signing a representation contract with one of them, proving sufficient economic capacity and reaching a minimum annual energy consumption, which might be in the order of GWh. For port authorities that choose not to participate in power exchange market transactions, the peak-valley time price of electricity should be improved in case of having a Time-Of-Use tariff (TOU) contracted with the energy retailer. The energy cost of the port would be reduced by using more energy in the valley periods; however, this is completely dependent on when the ships will call at the port.

- Energy companies guarantee the operation revenue of SSE: The minimum profit rate of ship enterprises using onshore electric power can be compromised by energy retailers. Specific agreements should ensure the economic benefits of shipping companies adopting shore-side electricity.

- Energy companies rent out electric power equipment: For the implementation of a shore-side electricity installation, the electric power equipment used onshore or onboard is purchased by an energy company, such as a retailer, or a third party, like an ESCO (Energy Service Company). Afterwards, electric power equipment is rented to port or ship enterprises based on contract conditions, such as arranged time and interest rate. The lease term separates electric power equipment's ownership and usage rights. Port or ship enterprises pay rent fees by instalment and obtain the right to use electric power equipment. The ownership of electric power equipment belongs to the ESCO. When energy retailers recoup the investment and interest of purchasing equipment by selling electricity, port or ship enterprises can pay the promissory price of electric power equipment based on the agreement and own the equipment. Either the lease contracts of electric power equipment can be designed to reduce the lease cost of port or ship enterprises. The energy retailers can rent out the electric power equipment in dynamic, synthetic, and shared rentals. Dynamic rental refers to the rental fee paid by port or ship enterprises to energy retailers linked with the economic benefit of shore-side electricity. The rent fee for electric power equipment can be maintained at a high level when the financial benefit of the shore-side electricity is good. On the other hand, the rental fee for electric power equipment can be reduced or even maintained at zero when the economic benefit of shore-side electricity is poor.

- Energy companies undertake investment and operation of SSE: Energy companies, such as energy retailers or ESCO, can undertake all or part of the investment cost of onshore equipment or modification cost of ships based on their knowledge of funds and technology. They can also be responsible for the operation of onshore electric power equipment. Energy retailers can provide port or ship enterprises with shore-side electricity services, including system design, technology selection, project financing, equipment procurement, equipment installation, system operation and maintenance, personnel training, and electricity monitoring. ESCO recoup the cost of investment through the sale of electricity [33].

- Energy companies provide value-added service of SSE: Through technologies of big data, cloud computing, the internet of things, and mobile internet, the information interaction between equipment of shore-side electricity and port energy network can be actively promoted by energy retailers or IT providers. Because of the various quantity of electricity consumption and means of payment, port and ship enterprises can be provided with personalized settlement service of electricity charges for using shore-side electricity. At the same time, other value-added services, including maintenance of electric power equipment, training of electricity utilization skills, and advertising, can be actively expanded and carried out to improve the electricity consumption experience of port and ship enterprises. The intelligence level of value-added services of shore-side electricity can also be enhanced.

This section concludes that new shore-side electricity and sale mechanisms can encourage port authorities to participate in power transactions actively and purchase electricity in the electricity market. Energy retailers can be encouraged to participate in the projects of shore-side electricity in various ways, such as guaranteeing the operation revenue of shore-side electricity, renting out electric power equipment, undertaking the investment or operation of SSE, and providing value-added services.

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4.3 Recommendations focused on the economic scope

The following table shows a summary of the recommendations proposed on the economic scope based on the different activities performed in the EALING project:

