White Paper: Towards Energy Self-Sufficiency in Ports

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EXECUTIVE SUMMARY

This deliverable comprises a white paper discussing evidence for viability of transition to energetic sustainability and carbon neutrality in ports incorporating marine renewable energy technologies. Reference is made to the European Green Deal and to the findings of the Atlantic Area Interreg (ERDF) ***PORTOS project: Ports Towards Energy Self-Sufficiency*** *(EAPA 784/2018)*.

It is shown how the methods developed over the PORTOS project allow identification of a suitable mix of marine and non-marine renewable energy technologies that will enable any given port to achieve the goal of Net-Zero. It is also found that transition to Green Port status is achievable through the development of a port specific roadmap, as outlined in the PORTOS project deliverables.

Challenges to the adoption of marine renewable energy harvesting in ports are observed. So too are the opportunities for future expansion of MRE harvesting to address the recent **Fit for 55** law (adopted 25 July 2023) relating to the decarbonisation of the shipping sector: ***FuelEU maritime initiative***.

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1. THE CHALLENGE OF RENEWABLE ENERGY TRANSITION IN PORTS

1.1. DESCRIPTION OF THE CURRENT STATE OF ENERGY USE AND EMISSIONS IN PORTS

Maritime Ports and Shipping Industries have been recognised as significant sources of pollution, greenhouse gas emission and noise. Ports are energy intensive zones of activity. Energy is consumed by port users - as supply of onshore power to vessels, refrigeration, storage, haulage etc - and energy associated with port operation itself – running administrative offices, cargo handling, cargo processing functions, navigation control and pilotage.

This energy has, until recently, been largely derived from carbon intensive sources. Thus, despite their undeniable economic importance, it can be seen that ports exert stress both on their immediate environment and on the health and wellbeing of local populace in addition to contributing to global environmental impacts.

This is true of most other industrial sectors, and in common with other sectors there is now a political and legal imperative to pivot towards the use of renewable energy sources to meet the global challenge of limiting and reversing anthropogenic climate change. Many ports have begun to install established wind and solar technologies for harvesting renewable energy. Often this requires capital investment and the availability of valuable space within the footprint of the port. However, by virtue of their position being adjacent to the maritime environment, ports are particularly well placed to take advantage of marine renewable sources of energy and also to float out existing technologies from onshore to offshore.

1.2. THE CHALLENGE

Thus, the challenge here is to demonstrate to different Port Authorities how best to make use of the renewable energy sources available to them and to demonstrate the positive outcomes for their business by following a path to Net Zero. In principle, such a pivot towards a mixture of marine and terrestrial renewable energy technologies will achieve their legal obligations, advance their competitiveness as ***Blue Ports*** within the context of the ***Blue Economy***, and improve health and wellbeing in their locality, demonstrating a commitment to sustainability of the communities they exist alongside.

1.3. PURPOSE AND SCOPE OF THIS WHITE PAPER

In this white paper we consider the evidence for the possibility of European Ports to transition towards net zero with respect to their **operational energy requirements** through the adoption of a port specific mix of renewable energy (RE) sources in place of traditional high carbon sources. Well-established RE technologies (terrestrial solar and wind) and are considered alongside the potential offering from less established technologies which capitalize on the extraction of renewable energy from the marine environment itself. In particular we describe example outcomes and conclusions from the Atlantic Area INTERREG (ERDF) ***PORTOS project: Ports Towards Energy Self-Sufficiency*** *(EAPA 784/2018)*.

The premise of PORTOS is that current and future energy requirements of a Port Authority can be achieved through a suitable mix of renewable energy sources, both onshore and offshore.

We discuss opportunities and barriers to this transition and outline policy suggestions that would facilitate effective transition towards the use of mixed onshore and marine renewable energy harvesting technologies.

2. THE PORTOS PROJECT: PORTS TOWARDS ENERGY SELF-SUFFICIENCY.

2.1. UNDERPINNING EUROPEAN ENERGY POLICY AND INCENTIVES

In order to achieve the goal of Carbon Neutrality in 2050, a package of Policy initiatives referred to as the ***European Green Deal*** was launched in 2019 by the European Commission (Consilium, 2023) and has been adopted by member states. As part of this, the ***Fit for 55*** package of proposals transform policy these initiatives into a legal obligation. **This requires a cut in member states' greenhouse gas emissions by at least 55% with respect to 1990 levels**.

