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EU-Funded Energy-Related Projects for Sustainable Ports: Evidence from the Port of Piraeus

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Abstract: Energy matters are a challenge for many ports and port industry stakeholders, especially in today's rapidly changing environment and on the back of multiple transitions in the sector. In particular, mainstreaming environmental targets and sustainability in port operation and development affects strategic choices. This article focuses on EU-funded energy-related projects in the Port of Piraeus, presenting field evidence in the form of a case study. We take stock of efforts undertaken, results achieved and impacts of the projects so far, in order to provide useful insights for the industry, but also reflections on policy and governance in this subject area. We argue that implemented projects have created added value for the port and clearly helped achieve its stated objectives, in relation to both energy and environmental issues and promoting sustainability. What is more, goal-setting has often been initiated within the framework of the projects and/or their implementation. In addition, project identification and implementation have produced positive externalities for the port, thus laying the groundwork for further change. Project impacts obviously depend on many different factors, as well as on their interaction. The momentum for EU-funded energy-related projects in the port sector will hold up and most probably grow, as will mainstreaming sustainability. Industry, policy and governance need to step up their efforts in order to maximise results.

Keywords: EU-funded energy-related projects; port operation and development; environment; sustainability; Port of Piraeus



Citation: Platias, C.; Spyrou, D. EU-Funded Energy-Related Projects for Sustainable Ports: Evidence from the Port of Piraeus. *Sustainability* **2023**, *15*, 4363. <https://doi.org/10.3390/su15054363>

Academic Editor: George Kyriakarakos

Received: 9 January 2023

Revised: 22 February 2023

Accepted: 27 February 2023

Published: 28 February 2023



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1. Introduction

The modern port industry faces major challenges. Among them, energy matters are in many ways critical for ports and industry stakeholders [1–3]. Port activities are quite energy-intensive and ports' energy needs constantly increase. Ports strive to take advantage of renewable energy sources, rationalise energy use, reduce energy consumption, and keep energy costs as low as possible, without compromising their market position and competitiveness. At the same time, several bigger ports realise the enormous business opportunities opening up in terms of expanding beyond traditional port activities to the highly promising and profitable energy sector, entering the energy market as energy producers and/or energy service providers. Since they are large energy consumers, it is rather tempting for them to become energy producers as well. And because they already provide port services to port users and other providers of port services, they can also act as energy hubs, as many business entities develop around ports, creating a potential market. Furthermore, according to EU legislation, ports “will provide for the availability of alternative fuels” [4,5]. A number of refuelling points for liquefied natural gas (LNG) will be put in place at ports across the EU, to enable LNG ships to circulate throughout the Trans-European Transport Network (TEN-T) Core Network by end-2025. By then, shore-side electricity supply is also expected to be installed as a priority in ports of the TEN-T Core Network, as well as other ports. Over and above any obligation arising, deployment of

alternative fuel refuelling and recharging infrastructure is becoming part of port strategies in order to increase their attractiveness and capture a share of this new market. All the above result in a complex landscape for ports and the port industry in general, as well as in many different challenges at all possible levels [1]. It is an imperative for ports to create adequate new infrastructure and adapt or upgrade existing one, introduce smart technology and innovative solutions, set and implement a clear vision and concrete strategic targets, mobilise investment resources and make use of available funding. At a policy and governance level, a clear policy on the relevant matters, a solid market regulation on the basis of an adequate legal and institutional framework, an effective governance system, as well as public funding resources are key requirements for success [6–10].

At the same time, mainstreaming environmental targets and sustainability in port operation and development affects strategic choices with regard to energy production and consumption [11,12]. Ports need to deal with environmental pressures and improve their environmental footprint, integrate sustainability considerations in port activities, business decisions, and development plans, contribute to a green transition, support decoupling from fossil fuels and the building of a climate-neutral economy [13–15]. Energy matters are strongly interlinked with environmental targets and sustainability. Sustainable solutions for ports largely go through decisions on energy matters.

Ports are involved in numerous EU-funded projects, which deal with the abovementioned challenges. As the result of a complex top-down/bottom-up approach, where policy and governance, on the one hand, and industry, on the other, set their targets and priorities, EU projects enable concrete solutions in ports and facilitate transition. Moreover, they promote innovative strategies, new contents and tools, support mentality changes, and create a new dynamic in the port sector.

In this context, this article focuses on EU-funded energy-related projects in the Port of Piraeus, providing evidence from the field, presented in the form of a case study. We argue that the projects implemented so far have created added value for the port and clearly helped achieve its stated objectives, both in relation to energy and environmental issues and promoting sustainability. What is more, goal-setting has often been initiated within the framework of the projects and/or their implementation. In addition, project identification and implementation produce positive externalities in the port, thus creating a favourable environment for further change. Project impacts depend of course on many different factors, as well as on their interaction. This needs to be taken into consideration by the port managers (port industry) and decision-makers (public policy and governance) accordingly.

Apart from the introductory remarks in Section 1, our paper is structured as follows: Section 2 offers a review of the academic research and existing literature on the subject. Section 3 discusses the analysis methodology and sources for our research. Section 4 presents the objectives of Piraeus Port Authority S.A. (PPA) with regard to energy matters and sustainability. Section 5 describes the main findings of our analysis. Section 6 seeks to place these findings within a broader analysis and evaluation context. Finally, Section 7 draws some conclusions from our analysis and looks at future prospects.

2. Literature Review

Due to the increasingly important energy sector in ports, relevant matters have attracted the interest of many scholars. Academic research and literature focused on different aspects of energy matters, attempting to study implications or opportunities for ports and shed light on real problems and/or possible solutions. Two popular areas of scholarly interest have been energy efficiency [16–18] and energy management [3,19], which some researchers explicitly link with one another [20]. The prospect of alternative fuels infrastructure and services in ports created a strong momentum in academic discussion that grew further following the adoption of Directive 2014/94/EU on the deployment of alternative fuels infrastructure. As a result, LNG bunkering has become an appealing subject for academia and practitioners alike [21–24]. The same goes for onshore maritime power supply in ports [25–29]. The ‘nearly zero-energy ports’ have also been a field of

particular interest [30–32]. Other research discusses evidence from case studies across the EU, providing additional knowledge into different relevant subjects [33–37]. It is obvious that more case studies are needed in order to build a sufficient body of literature and an in-depth understanding of the matters.

In the context of the environment and sustainability debate, scholars focused on different issues in ports [14–43] and the sustainable performance of ports and port activities [44–47]. Reports from the port industry and international organisations provided useful information and insights [2,11,12,48–51], supporting the discussion and providing practical guidance for stakeholders. Although these references clearly show an impressive scientific activity in recent years, energy matters had surprisingly a rather peripheral role in this debate. Only a few academic contributions addressed in a clear and targeted manner the nexus between energy, on the one hand, and environment, green development or sustainability, on the other. Taking into account the strong correlation of the above matters and the challenges for the port sector on the path towards sustainability, the relevant literature is insufficient in terms of its limited volume and linkages produced, but dynamics in these fields create a certain optimism for the future.

As regards EU-funded energy-related projects in ports, it is even more surprising that there exists no literature. The subject has remained totally out of scope, something which is hard to believe given its significance and expected multiple benefits for ports and port industry stakeholders, as well as local communities and the environment, but also because of all the efforts undertaken and public money spent on relevant projects. In this respect, our case study seeks to provide not only useful insights, but also essential input. The authors hope that the questions raised in this article and findings presented below will stimulate further discussion and future research.

3. Materials and Methods

Our research focus, complexity of the subject in question and lack of relevant academic literature suggest that empirical research is the most appropriate method in order to investigate EU-funded energy-related projects for sustainable ports. For our purposes, optimum empirical research relies on a case study methodology [52–54]. In this vein, a single-case design provides, on the basis of collected data and quantitative and qualitative analysis thereof, a solid ground for gaining specific, in-depth insights in a single port environment, making it easier to understand many different aspects and implications, as well as draw essential conclusions. The combination of descriptive, exploratory and explanatory approach methods is necessary for a comprehensive and multifaceted analysis of the subject in question [55].

Our case study has been carefully selected, given the relevance of the port for our research objective and access to information. Evidence from the Port of Piraeus is important since PPA S.A. has been involved in several EU-funded energy-related projects, which have been implemented in different fields of interest with the participation of many stakeholders from industry, academia, local authorities, etc. in large-scale partner schemes, producing quite remarkable results over the past seven years. The projects were funded under three different EU programmes (Connecting Europe Facility (CEF) -Transport, Horizon 2020 (H2020) and ADRION) and through two different financial instruments (CEF and INTER-REG). As a result, the experience of the Port of Piraeus in this field is particularly valuable for our research. At the same time, the Port of Piraeus has features and characteristics which reasonably attract special interest: it is one of the largest EU ports, part of the TEN-T Core Network, an important hub/node in intermodal transport and logistic chains with an enormous port traffic in terms of cargo and passengers, an enterprise that engages in many energy-intensive traditional port activities and some new business aspirations related to energy services, and a major investment in the EU port industry (see also Section 4). Furthermore, the Port is keen to mainstream environmental considerations in port operation and development and integrate sustainability concepts in its strategy and decisions. Starting from the premise that ports' idiosyncratic characteristics and specific circumstances likely

lead to different outcomes with regard to the implementation of EU-funded energy-related projects, as well as to their effects and impact on sustainability, our research does not seek to generalise on the subject, although some of the findings are assumed to be rather typical and some of the conclusions drawn in the context of our research go beyond the Port of Piraeus. In this respect, further scientific research in this field, e.g., by using a wider sample of ports or a comparative analysis, would be highly intriguing and promising for further exploration, understanding and theorising.