Table 6. Summary of recommendations – economic scope

Recommendations – economic scope
• Develop detailed power demand studies at the port level to know its future energy needs. Close cooperation between shipping lines and ports should be then encouraged.
• Develop a Cost-Benefit Analysis before implementing any SSE infrastructure to avoid the misallocation of limited resources and ensure the feasibility of the investment. In the CBA, it is important to consider if the grid upgrade is needed to operate the SSE installations.
• Consider the following aspects in any feasibility study for an SSE project (market/financial/economic aspects): demand evaluation; customized/tailored contract; electricity pricing and opportunities; competitors; market and financial evaluation; evaluation of economic cost-benefit; and impact assessment of shore side electricity in port/local economic profile.
• Create additional funding mechanisms (e.g., maritime fund under the EU ETS) to cover a bigger part of the needed investments. Existing mechanisms (Connecting Europe Facility, Recovery Funds) are not sufficient to reach the desired deployment.
• Increase the percentage of funding in existing mechanisms. 30-40% is still too little for the important investments needed in European ports.
• Have a permanent and comprehensive EU-wide tax exemption for the use of SSE in ports under the Energy Taxation Directive, which would put it on an equal footing with electricity generated on board ships and produced from tax-free marine fuel combustion.
• Encourage the application of port fee rebates for shipping companies at the ports at the EU level.
• Establish and/or negotiate an electricity tariff at the national level (or regional, depending on the context) that allows for competitive and predictable rates, thus encouraging shipping companies' decision to connect, especially in cases where they are not obliged to do so. The final price paid for the electricity is an aggregation of different concepts, such as tariffs for the use of transport and distribution grids, or taxes. In some countries, besides the energy delivered, the power supplied is also charged as a separate term. Different prices may also be applied as a function of the hour, the day, or the season (Time Of Use or TOU tariffs); or, in other cases, the tariff could be indexed to some market value, like the power exchange spot market (Real Time Pricing or RTP tariffs). Regarding SSE, tariffs that consider a fixed charge for the maximum power supplied or contracted are a barrier to the infrastructure's cost-benefit outcome. Specific rates

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for SSE that consider its special characteristics (for instance, a variable power rate) would contribute to a better economic result.

- Incentivise, at the European Commission level, the interaction between shipping companies, port authorities, solution providers and energy suppliers through specific working groups.
- Encourage EU ports to join the ESI index, thus encouraging ships to connect to shore-side electricity.
- Consider the port as an energy community, as indicated in section 3.
- Create a mechanism whereby the price of energy depends on the destination of the energy, favouring those consumers who contribute to meeting the objectives of the European Green Deal, as is the case with the SSE.

5 ENVIRONMENTAL SCOPE

5.1 Outlook of green energy production for SSE

One of the fundamental aspects of SSE facilities is the origin of the energy. From an environmental point of view, the energy mix that the European Union can offer in the context of the Green Deal and the future takes different paths depending on the country under consideration. This clearly impacts the certifications that energy companies offer their end customers regarding the origin of this energy. This issue impacts SSE-oriented port facilities for supplying ships. In addition, ports are often part of the cities that host them (91% in the EU), so future energy demand must also consider the grid capacity to avoid supply problems.

The current Renewable Energy Directive 2018/2001/EU [34] entered into force in December 2018 as part of the "*Clean Energy for all Europeans Packages*", aimed at keeping the EU a global leader in renewables and, more broadly, helping it to meet its emissions reduction commitments under the Paris Agreement. The directive states that the increased use of energy from renewable sources has a key part to play in promoting the security of energy supply, sustainable energy at affordable prices, technological development and innovation, as well as technological and industrial leadership while providing environmental, social and health benefits, and major opportunities for employment development.

In particular, reducing energy consumption, increasing technological improvements, incentives for the use and expansion of public transport, the use of energy efficiency technologies and the promotion of the use of renewable energy in the electricity sector, the heating and cooling sector and the transport sector are effective tools, together with energy efficiency measures, for reducing greenhouse gas emissions in the EU. The directive establishes a new binding renewable energy target for the EU for 2030 of at least 32%, with a clause for a possible upwards revision by 2023. This target is a continuation of the 20% target for 2020. To help EU countries meet this target, the directive introduces new measures for various sectors of the economy, particularly on heating and cooling and transport, where progress has been slower (for example, an increased 14% target for the share of renewable fuels in transport by 2030). It also includes new provisions to enable citizens to play an active role in the development of renewables by enabling renewable energy communities and self-consumption. It also establishes strengthened criteria to ensure bioenergy's sustainability. In 2021, the EC proposed to raise the target of the use of renewable energy for 2030 to 40% in the framework of this directive.

The new geopolitical and energy market reality requires a clean energy transition and an increase in energy independence from unreliable suppliers and volatile fossil fuels. The RepowerEU Plan sets out a series of measures to rapidly reduce dependence on Russian fossil fuels and fast forward the green transition while increasing the resilience of the EU-wide energy system. It is based on 1) diversifying – working with international partners to find alternative energy supplies; saving from the citizen, businesses, and organisations; and accelerating clean energy – renewables are the cheapest and cleanest energy available.