Currently 75% of EU greenhouse gas emissions come from energy use and energy production. Thus, decarbonisation of this sector is a clear priority. From a global standpoint, the Shipping sector is responsible for approximately 2.9% of emissions caused by human activities. In Europe it accounts for 3-4% of CO2 emissions. Thus, this sector, which is predicted to expand must also be the focus of decarbonisation.

With reference to ***Fit for 55*** various proposals have been suggested including the boosting of support for alternative fuel infrastructures in Ports and accelerating the adoption of renewable energy sources through an updating of the Renewable Energy Directive (Climate Action, 23). It was from these issues, referenced also in earlier policy initiatives and legal directives from the European Council that the focus of the ERDF PORTOS project was identified.

2.2. BACKGROUND TO PORTOS PROJECT

The ***PORTOS project: Ports Towards Energy Self-Sufficiency*** *(EAPA 784/2018)* was executed over the years 2018-2023. Its aims were *to assess, develop and promote the integrated use of renewable energy resources in Atlantic Area ports and increase their energy efficiency*. The project was also to establish a practical roadmap to a more competitive and sustainable sector.

As mentioned previously, the premise of PORTOS is that current and future energy requirements of a Port Authority can be achieved through a suitable mix of renewable energy sources, both onshore and offshore.

In order to gain acceptance from Port Authorities it is necessary to demonstrate how and under what circumstances the newer technologies associated with marine renewable energy harvesting can be viable replacements for existing carbon intensive energy supply. The Port Authorities should be given the knowledge and tools with which to identify an appropriate mix of modern energy harvesting technologies in order to achieve their own net zero. This must take into account the geographical location, the legal framework within which the port must operate and any further restrictions accounting for stakeholder requirements, navigation etc.

A model for the development of road maps and business plans for this transition is also essential. It is further necessary to have robust means for evaluating the potential environmental, economic and social benefits of the transition which can later be used to monitor performance.

Led by University of Porto, the project involved 16 partners and 7 associated partners including port authorities, maritime consultancies and academic institutions from within the Atlantic Area. An assessment methodology was developed and used to demonstrate how an appropriate mix of renewable energy sources could be identified to replace the existing high carbon energy sources.

The renewable sources considered comprised 1) Wind : onshore and offshore; 2) Solar: onshore and floating; 3) Tidal; 4) Wave.

2.2.1. Methodology

The technical methodology is outline in the infographic in Figure 1. Discussion of the technical methodology is beyond the scope of this white paper and can better be assimilated from the project handbook (**Deliverable 7.6**) and subsequently from the more detailed PORTOS technical reports linked to this.

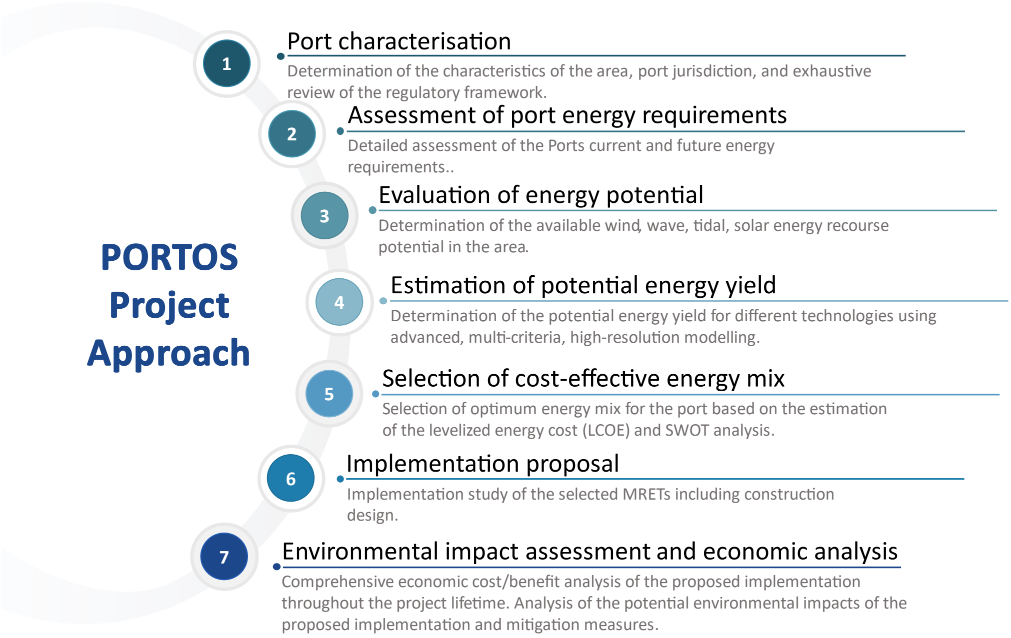

Figure 1: Schematic representation of the key elements of the PORTOS approach

2.2.2. Case Study Ports

The project identified five case study ports to exemplify a range of environments from which differing renewable energy sources could be harvested and from three member states within the Atlantic Area: Portugal, Spain and The Republic of Ireland. **Figure 2** shows views of the case study ports together with a broad classification of their marine setting.