Following the identification of EU-funded energy-related projects in the Port of Piraeus, two different sources have been used for data collection: on the one hand, grant agreements for the projects, i.e., the contracts signed between the EU and the partners' consortium for each EU project, which define activities to be undertaken, project duration, overall budget, rates and costs, EU budget contribution, deliverables, rights and obligations of the parties, etc.; and, on the other hand, interim and final implementation reports on the projects. Data were collected, processed and analysed for all 11 projects that fall within the scope of our research (see Appendix A). Quantitative and qualitative analysis is adequate for taking stock of efforts and assessing results and impacts.

An interview of a senior PPA S.A. official completed the picture obtained from the analysis of the collected data, providing clarification on different matters, as well as useful input for the evaluation of the projects and their results and impacts. The interview highlighted some issues of particular interest, e.g., strategic plans and priorities, expectations, future requirements on the governance side, etc., but mainly provided PPA's overall assessment of the projects, based on the experience gathered through the implementation of a considerable number of projects. The interview was based on the key informant method [56]. The interviewee was carefully selected among PPA officials as possible candidates in order to ensure the quality and reliability of the answers. The selection was based on the following criteria: the most relevant position and role related to design and implementation of EU-funded energy-related projects in the port, as well as most comprehensive knowledge of the issues. The interview was conducted in a semi-structured form, whereby a mixture of closed and open-ended questions was considered the most appropriate approach for drawing meaningful and useful conclusions, since it aimed at targeted question responses within a predefined framework, but also provided the flexibility for the participant to provide his/her own answers and personal views. Despite some intrinsic weaknesses recognised in this approach, for example, subjective perception of the issues under investigation, the value of the information obtained from the interview is highly relevant.

4. The Port of Piraeus

The Port of Piraeus, is the largest port in Greece. Located in the city of Piraeus, a few kilometres from the Greek capital, Athens, and at the crossroads of Europe, Asia and Africa, it is Greece's main gateway for cargo and passengers, a hub port for international trade (Figure 1) [57], a link between the Greek islands and the mainland, as well as a cruise home port. It is an important link of international logistic chains and a part of the TEN-T Core Network.

The Port of Piraeus ranks among the major European ports in terms of traffic volume, the largest passenger port in Europe and comes in seventh place among all European ports in container handling.

Following a share purchase agreement in 2016, 67% of the share capital of PPA S.A. was sold to COSCO (Hong Kong) Group Limited. Management and operation of the Port by the global operator China COSCO SHIPPING Corporation Limited supports further development and expansion of activities, whereby increasing traffic flows confirm a very positive trend and at the same time show the potential of the Port. PPA S.A. follows an ambitious port Master Plan, a 10-year Development Program, including a series of investments across all parts of the Port of Piraeus.

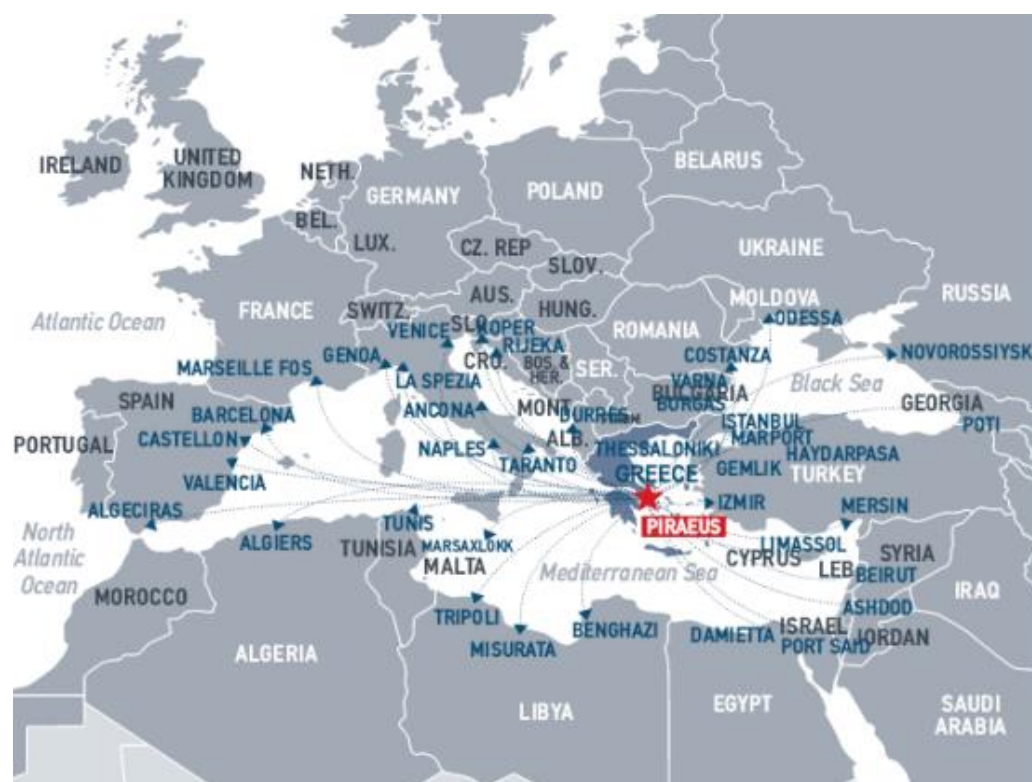


Figure 1. Location of the port and feeder network layout; Source: PPA S.A., 2018.

The port hosts a wide range of activities. It facilitates container, car and general cargo transport, free zone operations, coastal shipping, cruise shipping, as well as ship repair activities. The following map (Figure 2) presents the different port terminals dedicated to each one of these activities [57].



Figure 2. Port activities; Source: PPA S.A., 2018.

The Port of Piraeus is one of the leading Greek ports with regard to mainstreaming environmental concerns and sustainability in port operation and development [58]. PPA

S.A.'s mission is to provide high-quality port services, in a safe and sustainable manner. As stated by the Chairman of the PPA S.A. Board of Directors, the company applies an Integrated Quality, Environmental & Energy Management System in compliance with the requirements of ISO 9001:2015, ISO 14001:2015 & ISO 50001:2018 standards [59]. He goes on to stress that a priority of the port is to continuously improve the standards of services provided along with environmental and energy performance. Decisions on energy matters and sustainability considerations are an integral part of company vision and strategy. Key objectives are:

- Taking into account customers' energy needs and expectations and providing high-quality energy services;
- Reducing energy consumption;
- Improving energy performance through decarbonisation of port activities and reducing activities-related emissions;
- Increasing the share of alternative energy resources in port's energy mix;
- Designing new processes and procedures, facilities and activities, renewing or upgrading equipment and deploying new energy infrastructure under sustainability considerations;
- Improving environmental footprint of port activities and the port in general;
- Setting quality, environmental and energy efficiency criteria for procurement of products and services;
- Ensuring compliance with applicable legal and other obligations;
- Raising awareness among port's staff and other interested parties with regard to environmental and energy performance; and
- Increasing effectiveness of the Integrated Quality, Environmental & Energy Management System.

The commitment of the PPA to continue its dynamic course of sustainable development and technological transformation of the port also with regard to the energy matters is reiterated in every official statement and report [60,61].

5. Results

5.1. Identity of the Projects

Table 1 presents all EU-funded energy-related projects that have been implemented or are currently under implementation in the Port of Piraeus. PPA S.A. has been quite active over the past seven years, participating in 11 projects and coordinating one of them as a leading partner. The projects are considered part of the Port's wider planning and development strategy, for instance with regard to alternative fuels, but they are also linked to the needs that have been identified in the framework of the certification process of PPA S.A. under the abovementioned ISO standards. Advanced initiatives, innovative concepts, cutting-edge solutions made the projects particularly important for sustainable port operation and development. The projects have been submitted and approved within the framework of calls for proposals under the abovementioned CEF Transport, H2020 and ADRION programmes and were funded through the CEF and INTERREG financial instruments. Approval in a highly competitive environment indicates the adequacy and top quality of the projects. Most of the projects had a broad participation from industry, academia and research, local authorities, etc. from different EU Member States, depending on the project and expertise of the partners. A strong network of carefully selected partners in Greece and abroad was a very positive side-effect for the port with multiple benefits. PPA S.A. has proven to be a competent and reliable partner, taking on a very energetic role and making a significant contribution also to the design of the projects and elaboration of the project proposals. Full details of the projects are presented in Appendix A.

Table 1. EU-funded energy-related projects in the Port of Piraeus—General Identity.

Project Acronym	Project Full Title	Funding Framework	Leader
POSEIDON MED II	Poseidon MED II	CEF	DEPA Commercial S.A. (GR)
ELEMED	Electrification of the Eastern MEDiterranean area	CEF	Hellenic Lloyd's S.A. (GR)
SUPAIR	SUstainable Ports in the Adriatic-Ionian Region	ADRION	Area Science Park (IT)
SUPER LNG	SUstainability PERformance of LNG-based maritime mobility	ADRION	National Centre for Scientific Research "DEMOKRITOS" (GR)
NEORION	Green ShipBuilding	ADRION	University of the Aegean (GR)
PIXEL	Port IoT for Environmental Leverage	H2020	Universitat Politècnica de València (SP)
GREEN C PORTS	Green and Connected Ports	CEF	Fundación Valenciaport (SP)
EALING	European Flagship Action for Cold Ironing in Ports	CEF	Fundación Valenciaport (SP)
ARSINOE	Climate-Resilient Regions Through Systemic Solutions and Innovations	H2020	University of Thessaly (GR)
CIPORT	Cold Ironing in the Port of Piraeus: Taking the Final Step	CEF	Piraeus Port Authority S.A. (GR)
SUPER-LNG Plus	SUstainability PERformance of LNG-based maritime mobility Plus	ADRION	National Centre for Scientific Research "DEMOKRITOS" (GR)

Source: Authors (2022).