The Commission is proposing to increase the EU´s 2030 target for renewables from the current 40% to 45%. RePowerEU Plan would bring the total renewable energy generation capacities to 1,236 GW by 2030, in comparison to the 1,067 GW by 2030, envisaged under Fit for 55 for 2030. It also includes a regulation to increase energy efficiency in the transport sector.

Within this context, the concept of guarantee of origin plays an important role in determining the emissions reduction of the SSE facilities compared to the use of current fuels during ship calls. Promoting electricity from renewable energy sources and high-efficiency cogeneration is a priority objective for the European Union and its Member States for the security and diversification of energy supply, environmental protection, and economic and social cohesion. Furthermore, the exploitation of renewable energy sources can be a source of local employment, positively impact social cohesion, contribute to the security of supply and help to enable the objectives of the Kyoto Protocol to the United Nations Framework Convention on Climate Change to be met.

The guarantee of origin is an accreditation issued at the request of the interested party, which ensures that a specific number of kilowatt-hours of electrical energy produced in a plant in a specific period of time have been generated from renewable energy sources, defined in the *Directive (EU) 2019/944* [35] *on common rules for the internal market for electricity* as the energy coming from renewable non-fossil sources namely wind, solar (solar thermal and solar photovoltaic) and geothermal energy, ambient energy, tide, wave and other ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogas.

From a practical point of view, one of the environmental recommendations is that 100% of the energy supplied for SSE purposes to ships should be from renewable sources since the carbon footprint that would theoretically be avoided is 100% of the emissions generated by the burning of fossil fuel by the ship during the call.

5.2 Overview of environmental aspects regarding SSE installations

Currently, it is impossible to disaggregate the various emissions in ports to quantify those related to the transport. Still, further understanding of the specific contribution of the various port-related activities to air quality in the ports is not possible considering the current air quality monitoring systems. Nevertheless, the increased levels of NOx, SOx and PM in the air impact the health of the citizens in port cities and coastal areas.

Some of the pollution consequences due to the use of current fuels during port calls is the atmosphere deposition due to combustible particles and noise pollution due to the propeller, machinery, and the movement of the hull through the water. The auxiliary engine and other systems represent between 10 Hz to 10 kHz of frequency range with a low impact on the marine environment but a medium impact on the ship environment.

Replacing the power supply system of the vessels with the energy from an onshore facility effectively reduces the emissions while reducing the frequency of vibrations and the noise level in the port. Indeed, in the European Maritime Transport Environmental Report (EMTER) 2021 [36] published by EMSA and EEA[1], which comprises information about the international and EU environmental standards for maritime transport, it is stated in the report that SSE is a promising solution to improve air quality in ports and coastal areas. If the electricity supply relies on clean and renewable energy sources, SSE can reduce emissions to zero and decrease noise levels.

5.3 Environmental certificates and monitoring and reporting schemes

Several practical, bottom-up initiatives are voluntarily implemented by port management bodies. Overall, under EMTER report, at least 30 ports in the EU are operating at least one environmental charging scheme. Of these 30 ports, 25 offer rebates on port dues ranging from 0.5% to 20% to vessels certified under the Environmental Ship Index, the Green Award, the Clean Shipping Index, and the Blue Angel ecolabel.

Environmental Ship Index (ESI)

The Environmental Ship Index (ESI) identifies seagoing ships that perform better in reducing air emissions than required by the current emission standards of the International Maritime Organization (IMO). This initiative started in 2011 under the umbrella of the IAPH through the World Ports Sustainability Program project, and currently, over 8,000 ships benefit from it at more than 50 ports. The ESI evaluates the amount of nitrogen oxides and sulphur oxides that are released by a ship and includes a reporting scheme on the greenhouse gas emission of the ship. ESI has become the standard tool used by the world´s ports to reward and incentivise shipowners and exceed IMO emissions standards. The ESI Administration is managed and operated by Green Award Foundation. Moreover, it is a voluntary system designed to illustrate the environmental performance of sea-going vessels, providing a numerical representation of the environmental performance of ships regarding air pollutants and CO2 and noise. Also, it scores NOx and SOx emissions directly and proportionally; it gives a fixed bonus for documentation and management of energy efficiency and the installation of zero-emission at berth technics, for instance, shore-side electricity.