For each case study Port information was gathered into a series of reports.

Deliverables 5.1: Multi-parameter characterisation in which any specific restrictions to implementing marine renewable energy harvesting are identified.

Deliverables 5.2: Policies and legal frameworks operating at European, National and Regional levels with relevance to renewable energy and marine renewable energy in particular.

Deliverables 5.3: The Energy Consumption Characterisation of each Port including future plans for expansion.

Using the information presented in the above deliverables, it was then possible to evaluate candidate renewable energy sources and choose appropriate harvesting technologies for each case study port.

Deliverables 7.1 Present the suggested energy mix of technologies suggested for each case study port together with the environmental indicators to demonstrate the benefits achieved.

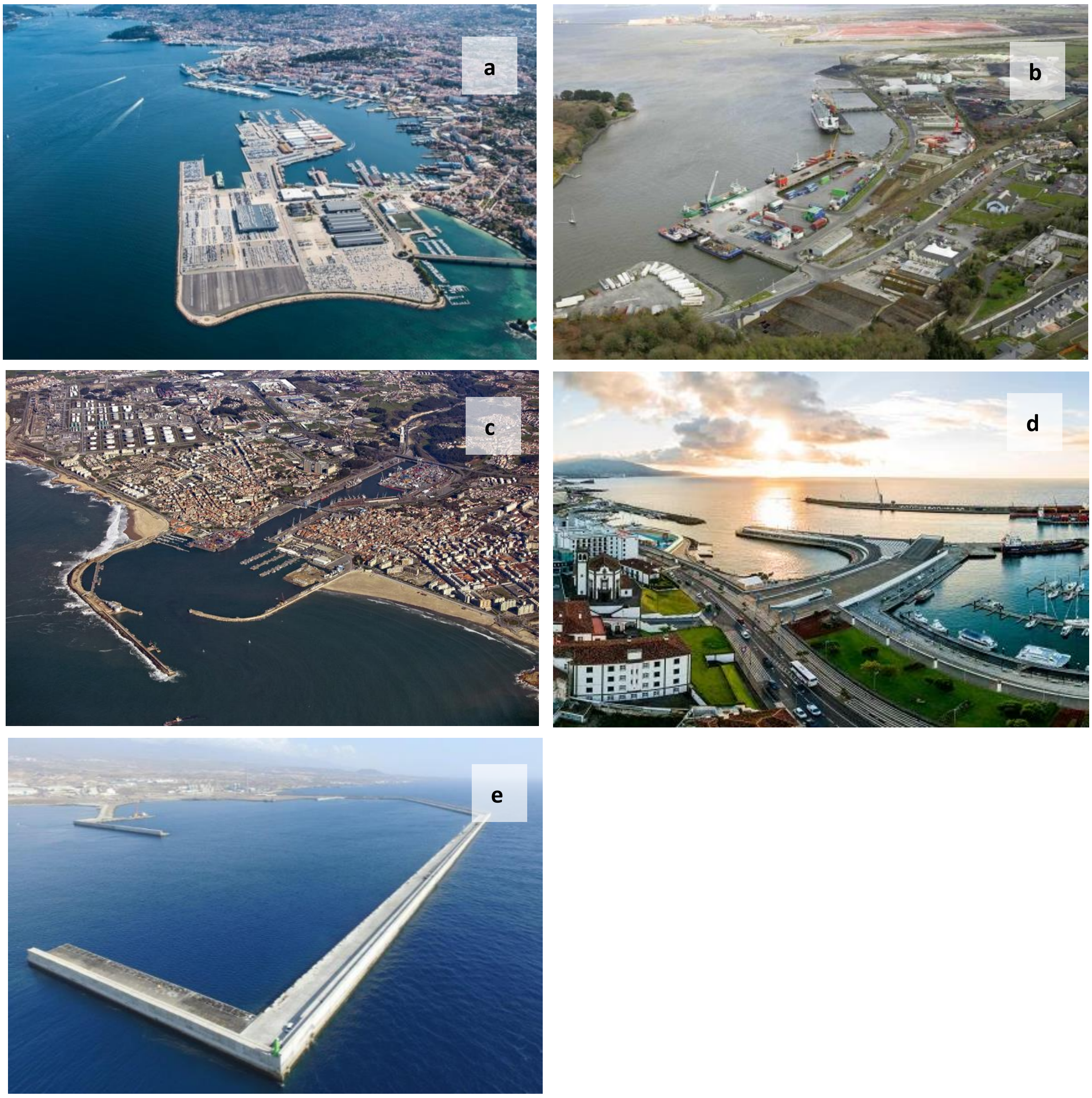

Figure 2 Case Study Ports. a) **Port of Vigo**, Spain – *estuarine/coastal*; b) **Port of Shannon Foynes**, Ireland – *estuarine*; c) **Port of Leixões**, Portugal- *deep water coastal*; d) **Port of Ponta Delgada**, Azores – *island*; e) **Port of Granadilla**, Canaries – *deep water island*.

Further outputs included the following:

Deliverables 7.2 Infrastructure Adaptation works and costing.

Deliverables 7.3 Environmental impact assessment

Deliverables 7.5 Roadmaps towards achieving sustainability of port operation.

These results could be analysed and generalised to other European ports or worldwide.

A key project output was guidance produced in the form of a handbook aimed at port operators. This showed how to evaluate a port's potential for adopting sources of renewable energy, select the most suitable and cost-effective technologies, adapt their infrastructure to incorporate these, and then estimate the resultant environmental improvement through the use of suitable indicators.

2.3. PORTOS Results

2.3.1. Legal Framework for Renewable Energy

2.3.1.1. European Level

Within the PORTOS project (**Deliverables 5.2: *Characterisation of Policies and Legal Framework for the harnessing of Marine Renewable Energy*** in the case study ports) it was noted that there is a well-defined strategic framework for the exploitation of Marine Renewable energy in Portugal, Spain and Ireland as a result of legal requirements imposed on member states by the European Council. *Clean energy for all Europeans* – a package of eight legal acts adopted recently continues to demonstrate strong commitment towards renewable energy. Current regulations and directives will have direct impacts on national regulations, and in the Spanish case as well as on the regional level.

2.3.1.2. National Level