The projects address different needs and priorities of the Port. Though, as indicated in the interview, even where complementarity among projects is not obvious, it is pursued within the framework of broader objectives, e.g., in relation to the Port's environmental footprint. A correlation of data from Tables 1 and 2 shows that some projects are a follow-up of previous initiatives, a necessary subsequent phase after successful implementation of the initial project. This is, for instance, the case of the projects POSEIDON MED II, SUPER LNG and SUPER LNG Plus.

Table 2. EU-funded energy-related projects in the Port of Piraeus—Financial identity.

Project Acronym	Start	End	Total (in €)	Participation PPA	Funding Rate
POSEIDON MED II	1/6/2015	31/12/2021	53,279,405	915,000	50%
ELEMED	1/4/2016	31/3/2018	1,475,000	67,591	68%
SUPAIR	1/1/2018	30/6/2020	1,448,707.40	135,707.32	85%
SUPER LNG	1/1/2018	30/6/2021	895,049.60	119,000	85%
NEORION	1/1/2018	31/3/2021	1,176,925	135,536.59	85%
PIXEL	1/5/2018	30/9/2021	4,890,222.50	274,256.10	100%
GREEN C PORTS	2/1/2019	29/12/2023	7,155,708	455,000	50%
EALING	1/6/2020	30/6/2023	6,960,240	191,219.51	50%
ARSINOE	1/10/2021	30/9/2025	15,643,021.25	497,000	70%
CIPORT	1/8/2021	30/11/2023	1,376,000	170,000	50%
SUPER-LNG Plus	1/1/2022	31/8/2022	149,800.30	20,118	85%
TOTAL			94,450,079.05	2,980,928.52	

Source: Authors (2022).

PPA participation in the total budget of the projects reflects the fact that the small part of the Port of Piraeus in almost all eleven projects serves a greater plan and has a rather strategic importance than its actual size, aiming to prepare the ground for further actions and having multiplying and accelerating effects in a broader sense. In this regard, it is plausible that "EU financial support" ranks last among responses to the interview question "What do you consider to be the most important contribution of EU-funded projects in this field?", i.e., behind "initiation of action", "content formulation", "cooperation and networking" and "implementation of the port plans". EU financial support has nonetheless been crucial. Despite the fact that the budget for the proposed interventions was not an issue for a company as big as PPA S.A., project decisions were made easier for the Management because of the high funding rate and low risk for the Port. The response "Maybe some of them" to the question "Do you think that the PPA S.A. would have proceeded with the

planning and implementation of these projects without the support of the EU?” implicitly corroborates this view.

The projects are considered to be the Port’s answer to upcoming legal obligations, as well as anticipated needs and challenges. Searching the ratio of the projects beyond legislation, it must be stressed that, from a methodological point of view, it is rather impossible to estimate the real demand for such projects, though it is obvious that the Port has made concrete decisions as per its business strategy, following the general trend in the industry toward sustainable energy solutions and based on the received input from already existing and potential customers, port services users and providers, which was also confirmed in the interview. A fundamental premise for the successful outcome of the efforts is that Port and port users (e.g., shipping companies) should be for instance with regard to the LNG-bunkering or the on-shore power supply to ships at berth on the same page.

5.2. Fields of Interest and Targets

The analysis of the projects, as presented in Table 3, shows that interventions concentrated on six fields of interest, namely energy infrastructure, energy-related soft actions, smart technology and innovation, renewable energy sources, rational use of energy and cutting energy consumption and costs, and alternative fuels. They are all highly relevant fields for port operation and development, since advances in each one can be drivers of change and efforts are most likely to have an impact on energy landscape and sustainability of the Port. The content of the projects was intended to address current and future challenges for the Port, in line with strategic choices and planning. The majority of the projects, seven out of eleven, focused on rational use of energy and cutting energy consumption and costs. Six projects addressed the preparation for the introduction of alternative fuels: three projects focused on LNG supply by the Port and another three on the deployment of onshore power supply (OPS) solutions. These are PPA’s top priorities and are expected to remain so in coming years. Soft actions, also a preferred subject area of the projects, supported to a large extent these major fields of interest, but soft actions included in SUPAIR, PIXEL, GREEN C PORTS and ARSINOE had different targets, focusing on studies, innovative technical solutions, and methodological frameworks, in their respective fields. Many of the projects targeted smart technology and innovative solutions for port operation and development, which are considered crucial for the “port of the future”, especially with regard to energy and sustainability. Infrastructure actions were kept to a necessary minimum at this phase, but projects created a solid ground for subsequent infrastructure works in the short- or medium-term. Surprisingly, only one project targeted renewable energy sources, leaving plenty of room for further future projects in this field.

Table 3. EU-funded energy-related projects in the Port of Piraeus—Fields of interest.

Project Acronym	Infra-Structure	Soft Actions	Smart Technology, Innovation	Renewable Energy Sources	Energy Use, Energy Consumption and Costs	Alternative Fuels	
						LNG Supply	OPS
POSEIDON MED II	X	X			X	X	
ELEMED	X	X			X		X
SUPAIR		X	X				
SUPER LNG					X	X	
NEORION	X		X		X		
PIXEL	X	X	X				
GREEN C PORTS	X	X	X				
EALING					X		X
ARSINOE		X	X	X			
CIPORT					X		X
SUPER-LNG Plus					X	X	

Source: Authors (2022).

A combined reading of Tables 2 and 3 shows that allocation of resources puts soft actions at the top, followed by infrastructure and rational use of energy and cutting energy consumption and costs, slightly above smart technology and innovation and alternative fuels, which are very close (see also Figure 3). Since the EU-funded projects were regarded as an opportunity for the Port to prepare future actions and were designed accordingly, budget allocation seems to follow this rationale overall.

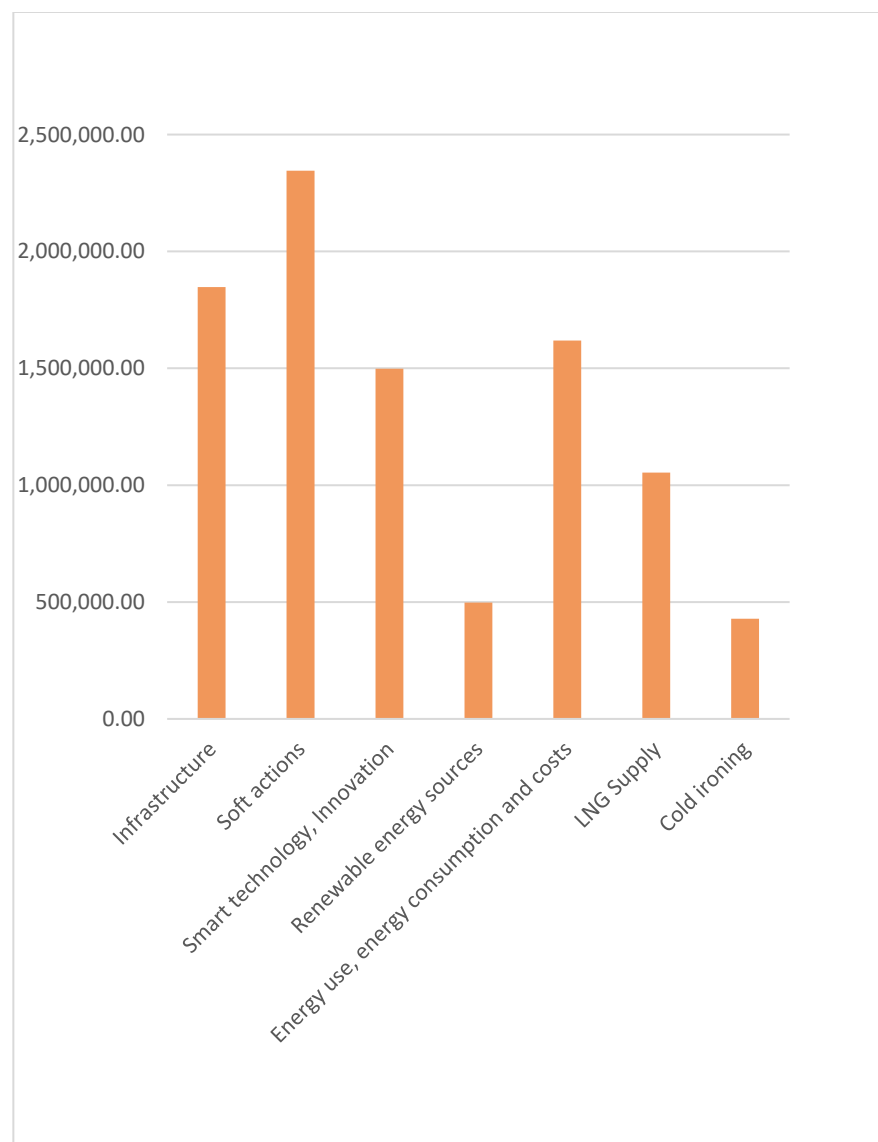


Figure 3. Allocation of resources. Source: Authors (2022).

