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Floating offshore wind sector development in the mediterranean: Economic, employment and social analysis

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ABSTRACT

Floating offshore wind (FOW) is emerging as a pivotal option for countries characterized by deep-water basins, where fixed-bottom technologies are not viable. Yet, the Mediterranean context still lacks integrated assessments for FOW. The objective of the present study is twofold: firstly, to quantify short- and medium-term costs, full-time equivalent (FTE) employees, and social acceptability of developing FOW in the Italian and Mediterranean context; and secondly, to assess the impact of national targets. The analysis adopts an integrated and replicable framework that combines techno-economic modelling, assessment of direct, indirect and induced employment, and public-acceptance evaluation, validated through a deep literature review and continuous consultation with stakeholders. Short-term capital expenditure is estimated in a range of 4.85-5.91 M€/MW, declining in the medium-term up to 4.13 M€/MW as learning, supply-chain maturation and port-hub industrialization materialise. Correspondingly, the levelized cost of energy ranges from 150 to 280 €/MWh in the short term and from 125 to 200 euro per MWh in the medium term. The FOW manufacturing, installation and construction phases have the potential to generate 14.4 kFTE/GW, whereas operations sustain approximately 1 kFTE/GW per year. Supply-chain localization is crucial, with a domestic-production pathway retaining 77% of potential employment, compared with 39% in import-reliant scenarios. This study demonstrates that FOW power industry has the potential to generate billions in investment, high added value and tens of thousands of employees. Yet, this potential can only be realised through the implementation of an integrated vision that combines policy, training, energy planning and infrastructure.

1. Introduction

As asserted in the “Offshore Wind Energy 2024 Statistics” report, published by WindEurope in March 2025, offshore wind energy has been identified as a pivotal technology in the achievement of energy transition and climate neutrality. This report states that the total installed capacity of offshore wind has reached 36.7 GW [1]. The United Kingdom led annual growth, followed by Germany, the Netherlands, and Denmark. Offshore wind has proven to be essential in meeting EU climate goals specifically, a 55% reduction in greenhouse gas emissions by 2030 and climate neutrality by 2050 [2]. Floating wind technologies are playing an increasingly important role [3], with a cumulative installed capacity of 233 MW and significant momentum in research and technological innovation [1]. The sector has experienced rapid development, driven by the opportunity to install floating turbines in deep waters thus unlocking new marine areas and significantly expanding useable energy potential. This innovation is closely linked to advances in materials, resilient mooring systems, and predictive digital monitoring and maintenance platforms [4,5].

Two main factors have supported this accelerated growth: on the one hand, political backing through EU strategies such as the European Green Deal and the RED (Renewable Energy Directive) II directive [6,7], on the other hand, substantial improvements in technical capabilities across the value chain from design to maintenance. The marine environment presents unique opportunities for the deployment of renewables such as wind energy, which has benefited from these developments both politically and technologically [8]. Today, offshore wind stands as a success story in the renewable energy sector, driven by technical advancements in robust platform design particularly floating systems capable of withstanding stronger winds in deeper waters, far from the

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coastline. The growing deployment of such systems is already transforming electricity production by offering zero-emission solutions [9]. The decision by EU Member States to invest in offshore wind also entails weighing economic costs against ecological impacts, especially when compared to more mature technologies such as onshore wind. While offshore wind offers important environmental and societal benefits, it may also come with higher costs and greater risks [10].

Nevertheless, offshore wind produces significantly fewer greenhouse gas emissions including mercury, nitrogen oxides, and sulphur dioxide as demonstrated both in Europe [11] and overseas [12]. A study by the American Wind Energy Association (AWEA) shows that every installed megawatt can prevent up to 2000 tonnes of CO_2 emissions annually [13], while also saving between 2 and 7 million litres of water each year [14]. It is noting that offshore wind farms do not consume additional land an increasingly critical issue in large-scale infrastructure development [15]. Energy performance is another notable advantage. Estimates suggest that offshore wind achieves higher capacity factors, typically ranging from 30 to 40%, compared to 20-25% for onshore systems [16,17]. Thanks to turbine capacities exceeding 5 MW, the offshore sector benefits from economies of scale [18]. The marine environment poses considerable technological challenges. As a result, offshore turbines must be specifically designed to withstand such conditions, often incorporating optimised shapes, twin-blade designs, or alternative tower structures such as lattice towers [19,20], which may also be more cost-effective due to fewer aesthetic constraints [21].

Beyond technology and economics, the deployment of offshore wind involves important implications for spatial and maritime planning, energy security, and social cohesion [22]. It also represents a strategic lever for decarbonization not only for the industrial sector but also for other energy-intensive industries [23]. Key elements for ensuring long-term social acceptance and success will include integration with existing power grids, development of energy storage systems and green hydrogen production [24] and the establishment of participatory governance models [25]. From this perspective, understanding the evolution of the offshore wind sector is of strategic relevance not only for assessing the technical and economic performance of these systems, but also for recognising their role as key drivers in the transition toward a decarbonised, resilient, and sustainable energy future [26].