It is observed that legal frameworks for the regulation, prohibition or approval of marine renewable energy harvesting varies between member states.

For instance, in Portugal the *Industrial Strategy for Marine Renewable Energy and Marine Spatial Planning* has created a well-defined legal framework for the marine renewable energy. This regulates licensing of maritime space, energy production, ancillary terrestrial facilities, the need for environmental impact assessments (EIA), the nature of tariff schemes and Marine Spatial Planning.

However, in Spain, whilst acts exist pertaining to established renewable technologies - wind, solar – there are no similar acts addressing the newer marine renewables technologies – tidal and wave – although general rules for EIA etc will be applicable. This lack of specific attention to MRE is likely due to the current level of technical uncertainty associated with the deployment of these technologies.

2.3.1.3. Regional Level

With regards the regional level interpretation and implementation of legislature it can be seen that there is variation between member states and between regions and Port Authorities within member states.

This is greatly dependant on the variation in expertise which can be patchy and dependent upon the size of the organization or Port Authority concerned. It is interesting to note that in the Azores there is particular expertise in geothermal energy production and until recently a landmark wave energy project had been operational on Pico Island.

2.3.1.4. Conclusion

Overall, the review of legal frameworks pertaining to Marine Renewable Energy implementation were found to be well developed at European level with some variation in interpretation at national level – with the more established renewable energies being better represented.

However, whilst interpretation of policies regarding marine renewable energy implementation into legislation at national and local levels needs to be developed, this will undoubtedly become the case once specific projects for harvesting marine renewable energy are programmed. A current example of such a ground-breaking project is the proposed floating wind farm that will supply the Port of Granadilla on Tenerife.

2.3.2. ENERGY MIX AND ASSOCIATED GHG REDUCTION

Using the PORTOS methodology (Fig 1) suitable renewable energy sources were identified for each case study port (**Deliverables 7.1: *Energy mix diversification in Ports***) . These were used to identify a suitable mix of technologies to install at each case study port. The capacity installed was designed to realise the total operational energy requirements of the port. Also shown are the annual greenhouse gas reduction estimates in Tonnes of CO_2.