1 European Environment Agency

Green Award

Green Award is a voluntary quality assessment certification scheme that inspects and certifies ships. Its mission is to identify, recognize and motivate environmentally responsible shipping through operating a non-profit certification scheme that assesses the safety and environmental performance using criteria in the following areas: ship lay-out and equipment, quality of the organisation/management; human factor; and continuous improvement. Up to now, over 1000 ships certified (inland and sea) and over 145 incentive providers, including ports and maritime service providers, have participated.

Regarding environmental issues, the main requirements to be awarded by the Green Award are SOLAS – Noise level onboard ships; MARPOL NOx emission limits; noise and vibration management; shore-side electricity; and prevention of pollution, including GHG and pollutants.

Clean Shipping Index

This is an independent and holistic labelling system of vessel's environmental performance, a practical tool for differentiating port and fairway fees or choosing more sustainable shipping alternatives. The basis of the index is a digital questionnaire covering general information about the shipping company as well as vessel-specific information. A key point is that this process goes beyond existing regulations and covers vessels of all types. Vessels are scored in SOx, NOx, CO2, PMx, chemicals and water & waste. Final scores for vessels are based on the outcome of the questionnaire. A total of 150 points can be obtained, 30 points for each of the parameters. The final score results in CSI Class 1-5 being five, the best score from 125 to 150 points. The emissions from auxiliary engines are included. When shore-side electricity or plug-in battery power is claimed, the same requirements are included for all the pollutants. In a port, the port tariff can be differentiated to those vessels with high environmental performance and, at the port, get a rebate on the port tariffs.

Blue Angel Ecolabel

The purpose of awarding the Blue Angel eco-label (German Federal Government) to environmentally friendly ship operations is to reduce emissions and releases of harmful substances from sea-going vessels into the marine environment. To achieve this goal, particularly high demands are placed not only on the shipping company and onboard management but also and above all, on measures to reduce emissions. The combination of these factors considers the complexity of the subject matter of environmentally friendly ship operation. The external energy supply while in port through onshore power supply or other external power generation means is one of the criteria that are evaluated for obtaining the Blue Angel Ecolabel.

In addition to environmental certificates, several reporting and monitoring initiatives, such as those described below, can contribute to the SSE deployment in EU ports.

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THETIS-EU

THETIS-EU is the EU-MRV system to report CO2 emissions from ships according to the EU Regulation 2015/757 [37] . This initiative serves as a platform to record and exchange the results of individual compliance verifications performed by the Member States. Since 2017, this robust integrated web-based automated reporting and notification system has allowed the publication of reliable data on ships´ carbon dioxide emissions. This tool supports the EC in fulfilling their monitoring and reporting obligations. Its scope is also aligned with the EU monitoring, reporting and verification (MRV) systems, with international initiatives to introduce efficiency standards for existing ships. One piece of information collected is the total CO2 emissions that are verified and accredited by an independent body.

IMO DCS (Data Collection System)

IMO adopted a mandatory Fuel Oil Data Collection System for international shipping to start collecting and reporting data to an IMO database from 2019. It was adopted by the IMO´s Marine Environment Protection Committee in October 2016 as amendments to Chapter 4 of Annex VI of Marpol, coming into force in March 2018. The fuel oil data report requires the following elements: the method used to measure fuel oil consumption; fuel consumption for each type of fuel; hours underway and distance travelled; power output (auxiliary engine(s) and main propulsion power); other information such as ice class (if applicable), EEDI, DWT, NT, GT, ship type, IMO number, start and end dates. The fuel oil data report shall be submitted to the Flag Administration, or any organization duly authorised by it for verification.

The following figure shows the differences between the EU MRV and the IMO DCS.

	EU MRV	IMO DCS
Entry into force	1st July 2015	1st March 2018
Scope	Ships above 5'000 GT Voyages to / from EEA ports of call	Ships 5'000 GT or above International voyages
First monitoring period	2018	2019
Procedures	Monitoring Plan (37 sections)	Data Collection Plan (SEEMP Part II) (9 sections)
Compliance (procedures)	Assessment Report (no need to be on-board)	Confirmation of Compliance (must be on-board)
Reporting	Fuel consumption (port / sea) Carbon emissions Transport work (actual cargo carried) Distance sailed Time at sea excluding anchorage	Total fuel consumption Distance travelled Hours underway Design deadweight used as proxy
Verification	Independent accredited verifiers	Flag administrations or Authorized Organizations
Compliance (reporting)	Document of Compliance (June 2019)	Statement of Compliance (May 2020)
Publication	Distinctive public database	Anonymous public database