In Italy, wind power technologies are now widely debated [27]; however, their actual development still faces several challenges. Indeed, Italy remains at an early stage in the development of the offshore wind sector, despite the significant potential estimated particularly in the Mediterranean basin [21]. The slow expansion of offshore wind energy in Italy can be attributed to a few critical factors. The most salient issues pertain to the complex permitting procedures, the constrained capacity of port infrastructure, and the absence of an established supply chain specifically geared towards offshore wind [28]. The lack of targeted training policies and limited collaboration between universities, research centres, and businesses continues to hinder the emergence of specialized professional figures. As highlighted in a 2024 study by Steen M. et al., the development and industrial capacity of EU member states is strongly linked to cooperation between industry and academic institutions [29]. The development of floating technologies represents a major opportunity for Italy, given the bathymetric characteristics of its surrounding seas, which are particularly well suited to floating structures [30].

According to the Renewable Capacity Statistics 2024 published by the International Renewable Energy Agency (IRENA), Italy still lags behind key European competitors in terms of installed onshore and offshore wind capacity. Italy's current total installed capacity is 12.31 GW [31]. This is approximately equivalent to half of France's capacity of 22.20 GW, and roughly one sixth of Germany's 69.46 GW [31].

It is therefore clear that in order to fully understand the mechanisms hindering the growth of offshore wind energy in Italy, it is necessary to conduct a study focusing on the economic, social, and employment-related implications this development would entail. This must be done using innovative methods and proposing effective models [32] which is the aim of this study.

1.1. Impact of shipyard conversion to energy hub for floating offshore wind

One of the primary impediments to the large-scale development of the FOW supply chain, particularly within the Mediterranean and Italian maritime contexts, is the inadequate configuration of existing ports and the paucity of available space for specialized shipyard installation. Under current paradigms, the construction of an offshore wind farm necessitates the establishment of temporary, modular sites that dictate a sequential and often unsustainable construction process. These traditional facilities typically operate through three discrete phases, pre-construction, construction, and operational, requiring the temporary closure of port infrastructure for pre-assembly and the utilization of specialized vessels for the complex transportation of turbines and anchoring systems. This model encompasses the management of all plant components, including turbines, foundation platforms, mooring systems, and electrical substations [33]. However, such a system is inherently burdened by significant operational and occupational challenges, primarily stemming from the logistical complexity of managing a temporary site and the resulting reliance on short-term, intermittent labour cycles [34].

The operational, logistical, and occupational limitations of the traditional shipyard can be overcome by implementing the novel concept of the Integrated Energy Hub. This model represents a fundamental evolution in industrial strategy, transitioning from project-specific nodes to a centralized platform for the continuous production and installation of FOW components. Unlike traditional yards, which are defined by repeated port reconfigurations and fragmented supply chains, the Energy Hub functions as a permanent, co-located industrial ecosystem. By synchronizing manufacturing, pre-assembly, strategic storage, and offshore deployment within a single geographical footprint, this approach fosters the establishment of regional networks where components are manufactured and subsequently assembled in situ. This consolidation effectively transforms the port from a mere transit point into a continuous production engine, obviating the necessity for repeated temporary yard mobilizations and enabling a profound industrialization of the entire value chain [35,36].

Fig. 1 shows the difference between a traditional wind farm construction site and an energy hub.

The structural advantages of this configuration are multifaceted and directly address the primary bottlenecks of global offshore decarbonization. Centralization allows for the application of advanced manufacturing principles, such as the serialized production of foundations and standardized electrical components, which are essential for achieving the economies of scale necessary to lower the Levelized Cost of Energy (LCOE). Furthermore, the permanent nature of the Hub fosters long-term socio-economic stability by replacing transient site labour with a stable, highly skilled workforce. This shift significantly mitigates the boom-and-bust cycles typical of offshore construction, thereby increasing the national content and retaining economic value within the domestic market through the creation of a specialized industrial district. By localizing the manufacturing of high-value components, the Hub reduces the carbon footprint associated with long-distance maritime logistics and enhances the overall sustainability of the supply chain.

Moreover, the Energy Hub acts as a catalyst for technological innovation and infrastructure resilience. The establishment of such a facility requires a sophisticated framework of enablers, including high-bearing-capacity quays capable of supporting the massive static and dynamic loads of assembled floating foundations, and long-term strategic agreements with port authorities to ensure land-use stability. These requirements underscore that the Energy Hub is not merely a permanent replacement for a temporary site but a profound industrial transition toward a resilient energy infrastructure. The model facilitates a "factory-

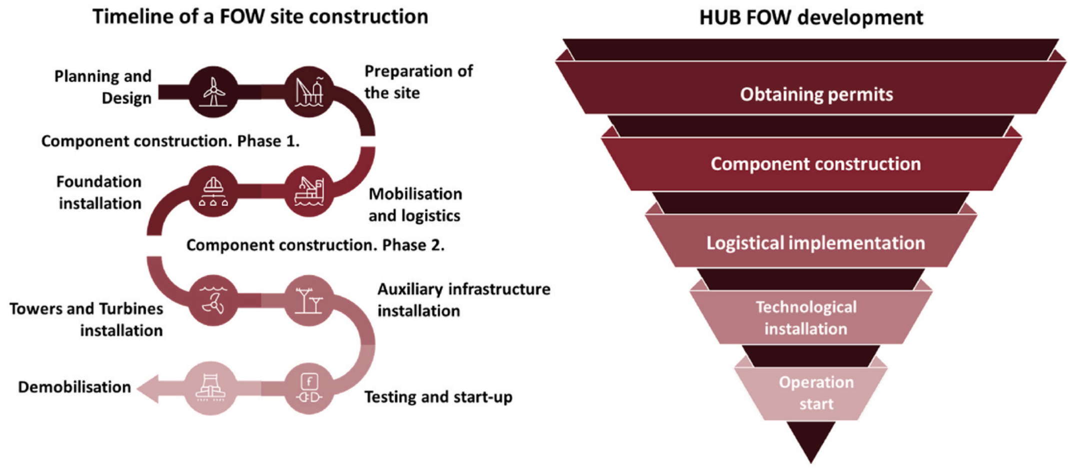

Fig. 1. Timeline of a FOW site construction vs HUB FOW development.