Port	Onshore Wind	Offshore Wind	Onshore Solar	Floating Solar	Wave	Tidal	Tidal Stream	**Totals**
Leixões	2.00		0.53		4.06			6.58
	1,394		***192***		***3,862***			***5,448***
Vigo			1.84	2.19				4.03
			559	***655***				***1214***
Shannon Foynes	0.5		1.17					1.67
	387		***337***					***724***
Ponta Delgada			0.29	0.39				0.68
			145	***248***				***389***
Granadilla			0.055	0.065				0.12
			46	**92**				**138**

Table 1 Energy mix and greenhouse gas reduction for case study ports. Value shown are: Installed Capacity / MW; **GHG reduction / tCO_2.**

From **Table 1** it can be seen that through the use of a mix of renewable energy technologies the requirements of all the case study ports were achieved.

It can be seen that not all renewable sources considered were found to be suitable within these case study ports. In particular, the absence of tidal technology is surprising in the case of Shannon Foynes. From the multicriteria analysis (**Deliverable 5.1: *Multi-Parameter Characterisation in Shannon Foynes Port***) it was found that deployment of tidal energy harvesting technologies would unacceptably impede navigation and port operation despite the abundance of resource available. The same. The true could also be the case for floating wind turbines.

This is, of course, a common challenge for any installation near a port. Thus, a recommendation would be for ports to partner with the owners of marine concessions and land without their jurisdiction in order to realise the full potential that floating wind, wave and tidal stream devices might make.

It should also be noted that the energy requirements for Port of Granadilla reflect the low level of current activity in this new port.

With regards to the key indicator of GHG gas emissions, the total five case study ports could see a reduction of **7,900 tonnes of CO_2 per annum**. Although this figure is dwarfed by the European emissions for the shipping and maritime sector (13.5% of EU total emissions, Consilium 2023), this figure can be equated to a reduction in consumption of **3.0 million litres of diesel** (UK Government, 2023).

2.3.3. Infrastructure Adaptation for the Installation of RE Technologies

In order to implement the suggested energy harvesting solutions at each case study port it is necessary to consider the necessary infrastructure costs that would allow their incorporation into existing or new Port structures. This information is essential for the selection of economically viable energy harvesting options which will form part of the business plans for the Port Authority in question. **Deliverables 7.2:** ***Adaptation of infrastructures in the case study ports*** provides this information for each of the case study Ports and thus allows a later estimation of the true cost of energy production over the lifetime of installation– the Levelized Cost of Energy (LCOE).

As an example, the installation of solar panels on the roof of an existing building requires consideration of the sophistication of technology to be installed, the mounting system to be used, its electrical connection to new or existing electrical grid and also any structural strengthening or access issues associated with the existing buildings.

For some technologies, the building of new structures is required. Figure 3 illustrates the incorporation of new wave energy conversion units into the extension of an existing breakwater structure. These units are difficult to introduce retrospectively but are ideal for use in new constructions or to provide extended protection to existing harbours.

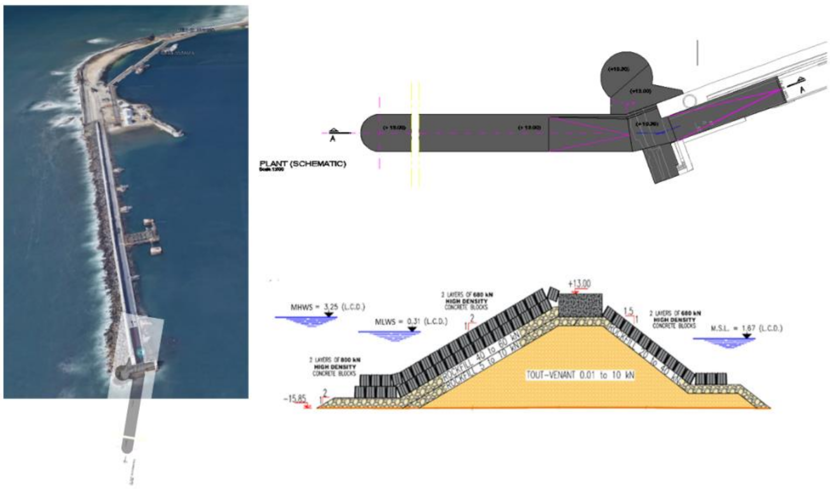

Figure 3 Proposed Wave Harvesting extension to Breakwater at Leixões

In conclusion, these reports demonstrate how the mix of technologies identified for each case study port were indeed possible to be incorporated into the port infrastructure with due consideration for costs and methods of construction, maintenance and decommissioning or reuse.