This is also reflected in Table 4. All projects fall under the category “studies” or “preparatory actions” and two projects represent a mix of these two categories, but none of the projects include any “works” so far. It seems that until recently the Port’s preparation for an energy transition was either too low or none at all. Concurrently, the PPA is thoroughly planning the next day for the Port and utilises EU-funded energy-related projects to this end. Therefore, we expect a more balanced picture in the future, with the category of “works” taking up a significant part of the Port’s efforts.

Table 4. EU-funded energy-related projects in the Port of Piraeus—Type of Action.

Project Acronym	Studies	Works	Mixed	Preparatory Actions
POSEIDON MED II	X			X
ELEMED	X			
SUPAIR	X			X
SUPER LNG	X			X
NEORION	X			
PIXEL			X	
GREEN C PORTS			X	
EALING	X			X
ARSINOE	X			X
CIPORT	X			X
SUPER-LNG Plus	X			

Source: Authors (2022).

The interview also showed that some new projects are in the pipeline, to be submitted for funding under EU programmes within the framework of new EU calls for proposals. Fields of interest for these pending submissions are energy management, alternative fuels infrastructure, renewable energy sources, hydrogen use and bunkering. They are deemed to be consistent with the choices made so far and current trends.

5.3. Results and Impacts

As presented in Table 5, seven out of eleven EU-funded energy-related projects in the Port of Piraeus have been fully implemented as scheduled, while the remaining four are currently under implementation and are expected to be completed in the course of 2023 and 2025. Two of these projects, namely PIXEL and GREEN C PORTS are already operational.

Table 5. EU-funded energy-related projects in the Port of Piraeus—Status report.

Project Acronym	End	Implemented	Implementation in Progress	Operational
POSEIDON MED II	31/12/2021	X		
ELEMED	31/3/2018	X		
SUPAIR	30/6/2020	X		
SUPER LNG	30/6/2021	X		
NEORION	31/3/2021	X		
PIXEL	30/9/2021	X		X
GREEN C PORTS	29/12/2023		X	X
EALING	30/6/2023		X	
ARSINOE	30/9/2025		X	
CIPORT	30/11/2023		X	
SUPER-LNG Plus	31/8/2022	X		

Source: Authors (2022).

An evaluation of the projects, as presented in Table 6, shows that most of the efforts are geared towards “energy services”, since PPA is increasingly aware that providing new energy services to port users can be very profitable and there is an urgent need to be adequately developed, making this a priority for the Port. This category is followed by “energy transition”, which is also a major challenge for coming years in terms of sustainability, and “energy infrastructure” as an enabler of change. Although all projects can be associated with energy targets to a greater or lesser extent, only SUPAIR concretely falls under this category. Finally, seven out of eleven EU-funded energy-related projects in the Port of Piraeus explicitly fall under the category “environmental impact/sustainability”, while the remaining four are indirectly associated therewith (Table 6).

Table 6. EU-funded energy-related projects in the Port of Piraeus—Evaluation.

Project Acronym	Energy Targets	Energy Infrastructure	Energy Services	Energy Transition	Environmental Impact/Sustainability
POSEIDON MED II	X		X	X	
ELEMED			X	X	X
SUPAIR					X
SUPER LNG			X	X	
NEORION		X			
PIXEL					X
GREEN C PORTS					X
EALING		X	X		X
ARSINOE					X
CIPORT		X	X		X
SUPER-LNG Plus			X	X	

Source: Authors (2022).

Table 7 presents the main results and impacts of the projects. It should be stressed that we do not go into every single result and impact, since that would by far exceed the scope of this research. It would have been in any event impossible to capture every single impact of the projects, as some will probably become visible only at a much later stage. Also, results for, and impacts on, third parties are hard to identify and externalities even harder. We look at several effects and impacts on the basis of selected indicators to provide an indicative picture of the projects' importance for the Port of Piraeus, thus showing the multi-layered nature of the projects, their complexity and multiple targeting from the outset. It should be noted that although we attempt to distinguish between results and impacts for analytical purposes, this distinction is in practice often extremely difficult.

The interview has confirmed that the projects had significant results for the PPA and third parties, highlighting as some key benefits the linkage between energy and sustainability matters, increased environmental awareness, but also enhanced collaboration culture and engagement in environment-friendly port operation. Beyond that, the interview has revealed that the projects have led to the development of a network of partners at home and abroad, ensuring significant positive spinoffs for PPA S.A. such as exchange of best practices, knowledge-sharing and cooperation for new project proposals.

Table 7. EU-funded energy-related projects in the Port of Piraeus—Selected indicators.

Project Acronym	Results	Impacts
POSEIDON MED II	<ul style="list-style-type: none"> Site evaluation study to address specific site issues related to LNG bunkering Risk assessment of LNG bunkering infrastructure and per type of bunkering operations Updating the Port's Master Plans with regard to the installation of LNG storage and bunkering infrastructure and operations at the Port Engineering studies to maximise technical solutions for LNG bunkering 	<ul style="list-style-type: none"> Assess bunkering fuel capacity requirements under current and future trades Establish that potential risks to the jetty, bunkered ship, adjacent port facilities and third parties/ships are within acceptable "as low as reasonably possible" levels Public authorities' feedback and approval, issue of permits by the relevant authorities Optimisation of harbour infrastructure and environmental/social impact assessment
ELEMED	<ul style="list-style-type: none"> Regulatory framework for Onshore Power Supply (OPS) Regulatory framework for shipping electrification Impact assessment on OPS and shipping electrification Risk assessment guidelines and training requirements Front-End Engineering Design for Piraeus Port (FEED study) 	<ul style="list-style-type: none"> Cutting emissions in port surrounding areas Reduction of noise & vibrations Upgraded quality of life Alignment with EU & international regulations Benefits for trade and tourism Support mobility & insular community

Table 7. Cont.

Project Acronym	Results	Impacts
SUPAIR	<ul style="list-style-type: none"> Action Plan aiming at the gradual configuration of the Port into a sustainable and low-carbon footprint transport hub Enhanced capacity of port authorities in the Adriatic-Ionian area to plan and implement sustainable, low-carbon, multimodal transport and mobility solutions with an integrated, territory-based approach Transnational strategy for low-carbon transport systems in the Adriatic-Ionian basin Network of Adriatic-Ionian Sustainable and Low-Carbon Ports. 	<ul style="list-style-type: none"> Methodological framework for assessing the technical and economic feasibility of actions focusing on: (a) mitigation of carbon footprint in the port area and (b) improving the recycling of package waste in passenger stations and cruise terminals Enhancement of the environmental and energy performance of the port enabling it to provide sustainable and high-quality services for both passengers and freight
SUPER LNG	<ul style="list-style-type: none"> Guidelines for safety reporting of LNG infrastructure in port areas Guidelines for safety reporting evaluation of LNG infrastructures in port areas Guidelines for emergency planning of LNG infrastructures in port areas Set of massive open online courses Creation of expert network on LNG safety 	<ul style="list-style-type: none"> Improve sustainable development and energy efficiency Improve operational/infrastructural resilience Sustainable transport of LNG
NEORION	<ul style="list-style-type: none"> Establish a transnational cluster in the Adriatic-Ionian region on green shipbuilding Facilitate the market uptake of research and innovation and push green shipbuilding sector towards new and rising markets Establish a green shipbuilding industry and enhance the diversification of the sector towards future growth markets 	<ul style="list-style-type: none"> Accelerate cooperation of key stakeholders in the sector in maritime regions Reinvigoration of the shipbuilding sector, one of the EU priorities in terms of innovation, competitiveness and research activities Formulate a vision and a specific support framework for the shipbuilding sector
PIXEL	<ul style="list-style-type: none"> Develop an operational management platform to enable a quicker, more accurate and in-depth knowledge of port operations Model and simulate port operations processes for automated optimization Develop predictive algorithms to model selected port operative processes 	<ul style="list-style-type: none"> Ability to interact, measure and compare several port operational data Parameterise the environmental impact caused by port operation processes in view of optimal resource use Bolster efficiency in energy demand, hinterland multimodal transport needs or anticipation of environmentally harmful actions
GREEN C PORTS	<ul style="list-style-type: none"> Designing upgrades in existing sensor networks and installing new sensors at the pilot ports Designing and programming of a port environmental performance IT platform Predicting air quality in the port and generating notifications to the city council and/or other government institutions Predicting noise level in the port 	<ul style="list-style-type: none"> Sensor networks affecting the port's performance and its impact over the city (e.g., weather and meteorological parameters like temperature, pressure, rain volumes, air quality parameters, wind, wave, current and tidal regimes, noise and traffic congestion). Receive real time data from the sensor networks and from existing operating systems in each port Receive alarms when certain tolerance emission levels are exceeded Generating notifications to the city council and/or other government institutions when certain tolerance noise emission levels will be exceeded at the neighbourhoods surrounding the ports
EALING	<ul style="list-style-type: none"> Definition of a common harmonised and interoperable legal and regulatory framework in order to facilitate the implementation phase of OPS infrastructure in the ports Front-end engineering design studies and other necessary technical studies feeding directly into tender specifications for ports Ensuring the port-to-vessel compatibility in the TEN-T Maritime Network Environmental studies Clean power supply plans and tender documents for the projected works CBA for the necessary electrification infrastructures Financial blending schemes 	<ul style="list-style-type: none"> Maturity and ready to launch the works on OPS equipment and infrastructure OPS can be included in the internal strategy of the port Final investment decision

Table 7. Cont.