at-sea" approach where the port serves as the primary assembly line, ensuring that the integration of turbines, mooring lines, and inter-array cables is optimised through standardized, repeatable procedures. As illustrated in Fig. 1, while the traditional process remains tethered to a sequential and fragmented logic, the Energy Hub operates as a centralized industrial system that stabilizes employment, optimizes resource allocation, and provides the industrial capacity required for the next generation of utility-scale offshore energy deployment.

1.2. Literature review

A comprehensive literature review was conducted, focusing on similar studies, within Europe over time to understand progress step by step. This survey highlighted various methodologies used, outcomes achieved, and numerical values for the full employment factor (FEF), which helps quantify employment benefits.

1.2.1. Early methodological foundations

As early as 2011, Esteban et al. [37] aimed to demonstrate how skills transition from the oil and gas sector could preserve jobs during the transformation of the UK's offshore industry. Their study analysed the decline in North Sea oil and gas production alongside the rise in offshore renewable energy, specifically fixed-bottom offshore wind and ocean energy. They developed an employment balance methodology based on 'employment factor' (EF) the number of jobs required to install, manufacture, and maintain 1 MW of renewable capacity. Their dynamic projections extending to 2050 suggested that by then, the UK offshore sector could achieve 30-40 GW of installed capacity and generate approximately 32,000 jobs across installation and maintenance phases, with FEF values ranging between 0.48 and 3.9 jobs/MW. However, their model was geographically limited to the North Sea and provided generalised rather than sector-specific phase data. However, as stated by the authors themselves, this methodological approach is based on simplified quantitative models and conservative assumptions. Furthermore, it ignores decommissioning costs, does not include a comprehensive analysis of the supply chain, and focuses exclusively on direct jobs. In the same year, Dalton and Lewis [38] examined job-creation metrics in the renewable sector in Ireland. Using the 2009 EWEA "Wind at Work" report data [39], they analysed two principal metrics Jobs/MW installed per year and Jobs per cumulative MW installed and proposed two additional indicators: Jobs per 1000 inhabitants and MW per million inhabitants. Their socio-economic model adopted a comparative and critical approach, evaluating employment indicators across installation, Operation and Maintenance (O&M), and manufacturing stages. They found that annual Jobs/MW was unreliable in 2007, it wrongly indicated 25 jobs per MW, but cumulative Jobs/MW matched the European average of 1.9 Jobs per cumulative MW for onshore wind. Employment factors for offshore wind were highly variable, ranging from 3.9 to 47 cumulative Jobs per MW. Ortega et al. [40] highlight how the metric they adopted, based on jobs/MW installed in a year, is highly sensitive to annual variations, which is why they themselves consider it unreliable. They recommend using cumulative jobs/MW metrics, which is what was done for this study. In 2013, the U. S. Department of Energy examined economic and job impacts of offshore wind development in the Southeastern U.S. using the JEDI (Jobs and Economic Development Impact) model by NREL (National Renewable Energy Laboratory). Their input-output spreadsheet-style tool modelled job creation across three categories project development and onsite labour, local revenue and supply chain, and induced impacts under scenarios from 2020 to 2030. In their Scenario B, for 4027 MW of capacity, they calculated the creation of 20,100 construction jobs and 6700 permanent O&M and induced jobs by 2030. A 2014 Norwegian research group [41] compared LCOE between floating offshore turbines and fixed-bottom systems using Life Cycle Cost Analysis (LCCA). They modelled a 500 MW floating array (100 turbines of 5 MW each) at 200 m depth against a fixed foundation at 30 m depth. Cost drivers included steel mass, mooring systems, and export cables. Their study offered an O&M employment estimate of 0.16 jobs/MW but did not detail EF values across other phases or apply socio-economic modelling. These aspects are expressly investigated in the proposed work. In 2015, Dismukes et al. [42] analysed offshore wind development costs across 41 European farms (1991-2012), using log-linear econometric regression controlling for capacity, distance from shore, depth, and country-fixed effects. To achieve these results, they adopt a methodology based on overnight cost, i.e. the estimated cost if the project were to be built in a single day, eliminating any type of distortion such as inflation, interest rates and construction duration. They found no significant economies of scale costs scaled constant and negative but statistically insignificant learning effects at the industrial level; however, at the country level costs increased over time. No EF estimates were provided and the study addressed Europe generally, not specific nations, which is done through the proposed research. Ortega et al. [40] in 2015 assessed the socio-economic impacts of wind and solar diffusion in the EU with emphasis on offshore wind. Their dynamic model used Eurostat data to estimate manufacturing, installation, and O&M demand. Spain, Germany, Denmark, Italy, and the UK were considered. They produced EF values 1.58 jobs/MW for O&M, 7.49 job-years/MW for installation, and 22.99 job-years/MW for manufacturing. However, cross-country aggregation and limited 2008-2012 data may reduce accuracy; indirect jobs were not addressed. On the contrary, one of the objectives of the proposed work is to estimate indirect jobs and analyse both direct data, derived from the manufacturing companies themselves, and data from literature and reports.