2.3.4. Environmental Impact Assessment and Business Plan Development

In order to proceed with any infrastructure project, both an environmental impact assessment (EIA) and an economic assessment are required. Exemplar EIA and business plans are combined in the PORTOS **Deliverables 7.3.2: *Feasibility Analysis for Renewable Energy Implementation at Case Study Ports*.**

The case study EIAs provide exemplars for how to perform assessments in the context of Ports adjacent to the marine space. The EU's Environmental Impact Assessment Directive stipulates that stressors arising from the implementation of RE harvesting technologies should be assessed for their interaction with the receptors: physical environment; pelagic habitats and species; protected habitats and species; benthic habitats & species; marine ecosystems and food chains; fish and fisheries; marine birds; marine mammals; humans.

The feasibility studies also comprise an Economic Assessment for each case study port which leads to a corresponding business plan. These consider the levelized cost of energy, capital and operational expenditure, net present value and pay-back year sensitivity.

In conclusion, the exemplar feasibility studies for each cased study port demonstrate how to apply environmental impact analysis and consideration of mitigation in environments that straddle terrestrial and marine regions; that the energy transitions for these ports towards energy self-sufficiency from renewable sources are economically viable with realistic pay-back intervals.

2.3.5. Road Maps Towards Adoption of Renewable Energy In Ports

The transition to the full use of renewable energy sources in ports by 2050 is described in PORTOS via a 2D road map (Figure 3). In this, the sequencing and timing of secondary and primary ambitions which attain various levels of renewable energy self-sufficiency through defined sets of actions is represented.

The phased plan outlined in Figure 4 comes from **Deliverable 7.5**: ***Roadmap towards energy mix diversification and possibly self-sufficiency***. It aims to provide a clear summary of the steps necessary to achieve energy self-

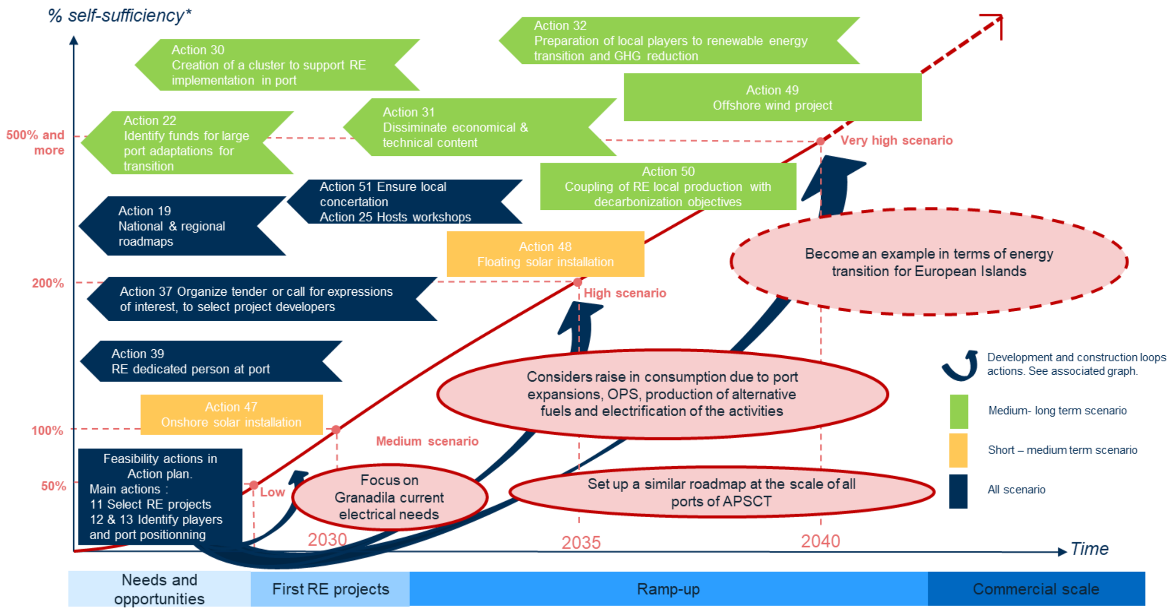

Figure 4 High level roadmap for Port of Granadilla

sufficiency in the new Port of Granadilla. The approach that it represents for modelling the transition process is flexible in its application. It can represent not only a plan for how to roll out the mix of technologies necessary to satisfy current energy need but can also take account of other events such as the recently announced offshore wind farm project. This will be used to offset the estimated growth in energy demand which might rise to over 500% of current usage for this ambitious new construction.