Project Acronym	Results	Impacts
ARSINOE	<ul style="list-style-type: none"> Port's assets climate change vulnerability assessment Corporate sustainability reporting system (SDG implementation dashboard). Manual for financial instruments to support the pathways to resilience 	<ul style="list-style-type: none"> Improve operational/infrastructural resilience Monitor/improve the implementation of the Sustainable Development Goals (SDGs) at port level.
CIPORT	<ul style="list-style-type: none"> Technical detailed studies for the electrification infrastructure at the Port of Piraeus' cruise berths (FEED studies, technical risk assessment, tender documentation) Environmental Impact Assessment Financial studies (CBA & Pricing Analysis) 	<ul style="list-style-type: none"> Maturity and ready to launch the works on OPS equipment and infrastructure at the Port of Piraeus' cruise berths OPS can be included in the internal strategy of the Port of Piraeus Final investment decision for the port
SUPER-LNG Plus	<ul style="list-style-type: none"> Support the safe exploitation of LNG for ship propulsion and port machinery Guidelines for safety reporting of LNG infrastructure in port areas Guidelines for safety reporting evaluation of LNG infrastructures in port areas Online open courses 	<ul style="list-style-type: none"> Improve sustainable development and energy efficiency Improve operational/infrastructural resilience Prevent any form of discrimination regarding the participation in the training activities on LNG bunkering

Source: Authors (2022).

While it is apparent that many of the impacts of the projects, as presented in Table 7, are directly or indirectly related to the environment/sustainable development, Table 8 focuses specifically on this issue in order to further highlight the importance of the projects. Once again it is ascertained that the projects are designed from the outset to follow a dual approach, combining energy and environmental objectives, but it is also practically impossible to separate energy from the environment/sustainability in port operation and development. As is the case for project impacts in general and as already pointed out above, the impacts on the environmental performance and sustainability of the port and/or third parties cannot be fully identified, they have not yet, or only partially, occurred, especially due to the fact that the projects are mostly preparatory actions. Tables 7 and 8 point to a changing landscape in the port and port cluster, which gives grounds for optimism in terms of the future.

The interview has confirmed that the projects serve environmental objectives and sustainable development to a great extent, as well as create a certain dynamic in the port in terms of energy and environment/sustainable development and for third parties. Among the results of the projects that are considered important in relation to these fields, the interview highlighted the studies and preparatory work within the framework of POSEIDON MED II and SUPER LNG/SUPER LNG Plus, ELEMED and EALING. The former three projects will help introduce LNG bunkering in a safe manner, considerably reducing emissions, the latter two will enable onshore power supply in the port, thus significantly contributing to improved air quality and noise levels in the port area and the city of Piraeus. Furthermore, the interview drew attention to the SUPAIR project that provided necessary data and improved the capacity of the port to plan and implement low-carbon and multimodal transport and mobility solutions.

According to the responses provided in the interview, the PPA and other parties involved have capitalised on the results of the projects to a large extent, but there is room for improvement. The most important requirements for the best possible use of project results are, as stated in the interview, the following: broad internal and external understanding of the importance of project results, cooperation among stakeholders/parties involved, integration of results in business decisions, port operation and development, as well as mobilisation of resources. Before that, dissemination of results within the port and beyond those directly involved, as well as to potentially affected third parties seems to be recognised as rather satisfactory, but there is also room for improvement.

Table 8. EU-funded energy-related projects in the Port of Piraeus—Impact on environmental performance/sustainability.

Project Acronym	Impact
POSEIDON MED II	<ul style="list-style-type: none"> • Improvement of environmental performance through preparatory actions for LNG bunkering • Improvement of energy efficiency • Reduction of carbon footprint • Elaboration of a sustainable LNG trading and pricing scheme
ELEMED	<ul style="list-style-type: none"> • Sustainable development • Improvement of energy efficiency • Reduction of emissions in port surrounding areas • Reduction of noise and vibrations • Upgraded quality of life
SUPAIR	<ul style="list-style-type: none"> • Monitoring and reduction of carbon footprint • Implementation of energy management plan
SUPER LNG	<ul style="list-style-type: none"> • Sustainable development • Improvement of energy efficiency • Improvement of operational and infrastructural resilience
NEORION	<ul style="list-style-type: none"> • Development of a platform supporting green shipbuilding • Establishment of a transnational pilot cluster supporting sustainability in shipbuilding • Development of a common strategy to enhance innovation capacities related to sustainable shipbuilding sector
PIXEL	<ul style="list-style-type: none"> • Increase support to decision-making and optimisation of port/city specific needs • Improve specifications of port processes regarding energy demand • Mitigate port activity air pollution levels due to selection of appropriate measures
GREEN C PORTS	<ul style="list-style-type: none"> • Upgrading existing sensor networks in Valencia, Venice and Piraeus • Evaluating real-time data in Bremerhaven, Wilhemshaven, Valencia, Venice and Piraeus • Decreasing port traffic congestion and reducing CO2 emissions by 10% for trucks entering and leaving the port • Optimising vessel calls at port before and after port closure due to bad meteorological conditions • Increase accuracy in air quality and noise level predictions estimated 24 h in advance
EALING	<ul style="list-style-type: none"> • Adaptation to the new legal framework for alternative fuels in the maritime sector • Improvement of energy efficiency • Reduction of carbon footprint
ARSINOE	<ul style="list-style-type: none"> • Increase resilience of port operations • Increase resilience of port infrastructure • Increase energy efficiency • Tool to monitor sustainability performance, support decision-making
CIPORT	<ul style="list-style-type: none"> • Adaptation to the new regime of alternative fuels utilisation in the cruise sector • Improvement of energy efficiency Reduction of carbon footprint in the port
SUPER-LNG Plus	<ul style="list-style-type: none"> • Promotion of sustainable development • Improvement of energy efficiency • Improvement of operational and infrastructural resilience

Last but not least, results and impacts of the projects depend on adequate support. As regards the question “What would you expect to be the support for your efforts in relation to similar projects in the future at EU policy and governance level?”, a support that is better linked to the needs of the port and more targeted calls came on top, followed by better consultation on the content of calls for project proposals. Easier and simpler submission/implementation procedures ranked third. Financial support came only at fourth place, confirming once again that funding is appreciated by the port, though it is not the primary motivation for the projects. Information ranking last shows that there

is no gap there for the port. The answer to the question “What would you expect to be the support for your efforts in relation to similar projects in the future at national policy and governance level?” shows that the port would appreciate support from the Greek State for project proposals at European level and better coordination. Easier and simpler submission/implementation procedures ranks third among answers provided, stressing that red tape at national and European level unnecessarily complicates every step in the process. Finally, information seems not to be an issue for the port.

6. Discussion

6.1. Main Benefits of the Projects

EU-funded projects in the energy sector have multiple benefits for the port and port stakeholders or local communities. First of all, EU calls for proposals have often been catalysts for action, pushing the port to identify problems or opportunities and work on solutions in the form of targeted interventions, becoming part of a wider project. The Port of Piraeus projects triggered concrete and targeted initiatives, enabling problem-specific solutions and creating added value for the Port and all parties involved, even third parties. Promoting a stronger linkage between energy and environmental objectives, they have facilitated mainstreaming of the environmental dimension in port operation and development, and have also contributed to improved environmental performance for the port, hence enhancing environmental sustainability. Although funding was often not the most important reason for the port to seek participation in an EU-funded project, despite the common presumption regarding port motivations, it has certainly made it easier for PPA S.A. Availability of funding always plays a role in a port’s decision to embark upon such an endeavour, especially when results are uncertain and tangible effects are not yet in sight. The Port was able to explore solutions and opportunities at minimum cost and risk. Furthermore, the PPA formed an active network of potential partners through successful participation in projects, seeking to take advantage of funding capabilities opening up in the EU system. This network, acting as an incubator for new ideas and project proposals, constantly encourages cooperation for new submissions and project content. Beyond the scope of each concrete project, benefits such as exchange of ideas, best practices and peer review pressure for improvements and advanced solutions emerge. A similar process takes place between the Port and port stakeholders and/or local communities in the phase of both planning and implementation. Each project creates a forum for reflection and communication among parties, thus, it is likely to produce positive feedback for action and trigger further cooperation on existing or new fields of interest. Last but not least, externalities such as a progressive mentality change in the port, enhancement of cooperation culture, promotion of result-oriented handling, emphasis on strategic planning, etc., are important spinoffs of the projects.

6.2. Achievements and Impact

Findings on the main benefits of EU-funded energy-related projects in the Port of Piraeus would be incomplete without a concrete evaluation of achievements and impact with regard to energy and environmental objectives so far. Of course, results of the projects might be easy to identify, but achievements and impacts are not. Intrinsic methodological constraints impede an evaluation in full, allowing us to capture only part of the picture. Some of the results achieved are considered enablers for further action. Others will reach their full impact only at a later stage. Many of them are assumed to meet requirements in order for the port to accomplish a qualitative leap in energy and environmental matters, but are not easily, or not at all, quantifiable. Despite this fact, it is possible to attempt an overall assessment and draw some general conclusions.

As an overall remark, it is stressed that the projects did not drastically change the energy landscape in/for the port. The projects were ambitious in their targeting, but ambitious targets require careful and methodical planning, as well as a step-by-step approach. The envisaged interventions were designed to be a game changer, though changes could

only follow on the ground of meticulous preparation. Therefore, the majority of the projects focused on necessary studies, intending works to start at a subsequent phase on the basis of their results. Most of the studies considered have been already completed and those remaining are currently under elaboration. In this respect, LNG bunkering and cold ironing became for instance quite a realistic prospect for PPA. The Port can now proceed with the construction of infrastructure and deployment of energy services and these are expected to be financed through new EU-funded energy-related projects or by self-financing.