1.2.2. Expansion of socio-economic and techno-economic modelling

Kahouli et al. [43] examined economic, and job impacts of the Saint-Brieuc offshore wind project in France (496 MW, 62 turbines). Using a regional I-O model, disaggregated into direct, indirect, and induced jobs across investment (2016-2020) and O&M (2020-2040) phases, they found 6.03 jobs/MW/year during investment and 1.02 jobs/MW/year during O&M totalling approximately 21.05 FTE jobs/MW/year [44]. Limitations include focus on French bottom-fixed technology in a single region. Part of the novelty of the proposed study is based on the adoption of a technology that is still in its early stages of adoption in the Mediterranean, namely offshore floating. In Spain, Varela-Vázquez et al. [45] studied bottom-fixed and floating offshore wind impacts, using input-output matrix (I-O) and life cycle assessment (LCA) to model scenarios to 2030. They estimated 1.12, 1.99, and 3.73 jobs/MW respectively and concluded that most job creation occurred in manufacturing and installation, highlighting the necessity of stable policies to develop domestic supply chains. Their study is heavily dependent on hypotheses and assumptions made about costs and national production capacity, while excluding the possible scalability of the work carried out. Connolly [46] assessed regional economic impact of Scottish offshore projects using I-O and Computable General Equilibrium (CGE) models to 2050, for a 2.4 GW rollout. Myopic CGE models showed higher impacts than I-O, and CGE using capital expenditure (CAPEX) alone yielded reverse trends. The I-O model suggested 3 jobs/MW, while the myopic CGE estimated 34 jobs/MW over lifecycle demonstrating how structural modelling variation affects employment estimates. Their research is based on a comparative approach between different models and does not include induced or net effects, as well as being heavily dependent on assumptions made about local content and general costs. Futuray et al. [47] developed a US multi-regional I-O (US-MRIO) model using Industry Ecology Lab data [48], capable of capturing local and cross-state spillover effects. While focusing on onshore wind in the U.S., without EF values, it represents progress toward comprehensive economic modelling. Their analysis was conducted considering only the short term (1 year), completely excluding induced effects and relying heavily on data automatically provided by their new model. In 2021, Schallenberg-Rodriguez et al. [49] studied socio-economic impacts of a 200 MW floating wind farm in Gran Canaria using a regional I-O adapted model under high and low local integration scenarios. They estimated 6.23 jobs/MW (high) and 4.9 jobs/MW (low) in CAPEX, 0.91 jobs/MW/year in Operational Expenditure (OPEX), and 1.4 jobs/MW/year for decommissioning. While FOW generated greater jobs per MW, it delivered lesser value-added than industrialised regions like France, their research focuses on the I-O methodology, which is well established but risks being limited by induced effects and the exclusive dependence of hypotheses on industrial capacity. Martinez et al. [50] provided the first geospatial LCOE mapping for floating offshore wind in the Mediterranean, analysing a reference [1] GW semi-submersible plant and parametrically modelling all CAPEX, OPEX and AEP components. Their work shows that the spatial variability of wind resources is the primary driver of LCOE, more influential than distance to shore or depth, with minimum values (~95 €/MWh) in the Gulf of Lion and the Aegean and values above 250 €/MWh in low-wind areas. Although the study does not address socio-economic aspects nor provide employment factors, it represents a key contribution to assessing the techno-economic feasibility of floating offshore wind in the Mediterranean and reinforces the need for integrated models including supply chain, employment and territorial impacts, as developed in the present study.

1.2.3. Dynamic cost-forecasting, learning-curve and supply-chain development

Shields et al. [51] introduced the FORCE model, a transparent and replicable framework for projecting future offshore wind costs based on empirical learning curves estimated through multivariate regression of historical CAPEX data and global deployment scenarios. The model distinguishes between fixed-bottom and floating technologies, showing higher learning rates for the latter due to greater potential for industrial maturation. Their projections indicate that floating offshore wind could reach an LCOE of around 64 $/MWh by 2035, although with wide uncertainty ranges driven by data variability and market conditions. While the report does not address socio-economic impacts or provide employment estimates, it represents a key methodological contribution for cost-forecasting and reinforces the need for integrated and dynamic modelling approaches, such as the one developed in the present study.