In conclusion, the PORTOS roadmaps for each of the case study ports provide confidence in how to program the necessary actions required to achieve energy self sufficiency within an adaptable framework.

3. Conclusions & Recommendations and Future Requirements

3.1. Renewable Energy for PORTS: Conclusion

Ports need to meet ambitious targets for decarbonization of port operation as outlined in recent legislation driven by the European Green Deal. As a sector, Ports are particularly well placed to capitalize on their positioning at the terrestrial/ marine interface close to sources of Marine Renewable Energy.

The PORTOS project has demonstrated that achieving energy self-sufficiency through the harvesting of a mix of renewable energy sources is achievable. The project has also provided extensive guidance on how Port Authorities can assess, plan and justify the transition to renewable energy and thus attain Green Port status fulfilling their legal obligations and improving their competitiveness.

However, it was found that many of the case study Ports are unable to fully capitalize on the local availability of the full spectrum of MRE sources. This is due to their deliberate establishment in locations sheltered from wave exposure and also because of requirements to preserve navigation where harvesting of tidal energy or installation of floating wind and solar might be possible.

Table 2 presents a SWOT analysis particularly focussed on the decarbonisation of Port operations through adoption of Marine Renewable Energy harvesting technologies.

Adjacency to MRE sources Fit 55 and the European Green Deal Port Authority jurisdiction	Traditional ports are sheltered. Low technology readiness levels of MRE Navigation requirements Other Stakeholders
Strengths	**Weaknesses**
Opportunities	**Threats**
Adaptation of existing structures and repairs Exposure of Deep-Water Ports OPS- onshore power supply to shipping Ports as Energy Exporters Offshore Renewable Energy farms Role in installation Green Port status Partnering with Energy companies	Competition from established technologies Extreme events driven by Climate Change Sea level rise complicates design Changing political will

Table 2 SWOT analysis: adoption of MRE in Ports

3.2. THE NEXT STEP: EXPANSION OF SCOPE

The scope of the PORTOS project was necessarily restricted in order to make progress against the challenge of **decarbonisation of Ports**. By expanding the scope in future analyses, it is envisaged that additional sources of marine renewable energy might become viable for harvesting by Port Authorities and a more integrated regional approach can be taken to energy generation with reduction in GHG emissions and other pollutants.

In particular the scope for technical consideration of the decarbonisation of Ports should be expanded to consider.

Grid connectivity and storage.

This will likely have an impact on Capital Expenditure and the viability of harvesting from new sites, outside the Port zone. Use of smart grids and storage can be used to smooth supply and balance over and under production form different sources.

Ports as energy exporters.

Where possible, increasing the installed capacity beyond the energy requirements of the Port itself will improve competitiveness through the provision of clean energy to shipping in the form of onshore power supply, and even electric fuelling in the future.

Extra-jurisdiction joint venture MRE projects.

As mentioned above, harvesting outside of the port area perhaps through partnership with energy companies intending to exploit offshore floating wind and tidal energy would further improve.

Biofuels and Hydrogen

Under the FuelEU Maritime initiative (adopted 25 July 2023), the Maritime sector is obliged to explore the possibilities of biofuels and other low carbon fuel systems. These will have significant impact on GHG emission and pollution associated with Ports and Shipping. Hydrogen has been highlighted as a vector for energy transmission from offshore wind or solar farms into electrical power, other fuels or even machinery and transport.

3.3. FINAL STATEMENT

By adopting and successfully implementing a mixture of RE technologies, ports can play a pivotal role in the decarbonization of the wider maritime sector. They can demonstrate the real-world viability of harmonising operational efficiency with environmental responsibility. We encourage port authorities, particularly those in the Interreg Atlantic Area, to utilize the PORTOS methodologies to develop their own roadmap for meeting their obligations under the European Green Deal.

We also encourage the future establishment of wider partnering and collaboration between ports and renewable energy companies to allow the possibility of harvesting marine renewable energy outside the normal port jurisdiction.

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