As far as sustainability is concerned, the studies have taken into consideration all relevant aspects and integrated this dimension in concrete requirements, which need to be implemented in all works and measures to be taken. Yet, already the intention to promote energy solutions for the Port and port stakeholders towards decarbonisation, alternative fuels or rationalisation of energy use is considered an important change. Some of the interventions have focused on environmental footprint, with enhanced environmental monitoring through smart monitoring systems or electric loading/unloading machinery representing two different examples. They may have their impact on a more environmentally friendly port operation, but they perhaps also show an increasing trend in mainstreaming the environmental dimension in port's everyday life and decisions.

6.3. Constraints and Obstacles

Although the importance of EU-funded energy-related projects for the Port of Piraeus and port stakeholders or local communities around the port has already been clearly demonstrated above, it must be stressed that they cannot solve the Port's each and every problem, meet all energy and environmental challenges and meet all its needs. Projects are targeted interventions, aiming to address specific problems and needs, provide concrete innovative solutions, support initiatives in new fields of interest and achieve leverage and multiplication effects using as few resources as possible. Apart from that, the complexity of energy and environmental matters, adding to the complexity of port business, operation and development, creates a challenging landscape for any initiative. Further challenges arise from the fact that energy-related interventions are cost-intensive, as they are time-consuming, making decisions for action more difficult. Experience from EU-funded energy-related projects' implementation has revealed serious obstacles. Among them are: legal uncertainty, an insufficient and problematic regulatory framework for port energy services, long overdue and extremely rigid permission procedures, a very complicated institutional and administrative environment, and the reluctance of stakeholders to support new initiatives and cooperate with one another. Obstacles do not only affect project implementation, they also adversely affect project planning, as they obstruct exploitation of results and impact of the projects to a full extent.

6.4. Challenges Ahead for the Port

Beyond the improvements achieved in the port energy sector and environmental performance, the implementation of the projects presented and analysed above laid the groundwork for further progress. Some projects contributed to the preparation of solutions for a smart energy port, LNG bunkering facilities or cold ironing. Other projects helped the Port and port stakeholders identify needs for further action, including new projects in order to complete what is still missing, improve existing elements, expand activities, etc. Hence, it is up to the Port to keep up efforts, take advantage of progress so far, and build upon existing results.

The evaluation of the projects has revealed a number of factors that are assessed as particularly important for seizing new opportunities opening up, in terms of new calls and funding available, but also for making the most of project outcomes, both major challenges for the Port of Piraeus. Know-how in project planning, preparing of project proposals and project implementation, as well as a large Europe-wide network of former and potential new partners are comparative advantages of the Port to capitalise on. Although these are not the only requirements for successful submission and approval of substantial project proposals,

they create a certain optimism that the Port will maintain and even enhance its dynamic course. Preparation for new submissions confirms that the Port has already incorporated project-related objectives into its strategic planning. Of course, it is an imperative for the Port to follow in the project selection a clear and coherent strategy in line with the company's vision and priorities, serving the objectives set in the most beneficial way. Energy and environment will most probably remain among the Port's top priorities for the future, but possible directions and concrete action still need to be defined. Challenges ahead for the Port are taking shape at every possible level. Focusing on critical requirements for best preparation of projects and utilisation of project results, the following are certainly of utmost importance:

- A broader understanding in the port that EU-funded projects are most beneficial for the purposes of the Port, if not necessary;
- A dedicated structure in the Port tasked with project planning and implementation, adequately placed in the company's organisation;
- Plenty of qualified and experienced personnel;
- Cooperation with port stakeholders, academia, etc.;
- Active participation in consultation and lobbying in the EU;
- Widest possible dissemination of results;
- Integration of results in business decisions and everyday life of the Port.

The Port of Piraeus has successfully managed to participate in significant projects and work out solutions with positive outcomes, although there is still plenty of room for improvement. It is almost self-evident that the degree to which the abovementioned requirements will be met will determine the level of success in each and every phase of involvement with EU-funded projects.

It becomes clear that challenges for the Port arise at many different levels. Project content is however the most important element for meaningful changes and maximum impact. To this end, it is critical to elaborate future projects onboarding best practices in the sector, but also recent research findings. The Port could benefit substantially from measures, for instance, in the field of energy management and operational planning, offering solutions towards sustainability [62]; measures so far missing from the projects. After all, some operations in the Port are extremely energy-intensive, thus energy-aware management or specific targeted measures can achieve tangible results, as shown in relevant research articles [63–66].

6.5. Policy and Governance Matters

From a policy and governance perspective, EU-funded energy-related projects are powerful tools, which motivate and at the same time enable ports and port stakeholders to take concrete action in order to achieve energy and environment-related objectives. Recognising the importance of interventions for encouraging and supporting changes and sustainable transition in ports, the EU mobilises political capital, administrative capacity and financial resources. Policy content, strategy concepts and mechanisms shape the landscape for the interventions. Project submission and approval, as well as implementation follow concrete EU rules and procedures. It is obvious that policy design and EU funding for energy projects in ports, as well as implementation of the projects take place in a very complex environment, where policy and governance interact, producing results and impacts. Therefore, it is essential to rely on evidence-based action and strengthen policy and governance feedback loops, which lead to optimisation and improvements. On the policy level, coherence is also crucial, since objectives pursued in ports through EU-funded energy-related projects fall under different EU policies, e.g., energy, transport, environmental policy, etc.

Momentum for EU-funded energy-related projects in the port sector will hold up and most probably grow, since the EU struggles with energy matters as shown by *REPowerEU* [67] and other EU initiatives which try to offer viable solutions. The *European Green Deal*, as a major long-term EU strategy, guarantees a long-lasting impulse for mainstreaming environmental concerns and targets in the projects, fostering sustainability in port

operation and development through energy transition [68–70]. The *8th Environment Action Programme*, guiding the EU's efforts until 2030, within the framework of the European environmental policy [71], will also push for progress. And of course the landscape for ports will drastically change with the *Fit for 55 Package* [72], a set of EU legislation aiming to put in place new initiatives across several policy areas, such as environment, energy, transport and economic and financial affairs towards achievement of *EU Climate Law* targets. This new framework poses an enormous challenge for the industry to adapt and be proactive. It is considered to be a strong impetus, but it is also an opportunity, for ports and the port sector in general. New projects will enable compliance and might even go beyond that. Financial support for the projects will be provided through the *2021–2027 Multiannual Financial Framework* and the new European recovery instrument, *NextGenerationEU* (NGEU) [73–75]. In any event, future EU-funded energy-related projects in ports will take place within a new framework shaped by the following legislative texts: Regulation (EU) 2022/869 on guidelines for Trans-European energy infrastructure [76], which replaced previous rules, and the upcoming Regulation on guidelines for the development of the Trans-European transport network [77,78], along with Regulation (EU) 2021/1153 establishing the Connecting Europe Facility and repealing Regulations (EU) No 1316/2013 and (EU) No 283/2014 [79]. These regulations will define policy contents and governance of the system, setting also clear priorities for the relevant projects, as well as guiding the sector with regard to future proposal submissions. For the most part, implementation efforts will be facilitated by the recently established European Climate, Infrastructure and Environment Executive Agency (CINEA) [80], the successor organisation of the Innovation and Networks Executive Agency (INEA). Although the new set-up is considered highly favourable to EU-funded energy-related projects, efficiency and results of the new system still remain to be seen in the practice. On the governance side, for instance, it is essential to reduce red tape and simplify procedures, but the new framework seems rather unable to make substantial improvements to this end.

7. Conclusions

Research findings based on the analysis of collected data, as presented above, make clear that the EU-funded energy-related projects that have been planned and implemented by the PPA S.A. promoted efforts in the energy and environment sector, with significant benefits on multiple levels. In our case study, the Port of Piraeus confirms the hypothesis that EU-funded energy-related projects not only provide and support solutions for ports in energy matters, but they also create real opportunities for change and transition in ports. The projects facilitate concrete initiatives in matters of port operation and development, as well as enable the implementation of sustainability strategies. Significant outcomes across a wide range demonstrate the high value of the projects. It is quite certain that many of these projects, if not all, would not have been carried out without EU support and several of their outcomes would remain out of reach. However, and despite the positive results of the projects and achievements so far, the impact of the projects depends on many different parameters. Thus, the port, key port industry stakeholders and public authorities should be committed to meeting the requirements for the best possible use of the projects and maximum impact. At the same time, there are still many challenges to be overcome. Therefore, the preparation and submission of project proposals is expected to continue and even increase in the years to come.

The article examines EU-funded energy-related projects for sustainable ports, providing evidence from the Port of Piraeus and useful insights on the topic, but future research may complement the picture, shedding light on many different aspects and offering knowledge about how energy matters and sustainability affects ports, port services users and providers, and communities around ports. Beyond environmental mainstreaming in the energy sector, a deeper and better understanding of environmental implications for ports and the port industry is necessary in order to better grasp the nexus of energy and environment issues in port operation and development, as well as energy strategies and decisions in

the ports sector within the framework of the sustainability debate. As EU-funded energy-related projects will continue to play a crucial role in the development of initiatives to achieve energy and environmental objectives in ports, we are confident that further scientific engagement in the field will follow. More case studies and/or comparative studies in the field would provide an important basis for sound scientific conclusions and practical application. Relevant research in port management and public policy could provide further meaningful contributions and eventually have a significant impact towards sustainability.