Larkin et al. [52] analysed Australia's offshore wind opportunities using semi-structured interviews and industrial path development theory. They revealed lack of federal-state coordination, poor training programmes, and competition between regions. They advocated for 'local content' policies to avoid benefits flowing abroad. Projected FTEs were approximately 1.5 jobs/MW for CAPEX and 0.15 jobs/MW for O&M [53]. Their work is focused on the Australian context and does not include quantitative modelling of economic impacts. In 2023, Brelik et al. [54] estimated employment effects of Poland's 6.3 GW offshore plan (to 2030), using regional I-O. They calculated 4.18 jobs/MW for CAPEX and 0.76 jobs/MW for OPEX, generating economic impact, although EF values were lower than those in France; emphasizing the importance of building supply chains for maximizing local impact. In their work, they use average annual CAPEX and OPEX values, exclude net effects, and are dependent on statistical data and assumptions made about the supply chain. Pashakolaie et al. [55] evaluated socio-economic and environmental co-benefits of the UK's Offshore Wind under the Renewable Obligation scheme using welfare economics, estimating EF of 1.6 jobs/MW (direct) and 1.03 jobs/MW (indirect), underscoring how targeted policy can amplify employment in the green energy transition. They do not include net effects and adopt a model that is heavily dependent on imports and local wages and is therefore based on the Anglo Saxo wages market. McKenna et al. [22] conducted a global interdisciplinary review of over 400 articles, categorising impacts into environmental/climatic, socio-economic/health, techno-economic and policy-regulatory. They found that recycling, social acceptance, and grid integration remain yet under-addressed issues, stressing the need for integration between technical and social sciences and flagging floating offshore wind as promising. However, their work did not include any quantitative analysis or modelling and does not address social acceptability and public perception. Thomas B. et al. [56] optimised floating turbine layouts (5-18 MW) via LCOE analysis across 19 Spanish Maritime Spatial Planning (MSP) zones. No EF values were provided, but the study offers key insights into favourable conditions for floating offshore development. They estimate costs based on European averages rather than site-specific analyses, as well as excluding social impacts. Finally, Rutovitz et al. [57] delivered updated EF and occupational shares for global electricity generation technologies via large-scale renewable energy firm surveys. They estimate 1.5 job-years/MW for installation, 13.68 job-years/MW for manufacturing, and 0.9 jobs/MW for O&M, noting high labour volatility during construction but stability until 2050. Although not Europe-focused, their methodology and data offer valuable benchmarks for future EF studies. However, the main limitation of their research concerns its lack of applicability in different contexts, as well as its heavy reliance on estimates of productivity cost declines. Benabadji et al. [58] extended the techno-economic analysis of offshore wind floating to the southwestern-Mediterranean, developing a geospatial mapping of the LCOE for Tunisia, Algeria and Morocco. Using a 5 MW NREL turbine on a semi-submersible platform and parametrically modelling CAPEX, OPEX, and Annual Energy Production (AEP) on a 20-year basis, the authors show that the spatial variability of the wind resource is the main determinant of LCOE, more relevant than depth or distance from the coast. The values obtained vary between 104 €/MWh in the windiest areas of Morocco and 245 €/MWh in the least favourable areas of

Algeria, with intermediate values in Tunisia. Although the study does not address socioeconomic aspects or provide employment estimates, it represents a significant contribution to the assessment of the feasibility of offshore wind floating in the Southern Mediterranean and confirms the need for integrated models that include supply chains, territorial impacts, and employment effects, as developed in this work.

Despite the growing interest of both academia and industry in FOW, the scientific literature remains very limited, and there is substantial variability and uncertainty in estimates of costs and socio-economic implications. All the studies examined rely on conservative assumptions, are limited in their analysis of the supply chain, which is not studied exhaustively, and use local content that is often estimated using generic assumptions. The focus is almost exclusively on direct employment, using Jobs/MW as a metric over a short period of time, which does not allow for stable and reliable research. Finally, excessive reliance on statistical data and I-O models does not allow for the dynamic effects of technological development over time to be properly captured. This is primarily due to the lack of a significant number of operating plants and mature projects [59]. The limited availability of data has so far prevented the development of detailed socio-economic analyses of this novel technology, which will play a key role in the energy transition of countries that cannot rely on bottom-fixed solutions.

1.3. Research gaps and aim of the work

There is a clear literature gap regarding the socio-economic implications of FOW in the Mediterranean context, specifically analyses that assess installation and operation-and-maintenance costs, levelized cost of energy, employment impacts, and social acceptance. Moreover, no studies to date have developed an economic model in close comparison with, and validation from, the main industry players, to build a robust framework grounded in the experience of those who will deploy the technology in the coming years.

The purpose of this study is to fill the gaps above identified, combining company information, report analysis and scientific literature, as well as proposing a new integrated framework. Part of the novelty of this work concerns the methodology adopted, as it differs from the current models used and provides a framework that is both adapted to the Italian national context and adaptable to other Mediterranean contexts. Existing Italian and Mediterranean studies on offshore wind typically analyse either technical feasibility, infrastructural constraints or broader economic implications. However, to our knowledge no study has combined techno-economic modelling, detailed employment estimation and social-acceptance analysis into a unified socio-economic framework specifically applied to floating offshore wind in Italy.

This study aims to provide an up-to-date and in-depth analysis of the economic, employment, and social impacts stemming from the development of floating offshore wind energy in Italy. The analysis was conducted using established economic models, which have been appropriately adapted to the national geographical and marine context and updated with data on the costs of next-generation floating technologies. The economic dimension has been explored through a detailed comparison with similar projects already underway or planned in Europe, drawing on peer-reviewed scientific sources, technical exchanges with industry experts, and consultations with industrial operators. Given the high variability of costs over time, several short- and medium-term investment scenarios were examined to offer a more comprehensive and realistic outlook on the expected economic developments. One of the key contributions of this study lies in the estimation of employment impacts associated with the deployment of floating offshore wind in the short and medium term. In particular, it presents a detailed quantification of direct, indirect, and induced jobs per gigawatt of installed capacity, disaggregated by phase (installation, manufacturing and supply chain, operation and maintenance) and according to the various industrial policy options available. A particularly relevant aspect of this work is the assessment of the impact that policies favouring domestic production of floating wind technologies may have on job creation in Italy. Another innovative feature of the study concerns the analysis of the constraints and challenges related to construction logistics, defined as temporary worksites dedicated to civil engineering projects, particularly with regard to port infrastructure in Italy. Conversely, a potential boost to the floating offshore wind supply chain could be provided by adopting a hub-based system. This approach makes it possible to carry out a precise evaluation of the national economic potential linked to the production and installation of floating offshore wind farms, as well as the corresponding socio-economic impact of the sector in the short to medium term.