Figure 13. Main differences between EU MRV and IMO
Source: www.verifavia-shipping.com

In relation to IMO DCS, it is worth mentioning the **CII (Carbon Intensity Indicator)** that measures how efficiently a vessel above 5,000 GT transports goods or passengers (applicable to all cargo, RoPax and cruise ships) and is given in grams of CO2 emitted per cargo-carrying capacity and nautical mile. It is calculated based on the reported IMO DCS and the ship is given a rating from A (major superior) to E (inferior performance level). For ships that achieve a D rating for three consecutive years or an E rating in a single year, a corrective action plan needs to be developed as part of the SEEMP Part III (Ship Energy Efficiency Management Plan). From 2024, at the latest by 31 March, the CII must be calculated and reported to the DCS verifier together with the aggregated DCS data for the previous year, including any correction factors and voyage adjustments.

5.4 Environmental legal framework affecting the construction and operation of SSE installations

Concerning the environmental aspects contributing to the electrification of EALING participating EU ports and the formation of a harmonised regulatory framework on SSE for vessels calling at EU ports, it should be noted that the main national regulations related to environmental impact and noise pollution issues which are also regulated for the development of SSE facilities in ports, are based on Directives of the European Parliament and of the Council. Specifically, the 8 participating EU Member States (Spain, Italy, Greece, Romania, Bulgaria, Portugal, Ireland, and Slovenia) in EALING Action have already integrated into their national legislation EU Directive 2001/42/EC [38]of the European Parliament and the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment as well as EU Directive 2011/92/EU [39] of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment.

In addition and complementarily to the aforementioned EU Directives, in the majority of the participating Member States of EALING Action, EU Directive 2005/33/EC of the European Parliament and of the Council of 6 July 2005 concerning the Sulphur content of marine fuels[2] (and subsequent related directives) have been transposed into their national legislations and constitutes an initial legislative act related to environmental aspects that paved the way towards the adoption of shore-side electricity as an alternative solution at European ports. As mentioned above, provisions of IMO MARPOL 73/78 – Annex VI – Regulations for the prevention of air pollution from ships were also included in the general regulatory framework related to environmental issues and simultaneously contributing to the SSE development at EU ports.

As concerns the environmental aspects of port facilities for electricity production offering shore-side electricity to vessels calling at their ports, EU Directive 2015/2193 [40] of the European Parliament and of the Council of 25 November 2015, on the limitation of emissions pollutants into

[2] EU Directive 2005/33/EC

the air coming from combustion plants for obtaining environmental titles must also be taken into consideration. Furthermore, energy efficiency can be achieved by shore-side electricity at European ports derived from renewable energy sources and is included indirectly in EU Directive 2012/27/EU [41] of the European Parliament and of the Council of 25 October 2012 on actions for improving energy efficiency and reduction of GHG emissions including the use of renewable energy sources (RES).

National laws of each Member State based on these EU Directives include a list of projects that also take into consideration the technical specifications of SSE facilities as a subject of an ordinary or simplified Environmental Impact Assessment. In detail, the national regulatory framework of each Member State participating in EALING Action includes regulations that refer to different environmental assessment approval decisions for port infrastructures development depending on the type of the proposed infrastructure and the significance of the impacts on the environment due to the construction works of each proposed port infrastructure (very significant impacts on the environment, or significant impacts on the environment, or local but not significant impacts on the environment).

These mandatory environmental assessment procedures leading to the required environmental permittances take place before the construction works of facilities and installations at commercial ports, terminals for loading and unloading connected to land and public transport ports, as well as before construction works for the development or expansion of electricity transmission lines close to the ports.

Specifically, national regulations in each participating Member State of EALING Action concerning the environmental impact procedures define the specific requirements, the procedure, and the scope of assessment on the conditions and procedure in order to perform the assessment of the compatibility of plans, programs, projects and investment proposals with the subject and objectives of conservation of the environment.