Author Contributions: conceptualisation, all authors; methodology, C.P.; software, D.S.; validation, all authors; formal analysis, C.P.; investigation, all authors; resources, C.P.; data curation, all authors; writing—original draft preparation, C.P.; writing—review and editing, all authors.; visualisation, all authors; supervision, C.P.; project administration, C.P. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study did not require ethical approval.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available upon request from the corresponding author.

Acknowledgments: The authors would like to express their gratitude to the PPA S.A. for data made available for the purposes of the study and the interview granted. Special thanks goes to the Special Issue’s editor George Kyriakarakos and also to the reviewers for their remarks and suggestions.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. Identity of EU-Funded Energy Projects in the Port of Piraeus

Project Name	Project Summary
POSEIDON MED II	<p>Short Description: The project is a continuation of the “COSTA II–East (Poseidon-Med)”—2013-EU-21019-S and the “Archipelago-LNG”—2013-EL- 92080-S Actions which together form part of the Global Project aiming to take all the necessary steps towards adoption of LNG as marine fuel in East Mediterranean Sea, while making Greece an international marine bunkering and distribution hub for LNG in southeastern Europe. The Action will build on the achievements of the abovementioned projects, as well as on the results of “COSTA”—2011-EU-21007-S which delivered the Master Plan for LNG as a marine fuel in the Mediterranean region. The specific objectives of the Action are to:</p> <ul style="list-style-type: none"> • facilitate the adoption of a regulatory framework for the LNG bunkering • design the extension of Revithoussa LNG terminal; • design and construct an LNG-fuelled specific feeder vessel; • implement technical designs and plan approvals for the retrofit/new building of LNG fuelled vessels and for additional ports’ infrastructure for bunkering operations; • examine potential synergies with other uses of LNG; • develop a sustainable LNG trading and pricing pattern; • develop financial instruments to support the port and vessel installations. <p>Project details: Programme: CEF Transport. Action: 2014-EU-TM-0673-S. Call year: 2014. Location of the Action: Cyprus, Greece, Italy. Implementation: June 2015 to December 2021. Maximum EU contribution: €26,639,703. Total eligible costs: €53,279,405. Percentage of EU support: 50%. Coordinator: DEPA COMMERCIAL (DEPA) S.A. (Greece). Transport corridor: Baltic—Adriatic, Mediterranean, Orient-East-Med.</p> <p>https://ec.europa.eu/inea/en/connecting-europe-facility/cef-transport/2014-eu-tm-0673-s and https://www.poseidonmedii.eu/ (accessed on 16 December 2022).</p>

Project Name	Project Summary
ELEMED	<p>ELEMED—ELectrification of the Eastern MEDiterranean Area</p> <p>Short Description: This MoS-wider benefit Action (twinned with Action 2015-EU-TM-0236-S) was focused on the assessment of the possibilities to introduce onshore power supply and electric propulsion for ships in the Eastern Mediterranean. It included four ports in three EU countries: Cyprus (Limassol port), Greece (Port of Killini, Port of Piraeus) and under the twinned project—Slovenia (Port of Koper). The Action consisted of background and preparatory studies aimed at providing a basis for preparation of a front-end engineering design (FEED) for cold ironing installations in four ports with a pilot action demonstrating cold ironing at the Port of Killini. The Action was a part of a Global Project on implementing environmentally friendly maritime transportation in the Adriatic-Ionian Sea. The Action contributed to promoting onshore power supply solutions and electricity-based propulsion systems for vessels leading to improved environmental performance of shipping and ports.</p> <p>Project details: Programme: CEF Transport. Action: 2015-EU-TM-0235-S. Call year: 2015. Location of the Action: Cyprus, Greece. Implementation: April 2016 to March 2018. Maximum EU contribution: €818,649. Coordinator: Hellenic Lloyd’s S.A. (Greece). Transport corridor: Orient-East-Med.</p> <p>https://ec.europa.eu/inea/en/connecting-europe-facility/cef-transport/2015-eu-tm-0235-s and https://www.elemedproject.eu/ (accessed on 16 December 2022).</p>
SUPAIR	<p>SUPAIR—Sustainable Ports in the Adriatic-Ionian Region</p> <p>Short Description: SUPAIR responds to a major challenge, tackling emissions reduction from shipping and onshore port operations with an integrated approach, enhancing port authorities’ capacity to plan and implement low-carbon and multimodal transport and mobility solutions and further empowering the main political, technical, trade stakeholders and partners in related decision-making. SUPAIR puts together a transnational network of port authorities, technical organisations, relevant actors to jointly elaborate a durable and transferable methodology; then develops operational action plans complete with technical and feasibility studies in the 7 partner ports; it ultimately implements dedicated actions and produces a transnational strategy for port-based low-carbon transport systems to increase the network, disseminate, enhance and widen scope, methodology and results. The transnational development and implementation (3 EU and 2 IPA countries) of methodology and actions insisting on a broad range of fields, with an innovative territory-based approach, involving port authorities, technical partners, stakeholders and institutional actors guarantee quality, durability and transferability.</p> <p>Project details: Programme: INTERREG-ADRION. Project Number 33. Programme Priority 3 “Connected Region”—Specific objective “Enhance capacity for integrated transport and mobility services and multimodality in the Adriatic-Ionian area”. Call year: 2016. Location of the Action: Albania, Greece, Italy, Montenegro, Slovenia. Implementation: January 2018 to June 2020. ERDF budget: €1,052,948.25. IPAII budget: €178,453.04. Total budget: €1,448,707.43. Percentage of EU support: 85%. Lead Partner: Area Science Park (Italy). https://supair.adrioninterreg.eu/ (accessed on 16 December 2022).</p>

Project Name	Project Summary
SUPER LNG	<p>SUPER LNG—Sustainability PERFORMANCE of LNG-based maritime mobility</p> <p>Short Description: Environmental pressure in port areas and in urban areas close to ports is high owing to emissions from ships, port machinery and transport to/from the port areas. LNG is proposed as a low-carbon clean fuel for marine transport in port areas. The boost of LNG marine and terrestrial propulsion may be a key to enhance the sustainability of port areas, protecting health of population and cultural heritage. However, distribution networks and port infrastructures for the bunkering of LNG-powered ships requires technologies and solutions assuring a high level of safety in touristic areas of the Adriatic and Ionian seas, avoiding trade-offs among environment protection and safety of passengers and personnel. The overall objective of the project is to increase the level of safety, environmental quality and sustainability of LNG maritime transportation in the Adriatic sea. It aims at providing a uniform framework to support the implementation of technical systems for the distribution and supply of LNG in port areas, meeting the requirements of the Seveso Directive (Directive 2012/18/EU). The main outputs of the project are:</p> <ul style="list-style-type: none"> • A strategy for harmonised guidelines for the safety assessment of LNG supply systems in the Adriatic-Ionian area, sharing experience and practices derived from safety and security directives applied in conventional facilities; • An Action Plan, so as to share among EU the framework of the technical guidelines and best practices addressing the standardisation of the technological solutions proposed for LNG supply; • Creation of a network establishing a permanent educational system in the area of safety and forming experts for port operators, maritime educational instructions, public authorities, and other stakeholders; <p>Project details: Programme: INTERREG-ADRION. Project Number 118. Programme Priority 3 “Connected Region”—Specific objective “Enhance capacity for integrated transport and mobility services and multimodality in the Adriatic-Ionian area”. Call year: 2016. Location of the Action: Greece, Italy, Slovenia. Implementation: January 2018 to June 2020. Total budget: €895,049.68. ERDF budget: € 760,792.21. Percentage of EU support: 85%. Lead Partner: National Center for Scientific Research “DEMOKRITOS” (Greece). https://superlng.adrioninterreg.eu/ (accessed on 16 December 2022).</p>
NEORION	<p>NEORION—Green ShipBuilding</p> <p>Short Description: The project aims at establishing a transnational Cluster in the Adriatic-Ionian area on green shipbuilding that will accelerate both the cooperation of key actors and innovation in the industry. NEORION is expected to reinforce the traditional shipbuilding sector through coordinated efforts that will facilitate the exploitation of innovative technologies and technology transfer between new complementary markets such as new materials & specialised vessels. As main outputs, the project aims at enhancing the innovation capacity of the sector, creating a sustainable shipbuilding ADRION cluster, developing tools to favor the cooperation of SMEs with research institutions and provide action plans to both foster economic growth of the sector and benefit the regional business ecosystem, through actions targeted to and initiated by representatives of the Quadruple Helix. NEORION aims at exploiting joint assets of the participating countries to eventually create a transnational innovation system for green shipbuilding. Expected impact is the creation of an ADRION Cluster that will maximise growth potential, synergies & the diversification of the shipbuilding market.</p> <p>Project details: Programme: INTERREG-ADRION. Project Number 751. Programme Priority 1 “Innovative and smart region”—Specific objective “Support the development of a regional innovation system for the Adriatic-Ionian area”. Call year: 2016. Location of the Action: Croatia, Greece, Italy, Slovenia. Implementation: January 2018 to March 2021. ERDF budget: €1,000,386,25. Total budget: €1,176,925. Percentage of EU support: 85%. Lead Partner: University of the Aegean (Greece). https://neorion.adrioninterreg.eu/ (accessed on 16 December 2022).</p>