2. Methodology overview

The present study adopts an integrated framework to evaluate the economic, employment, and social impacts of floating offshore wind deployment in Italy, with specific reference to installations in the Mediterranean Sea. The methodology combines techno-economic modelling, input-output employment analysis, and social perception assessment, providing a coherent evaluation tool tailored to the Italian context which can be leveraged to elaborate a replicable industrial development model for the FOW sector within the Mediterranean.

The techno-economic modelling has been conducted on a reference-scale 0.5 GW floating offshore wind farm, consistent with the cluster configurations envisaged in Italy's offshore wind plans and comparable to advanced projects in the United Kingdom, Norway, and Spain. The economic analysis has been performed by structuring the cost breakdown of floating offshore wind across the full project lifecycle, including development, construction, commissioning, port logistics, installation, manufacturing, and operation and maintenance. Cost definition was complicated by the early-stage nature of floating technology, the absence of a consolidated learning curve, and CAPEX volatility during the pre-FEED phase. To mitigate these uncertainties and ensure robustness, the analysis drew on European datasets of commissioned or authorised projects, publicly available data from regulatory agencies and technical bodies (e.g., Danish Energy Agency). Therefore, in order to mitigate the difficult of the costs definition, elicitations with industry experts, developers, and suppliers are crucial for the economic analysis, particularly to justify reference CAPEX values given the significant cost uncertainty stemming from component market volatility, dependence on foreign suppliers, and the absence of economies of scale in a pre-commercial phase where domestic manufacturing remains marginal. Thereafter, the reconstructed cost benchmarks have been employed to derive the project's economic sustainability indicator.

Cost benchmarks were reconstructed to estimate key economic indicators under two short-term and one medium-term scenarios, aligned with Italy's National Energy and Climate Plan (NECP) (2.1 GW by 2030) and RED II (3.8 GW by 2033) capacity targets.

Specifically, two primary scenarios were defined. The short-term analysis (pre-2030) represents a pre-commercial condition where the national supply chain is either absent or in an embryonic phase. The medium-term (2030-2035) analysis presupposes the activation of a structured national industrial supply chain, projecting a significant CAPEX reduction, driven by the progressive internalization of critical value chain phases. Scenario ranges account for investment uncertainty and technological learning dynamics.

Beyond the economic dimension, the analysis quantified the employment impacts associated with the NECP and RED II installation trajectories. Employment effects were quantified using a sectoral input-output approach, distinguishing four project phases (development, construction, operation, decommissioning) and disaggregating direct, indirect, and induced full-time equivalent jobs. The model further differentiates occupational categories and industrial sectors, while integrating local content assumptions to test domestic supply-chain effects. Three localization scenarios have been examined:

Technology Import - low localization, high reliance on imports.

- Reference - medium localization, mixed domestic-international supply chain;
- Domestic Production - high localization, reflecting a strategic national industrial pathway.

This strategic pathway implies a paradigm shift from temporary yard models to the creation of permanent, automated energy hubs, designed to overcome logistical limitations and enable the co-location of manufacturing and power generation activities.

This structure enables a consistent evaluation of Italy's potential for job creation and industrial development along the floating offshore wind value chain.

Furthermore, the framework also incorporates a social acceptability component, based on a survey of 500 citizens designed to capture public perceptions across key dimensions: visual and landscape impacts, perceived environmental benefits, contribution to energy security, expected employment effects, and concerns regarding costs, marine ecosystems, and technological risks. Both quantitative and qualitative data were statistically analysed to identify main perception drivers and potential social barriers. The inclusion of this social dimension, alongside economic and occupational assessments, provides an integrated evaluation of floating offshore wind in Italy, consistent with the broader objectives of this study. The graphical methodology overview has been illustrated in Fig. 2.

2.1. Survey methodology

A survey has been developed to elicit techno-economic estimates and strategic insights regarding floating offshore wind projects in the Italian context. In light of the paucity of relevant literature and the current suboptimal Technology Readiness Level (TRL) of floating solutions [33], expert elicitation has been adopted as a rigorous method for understanding technology trajectories and economic impacts under conditions of uncertainty. This approach is particularly applicable to emerging technologies where estimates may not be obtainable through other conventional empirical approaches. Expert elicitation serves to obtain informed judgements about factors affecting cost structures and employment multipliers, effectively complementing the quantitative results of input-output analysis. As the selection of a qualified and diverse group of experts increases the credibility and representativeness of the findings, the consultation has involved key stakeholders operating in the Italian wind energy sector. Specifically, participants were identified among companies associated with ANEV (Associazione Nazionale Energia del Vento), which currently comprises around 120 member companies [60].

The survey was designed for self-completion by the identified experts, by following the established methodology found in literature [61]. After providing formal consent for the processing of data, respondents were guided through a series of questions meticulously tailored to encompass three thematic macro-sections: technical-constructive parameters, cost analysis and employment aspects of the national supply chain.