Towards the general framework for SSE facilities development at European ports are the issuance of National Strategies for Sustainable Development in some of the EALING European Member States aiming at the reduction of air emissions into the atmosphere, the National Action Plans for environmental sustainability and the EU Directive 2008/50/EC [42] of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe for reducing harmful effects of greenhouse gas emissions on human health and the environment. Contributing to the establishment of shore-side electricity as a port service at European ports, the EU Regulation No. 757/2015 [43] of the European Parliament and of the Council of 29 April 2015 on the monitoring, reporting and verification of carbon dioxide emissions (CO_2) from maritime transport should also be referred. Moreover, regional environmental energy plans promoting energy savings and energy efficiency, as well as diversification of energy sources for the transportation sector, contribute to the promotion of SSE installations at ports and the production and use of shore-side electricity in the maritime sector. At the national level, climate actions, low carbon planning and development plans, air quality plans and noise maps of ports in the majority of the participating European Member States in EALING Action constitute part of the overall legislation focused on environmental issues of SSE facilities development in EU ports and contribute towards the radical electrification of ports and of the maritime transport in the European Union.

The majority of EALING participating EU Member States have transposed into their national legislations the EU Directive 2002/49/EC [44] of the European Parliament and of the Council of 25 June 2002 related to the assessment and management of environmental noise during the implementation of construction works at ports, also including the SSE installations development and the definition of ports as acoustic easement zones which must comply with noise emission limit values. At the national level, separate strategic noise maps for noise emitted by water transport could be included within the strategic port maps for specifying noise emission limit values applicable to port infrastructure and activities (including SSE facilities deployment).

However, although the complex regulation is to be considered when implementing SSE installations, it should be noted that the environmental impact of the implementation is small and, compared with the benefits from the SSE, almost negligible.

5.5 Recommendations focused on the environmental scope

Based on the previous sections, the following table shows a summary of recommendations focused on the environmental scope proposed by the EALING consortium.

Table 7. Summary of recommendations – environmental scope

Recommendations – environmental scope
• Promote the creation of an environmental certificate addressed to shipping lines, focused on the use of electricity when at berth, following the example of ESI, Green Award, CSI, or Blue Angel label. Ports could use this index to reward ships that have better environmental performance and especially SSE compatibility beyond regulatory requirements, but shipping companies could also use it as a promotional instrument.
• Encourage the registration of ships in the Clean Shipping Index (CSI). Any vessels equipped onboard with the required SSE technology achieving a high score in CSI could access rebates in the participating European ports.
• Include in the THETIS MRV scheme and IMO DCS information on the technical specifications of each ship to facilitate the SSE service during the port calls.

Note: other recommendations closely linked to the environmental scope are included in the policy/legal and economic scope sections.

6 SOCIAL SCOPE

6.1 Overview, findings, and challenges related to the social scope

Emission reduction is the main incentive for the implementation of SSE, as air pollution represents a major environmental health risk. Using traditional fuels to generate energy while in port, ships emit particulate matter (PM) and nitrogen oxides (NOx). Ships are also responsible for most sulphur oxides generated in the port environment. The European Environment Agency (EEA) estimated that in 2019, 307,000 people died prematurely due to exposure to fine particulate pollution in the EU. Connecting to the electricity grid makes it possible to eliminate these pollutants, thus improving the local population's health.

SSE eliminates the presence of these harmful elements along with the noise generated by the auxiliary engines, which greatly benefits the population. In addition, it eliminates the vibrations caused by the operation of auxiliary engines, thus improving the comfort of the crew and passengers on board. Therefore, SSE deployment is expected to produce a high value for port stakeholders and citizens.

For this reason, **cooperation between port, shipping and city stakeholders** is crucial to 1) address citizens' concerns related to the quality of life near ports, 2) raise awareness among all actors of the importance of working together for the common benefit of improving the health of citizens; and 3) receive the necessary public financial support, not only to develop the SSE facilities but also to invest in the external grid to ensure that there is no lack of capacity that impacts on the lives of citizens. Ensuring cooperation between port and city stakeholders would avoid situations such as not being able to supply power to ships due to a lack of capacity in the city grid.