Project Name	Project Summary
PIXEL	<p>PIXEL—Port IoT for Environmental Leverage</p> <p>Short Description: PIXEL is the first modular solution combining strong methodology and smart technology for small and medium port ecosystems. It enables optimisation of operations through Internet of Things (IoT), while reducing environmental impact. In addition to a lack of tools for environmental impact assessment, an effective integration of operational data is far from optimal in most ports. Digitalisation does not reach every ecosystem equally, creating considerable gaps between large and small ports. PIXEL addresses all those issues by providing an easy-to-use open-source smart platform for operational data interchange in ports and its associated agents (e.g., cities). The project expects to improve several indicators in varying use-cases e.g., reduce energy consumption by 5%, average cost per passenger by 6% and average waiting times for vessels and trucks by 85%. PIXEL provides tools and guidelines leveraging technology with a unique approach: creating a single environmental metric for ports and modelling and optimising processes after gathering all available information.</p> <p>Project details: Programme: Horizon 2020. H2020-EU.3.4.—SOCIETAL CHALLENGES—Smart, Green And Integrated Transport. Topic: MG-7-3-2017—The Port of the future. Contract Number: 769355. Location of the Action: Croatia, France, Greece, Italy, Slovenia, Spain. Call year: 2017. Implementation: May 2018 to September 2021. EU contribution: €4,890,223. Total eligible costs: €4,890,223. Percentage of EU support: 100%. Coordinator: Universitat Politècnica de València (Spain).</p> <p>https://ec.europa.eu/inea/en/horizon-2020/projects/h2020-transport/infrastructure/pixel and https://pixel-ports.eu/ (accessed on 16 December 2022).</p>
GREEN C PORTS	<p>GREEN C PORTS—Green and Connected Ports</p> <p>Short Description: The GREEN C Ports Action will pilot the use of sensors, big data platforms, business intelligence tools and artificial intelligence modelling at the ports of Valencia, Venice, Piraeus, Wilhelmshaven and Bremerhaven, contributing this way to the future rollout of these technologies in the market. The first phase of the project will comprise the design, acquisition, engineering adaptation and installation of the different sensor networks at participant ports. These sensor networks will gather environmental data of different types (e.g., air quality parameters, weather information, noise, congestion at gates), transmitting it to a Port Environmental Performance (PEP) IT platform that will be programmed to receive real-time data from sensor networks and existing operating systems in the port (i.e., PCS, PMIS and TOS). The second phase of the project will start once the installation of the necessary equipment to build the required environmental sensor network is completed. At this stage, partners of the GREEN C Ports project will develop methods and analytics following big data techniques and advanced modelling, which will allow predictive analyses of ports' environmental performance. By analysing the data gathered from the sensor networks together with existing information supplied by different port authorities and community systems, it will be possible to build models and advanced algorithms to predict in real time the impact of the environmental conditions over port operations (ship loading/unloading, port congestion, traffic management, etc.) and also over nearby city areas in terms of air quality, noise and other relevant parameters.</p> <p>Project details: Programme: CEF Transport. Action: 2018-EU-TM-0117-S. Location of the Action: Germany, Greece, Italy, Spain. Call year: 2018. Implementation schedule: April 2019 to March 2023. Maximum EU contribution: €3,577,854. Total eligible costs: €7,155,708. Percentage of EU support: 50%. Coordinator: Fundación de la Comunidad Valenciana para la Investigación—Promoción y Estudios Comerciales de Valenciaport (Spain).</p> <p>https://ec.europa.eu/inea/en/connecting-europe-facility/cef-transport/2018-eu-tm-0117-s and https://greencportsproject.eu/ (accessed on 16 December 2022).</p>

Project Name	Project Summary
EALING	<p>EALING—European Flagship Action for Cold Ironing in Ports</p> <p>Short Description: In the context of the European Green Deal, the “EALING” Motorways of the Sea Action contributes to a Global Project aiming to accelerate the transition to electrification and deployment of Onshore Power Supply (OPS) solutions by 2025 in at least 16 EU maritime ports belonging to three different sea basins: the Mediterranean, the Atlantic Ocean and the Black Sea. The Action aims to establish a suitable technical framework based on EU and national legislations, and to lead all the necessary preparatory studies for effective implementation of OPS infrastructure in the ports of the EALING consortium. The specific objectives of the Action are:</p> <ul style="list-style-type: none"> • analysing the technical standards and obstacles, and proposing a harmonised approach for deployment of OPS infrastructure and equipment in the ports and maritime fleet adaptation; • implementing all the required studies for the future works in the ports: front-end engineering studies and other technical studies, environmental studies, clean power supply plans, CBA and financial blending schemes. <p>The Action will result in further development of a common framework for electrification of the ports and maritime fleet adaptation, and delivery of all the necessary technical and design studies on OPS solutions so that the Port Authorities will be ready to launch the construction and equipment phase.</p> <p>Project details: Programme: CEF Transport. Action: 2019-EU-TM-0234-S. Call year: 2019. Location of the Action: Bulgaria, Germany, Greece, Ireland, Italy, Portugal, Romania, Slovenia, Spain. Implementation schedule: June 2020 to June 2023. Maximum EU contribution: €3,480,120. Total eligible costs: €6,960,240. Percentage of EU support: 50%. Coordinator: Fundación de la Comunidad Valenciana para la Investigación—Promoción y Estudios Comerciales de Valenciaport (Spain). https://ec.europa.eu/inea/en/connecting-europe-facility/cef-transport/2019-eu-tm-0234-s and https://ealingproject.eu/ (accessed on 16 December 2022).</p>
ARSINOE	<p>ARSINOE—Climate-resilient Regions through Systemic Solutions and Innovations</p> <p>Short Description: The aim of the EU-funded ARSINOE project is to leverage innovation for climate adaptation across a series of key systems—from biodiversity to flooding and sea level rise, and from droughts and water scarcity to heatwaves and deforestation. ARSINOE will build an ecosystem for solutions to climate change adaptation. It will develop a methodological framework for combining the systems innovation approach with the Climate Innovation Window, a reference portal, to create a new three-tier approach that will be showcased in nine widely varied demonstrators, as proof of concept. The project’s overall aim is to show the way towards a green, digital, inclusive, resilient and sustainable future.</p> <p>Project details: Programme: Horizon 2020, H2020-EU.3.5.—SOCIETAL CHALLENGES—Climate action, Environment, Resource Efficiency and Raw Materials, Topic: LC-GD-1-3-2020—Climate-resilient Innovation Packages for EU regions. Grant agreement ID: 101037424. Call year: 2020. Implementation schedule: October 2021 to September 2025. EU contribution: €15,643,021.25. Total eligible costs: €15,643,021.25. Percentage of EU support: 100%. Coordinator: University of Thessaly (Greece). https://cordis.europa.eu/project/id/101037424 and https://arsinoe-project.eu/ (accessed on 16 December 2022).</p>
CIPORT	<p>CIPORT—Cold Ironing in the Port of Piraeus: Taking the Final Step</p> <p>Short Description: The Action addresses the Core maritime Port of Piraeus, located on the Orient East-Med Core Network Corridor. It is part of the Global project which aims to transform the Port of Piraeus into a Green Cruise Hub. The Action aims to provide the final studies and engineering designs for the development of OPS technology for four cruise vessels positions at the Themistoklis coast in the core maritime Port of Piraeus.</p> <p>Project details: Programme: CEF Transport. Action: 2020-EL-TM-0062-S. Location of the Action: Greece. Call year: 2020, Implementation schedule: August 2021 to November 2023. Maximum EU contribution: €688,000. Total eligible costs: €1,376,000. Percentage of EU support: 50%. Coordinator: Piraeus Port Authority S.A. (Greece). https://ec.europa.eu/inea/en/connecting-europe-facility/cef-transport/2020-el-tm-0062-s (accessed on 16 December 2022).</p>

Project Name	Project Summary
SUPER-LNG Plus	<p>SUPER-LNG Plus—Sustainability PERFORMANCE of LNG-based maritime mobility PLUS</p> <p>Short Description: Environmental pressure in port areas and in urban areas close to ports is high owing to emissions from ships, port machinery and transport to/from the port areas. LNG is proposed as a low-carbon clean fuel for marine transport in port areas. The boost of LNG for marine and terrestrial propulsion may be a key to enhance the sustainability of port areas, protecting health of population and cultural heritage. However, distribution networks and port infrastructures for the bunkering of LNG-powered ships requires technologies and solutions assuring a high level of safety in touristic areas of the Adriatic and Ionian Sea, avoiding trade-offs among environment protection and safety of passengers and personnel. The overall objective of the SUPER-LNG PLUS project is to increase the level of safety, environmental quality and sustainability of LNG maritime transportation in the Adriatic and Ionian seas, while the goals are to promote the SUPER-LNG project outcomes and results to national/regional/level and also to promote the use of project outcomes to potential beneficiaries.</p> <p>Project details: Programme: INTERREG-ADRION. Project Number 1267. Programme Priority 3 “Connected Region”—Specific objective “Enhance capacity for integrated transport and mobility services and multimodality in the Adriatic-Ionian area”. Call year: 2021. Location of the Action: Greece, Italy, Slovenia. Implementation: January 2022 to June 2022. Total budget: €149,800.32. Percentage of EU support: 85%. Lead Partner: National Centre for Scientific Research “DEMOKRITOS” (Greece). https://superlng.adrioninterreg.eu/ (accessed on 16 December 2022).</p> <p>Source: Innovation and Networks Executive Agency—INEA, Interreg ADRION Programme, Authors (2022).</p>

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