The first section of the survey entails an analysis of the

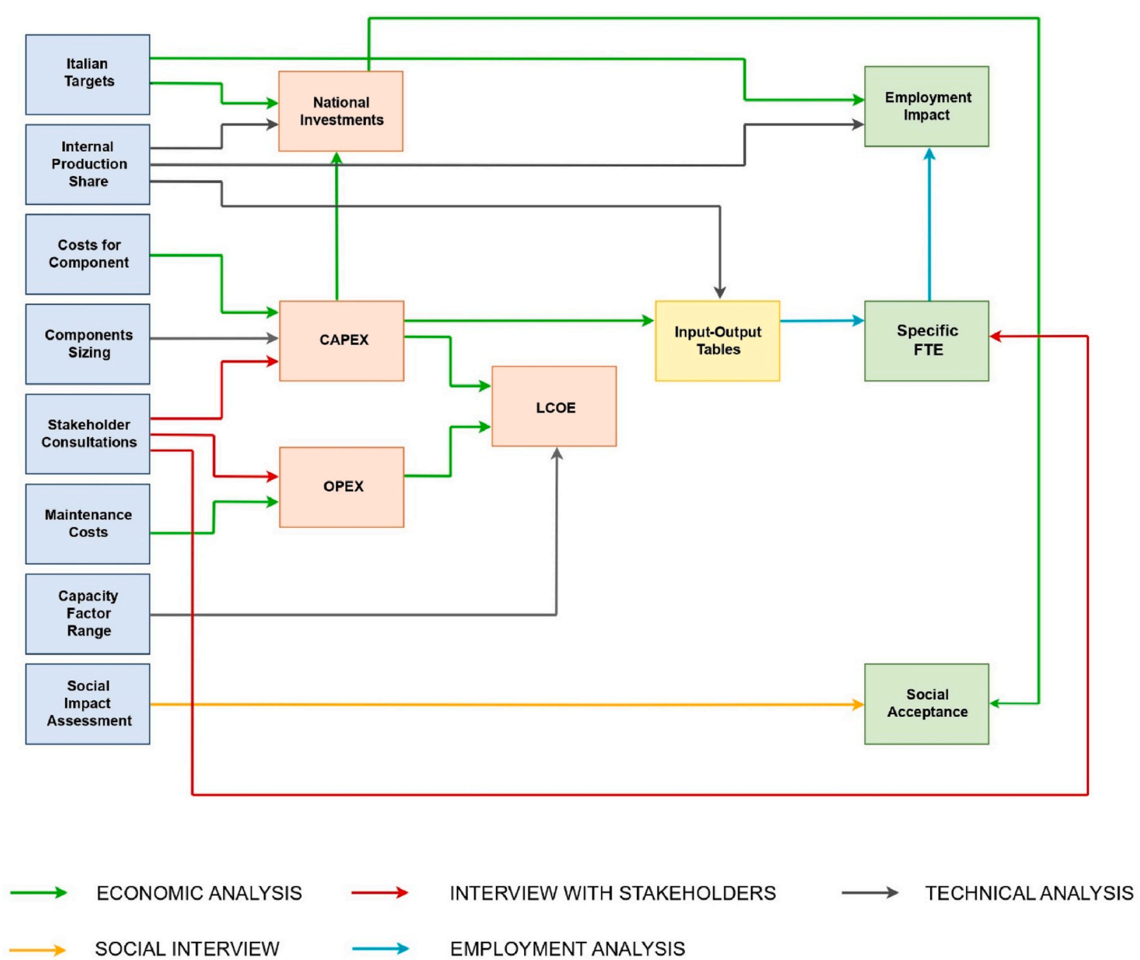

Fig. 2. Scheme of the methodology adopted.

characteristics of a reference installation. Given the early stage of market development, this part requires a detailed evaluation of the plant's architecture, including total installed power, distance from the coast, and the specific configurations of foundations and anchoring systems. Furthermore, the survey includes dedicated inquiries regarding installation procedures and logistics operations, which are essential for defining the technology's maturity in the Mediterranean basin.

The second block is dedicated to cost analysis, focusing on the primary economic drivers necessary to parameterize the employment estimation model, with a focus on CAPEX, OPEX and labour requirements at different stages of the project life cycle. Respondents are asked to provide estimates for Capital Expenditure and Operational Expenditure, broken down into specific cost items such as materials, specialized offshore vessels, electrical systems, and maintenance strategies. Additionally, essential financial parameters, insurance costs, and tax charges are included to ensure a robust evaluation of the project's financial life cycle. This quantitative information enables the calibration of sectoral coefficients, enhancing the reliability of the resulting methodology framework.

The final section of the survey addresses employment and supply chain dynamics through a combination of quantitative and qualitative questions. This group of questions is designed to assess the activities undertaken in Italy and the potential for domestic content within the supply chain. Experts are required to identify the requisite skills for the workforce and the potential for employment growth associated with the localization of production activities. The survey facilitates the integration of qualitative assessments into quantitative estimations, thereby providing a more comprehensive evaluation of the prospects for the advancement of the national supply chain [62,63]. The qualitative evidence collected regarding industrial needs and barriers facilitates the interpretation of employment multipliers in the Italian context. Consequently, the survey serves as a complementary and necessary component to the input-output analysis, thereby enhancing the accuracy and robustness of the final estimates regarding the socio-economic impacts of floating offshore wind in the national industrial landscape.