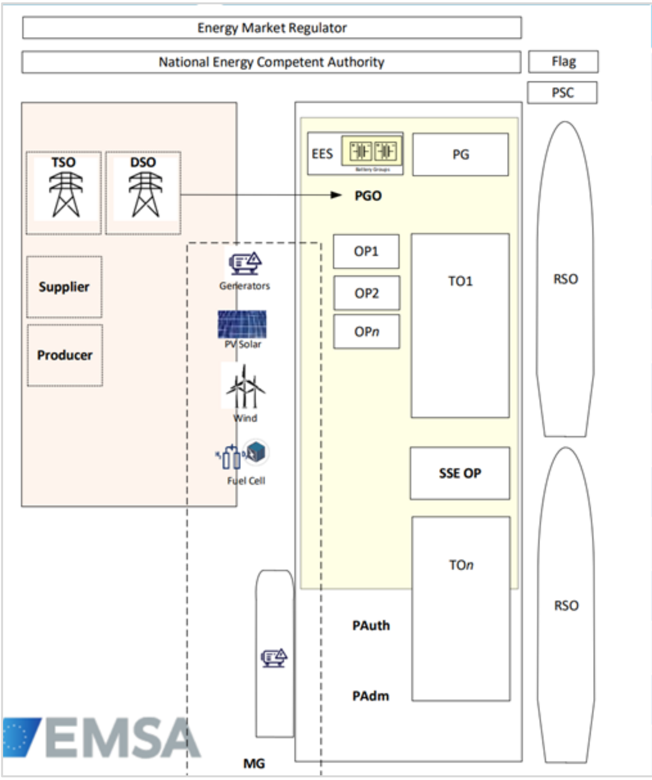
As for the actors involved in the operational part, different actors participate in SSE projects and assume different roles and responsibilities, as shown below.

Table 8 Shore-side electricity stakeholders

Stakeholders		Role in SSE context
TSO	Transmission System Operator	Transmission of electrical power at the national/regional level, between generation plants (upstream) and distribution (downstream).
DSO	Distribution System	Maintenance of both short- and long-term capability of equipment, installations, and networks to supply electricity continuously and

	Operator	reliably while meeting the quality requirements in force.
CA/ MBP	(Port) Competent Authority/ Management Body of the Port	Ref. to Regulation 2017/352 – Port Services Regulation Articles 2(3) and 2(5) – organisation, administration, and management of the port infrastructure and one or more of the following tasks in the port concerned: the coordination and management of port traffic, the coordination and control of the activities of the operators.
RSO	Receiving Ship Operator	Shore side electricity (SSE) ship consumer at berth, responsible for ensuring interoperability and interconnectivity on the ship side. 1st connection certification and maintenance of conditions for connectivity. Responsible for keeping the load.
OP	Intra-Port Operator	Port operators/port service operators are responsible for the maintenance of consumer-side protection devices and electrical safety in line with Intraport electricity electrical grid requirements.
MG	Microgeneration	Any operator is developing and operating units of microgeneration of electricity, integrated within the port, supplying electrical power to the port grid.
TO	Terminal Operator	Management and operation of terminal grids dedicated to the terminal operation. Development, management, and operation of terminal-based SSE systems. Responsible for the electrical safety of terminal grids.
PGO	Port Grid Operator	Management, development, and operation of the intra-port electrical power grid, including SSE/SSE/SBS grid interface infrastructure.
EES	Electrical Energy Storage	Management, development, and operation of intra-port electrical power grid, including SSE/SSE/SBS grid interface infrastructure.
SSE OP	SSE Operator	Provision of electrical power to ships at berth, on SSE or SBC, AC or DC, including maintenance, development, and operation of SSE equipment.
PSC	Port State Control	Verification/enforcement of compliance with RSO statutory obligations, remarkably in the context of safety, including safety and certification of SSE equipment onboard.
Flag	Flag State	
Class	Classification Society	Third-party verification of RSO statutory responsibilities, particularly in the context of safety, including SSE equipment safety certification.
Other	International Standardization Bodies	Definition of standard technical requirements for SSE interconnectivity and interoperability.
	Regulator/ Energy Competent Authority	Definition of minimum requirements to ensure safe and integrated deployment and operation by electrical power grid operators, including those in the operation of SSE infrastructures.

Source: EMSA



Stakeholders	
TSO	Transmission System Operato
DSO	Distribution System Operator
PAuth	Port Authority
PAdmin	Port Administration
RSO	Receiving Ship Operator
OP	Intra-Port Operator
MG	MicroGeneration
TO	Terminal Operator
PGO	Port Grid Operator
EES	Electrical Energy Storage
PG	Port Generation
SSE OP	SSE Operator
PSC	Port State Control
Flag	Flag State

Figure 14. Stakeholders in shore-side electricity context
Source: EMSA

Clearly, different combinations and port-specific arrangements are possible, and both the diagram and table above include generic references to potential stakeholders in SSE.

It is worth noting that throughout the EALING project, one important barrier that has been detected is that there is no coordination between the different actors playing a role in different technical stages of SSE infrastructure projects, and this results in high consumption of time and resources.

Another very relevant aspect at the social level is **training and qualification**, not only for the SSE operation but also for everything that surrounds it. In this regard, new jobs must be developed as well as new certifications (for instance, for the correct use of the Cable Management System) to ensure that the staff is adequately prepared and has the necessary skills to install and operate SSE systems.

The IMO Interim SSE guidelines include a section on Personnel, training, and familiarisation, in which it is stated that it should be ensured that onboard personnel involved in SSE operations are familiarized with the onboard SSE system for safe operation under STCW (International Convention on Standards of Training, Certification and Watchkeeping for Seafarers) regulation I/14.

IMO states that a PIC (Person In Charge) onboard responsible for the ship-side installations in service should be nominated and that only trained and familiarized personnel authorized by the PIC should be involved with the physical connection, power transfer and SSE disconnection procedures.

Concerning the competences necessary for the functioning of the SSE, they are differentiated as follows:

- High-voltage SSE systems:
  - Electro-technical officers holding a certificate of competency in accordance with the requirements of regulation III/6 of the STCW Convention (International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW); or
  - Chief engineer officers and second engineer officers on ships powered by main propulsion machinery of 3,000 kW propulsion power or more holding a certificate of competency in accordance with the requirements of regulation III/2 of the STCW Convention and who have completed training under section B-III/2 of the STCW Code.
- Low-voltage SSE systems:
  - Electro-technical officers holding a certificate of competency as per the requirements of regulation III/6 of the STCW Convention; or
  - Chief engineer officers and second engineer officers on ships powered by main propulsion machinery of 750 kW propulsion power or more who, at least hold a certificate of competency in accordance with the requirements of regulation III/3 of the STCW Convention.

In addition, it is included that electro-technical officers, chief engineer officers, and second engineer officers that meet the above requirements should conduct onboard training and familiarization for personnel and adequately document training records. Finally, it is stated that a person designated by PIC should be on duty during the SSE service following connection and power transfer.

However, no references have been found regarding the competencies and qualifications of the persons directly involved in the operation and maintenance of SSE facilities on the port side. Only EMSA, in the *Guidance on SSE to Port Authorities and Administrations,* includes two aspects related to training: 1) the need to define regular training of emergency response and 2) the recommendation to provide high-voltage operation and shore power usage safety training for the relevant personnel in relation to the Cable Management System.

According to the EALING Port Questionnaire carried out as part of Activity 1, on the port side, the competencies and qualifications needed to operate the SSE installations (based on the 26 replies received from EU ports) are: 1) Electrical engineering; 2) Civil engineering, and 3) Marine engineering/Naval architecture.

In addition, when the ports participating in the questionnaire were asked about training needs, they cited the following:

- For the Port Authorities: training on financing, safety and security, regulatory standards and other aspects related to SSE systems and connections onboard the ship were identified by the ports participating in the questionnaire.

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- For the SSE operators: safety and security; electrical knowledge (including risk assessment and electrical loading), synchronisation between shore and ship (plug-in/plug-out) and SSE facilities' maintenance and efficient use.

6.2 Recommendations focused on the social scope

In summary, the following table shows the recommendations proposed in the social scope to contribute to deploying SSE installations in EU ports.

Table 9. Summary of recommendations – social scope

Recommendations – social scope
• Incentivise, at the European Commission level, interaction, and collaboration between all the stakeholders, especially the shipping companies, port authorities, solution providers and energy suppliers. One possible example of realising this collaboration could be the AIVP association (Association Internationale Villes et Ports), whose mission is to improve the relationship between the port and the city.
• Involve the public in the port's plans for the provision of SSE. Make them aware of the positive impact SSE will have and the importance of working together for the common benefit of improving the health of citizens, with the ultimate goal of gaining their acceptance and facilitating necessary future actions outside the port (e.g., grid expansion).
• Create at the port level a specific working group involving all the operational stakeholders to ensure the proper coordination and management of the facilities.
• Develop operational manuals for port operators to train them in the operation of the SSE, especially on safety aspects.
• Develop guidelines to train on financing and regulation/legislation aspects related to SSE installations.
• Work closely with universities and vocational training centres to cover the training profiles needed for SSE operations.

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