Fig. 3 represents the graphical pathway for the stakeholders elicitation.

2.2. Economic model

The economic model developed in this study is structured to provide a robust and integrated framework for assessing the financial viability of FOW projects. This methodology, specifically developed and calibrated for the unique logistical and regulatory context of Italy, is replicable for assessing FOW potential in other national contexts within the Mediterranean basin. The model comprises a detailed disaggregation of CAPEX and a subsequent calculation of the LCOE.

It is acknowledged that FOW technology is of a pre-commercial nature, and that there is associated cost volatility. Thus, the total investment is meticulously disaggregated into its primary constituents, in

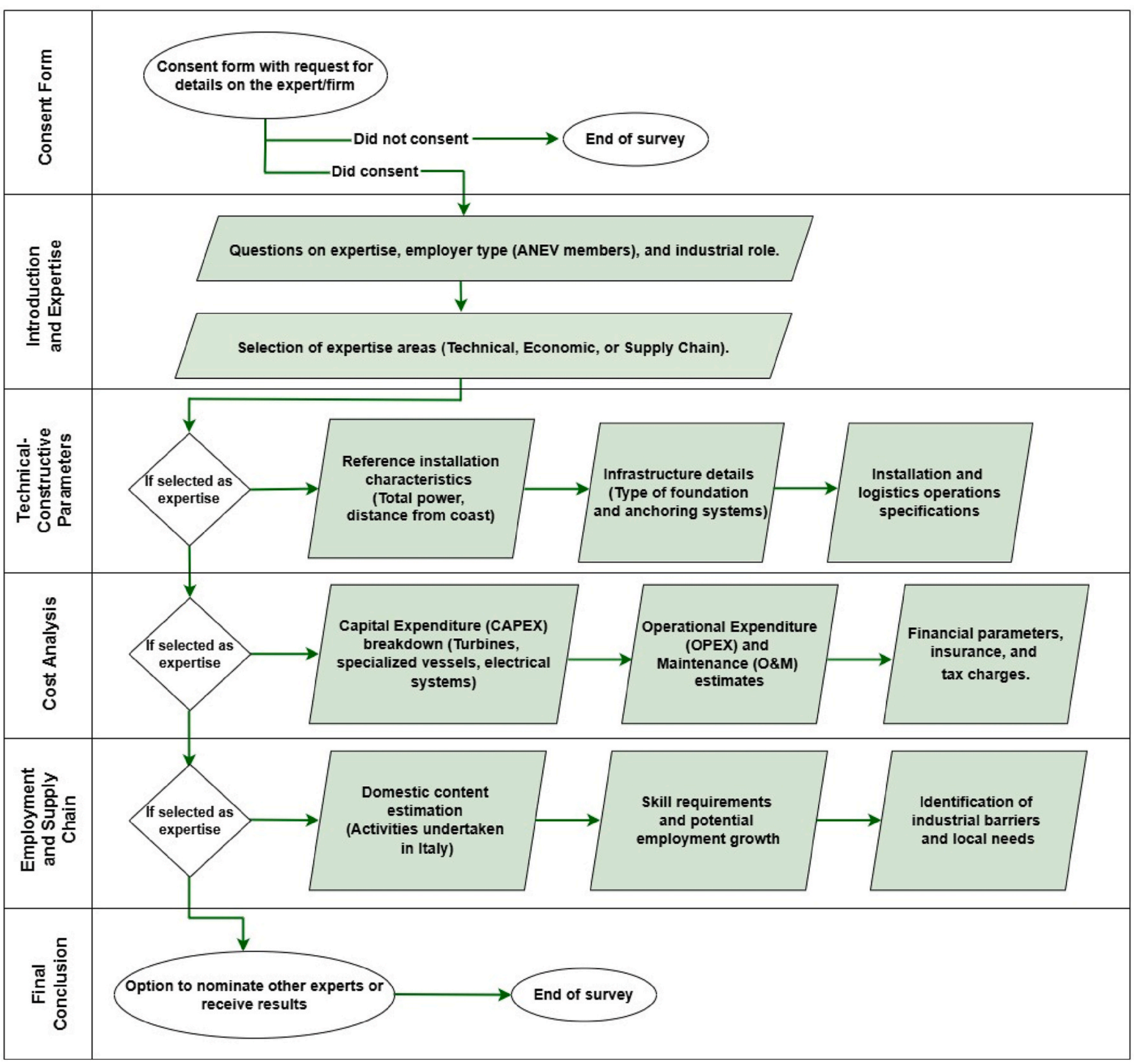

Fig. 3. Survey design and the structure of the questions presented to stakeholders.

order to introduce a comprehensive view of the project's cost structure. Manufacturing costs for the turbine, foundation, and mooring system, in addition to the complete electrical infrastructure (comprising array cables, export cables, and the offshore substation) and expenditures associated with port and staging operations, installation, and overall project development have been analysed. The data underpinning this breakdown was synthesized from multiple sources, including European project databases, public data from regulatory bodies, and direct consultations with industry experts, to ensure the robustness of the economic estimates.

These detailed capital costs serve as a primary input for calculating the LCOE, a critical econometric parameter that measures the average net present cost of electricity generation over a plant's lifetime [64]. The LCOE is computed according to the following Equation (1) [58]:

$$LCOE = \frac{crf^{*}CAPEX^{*}PC + OPEX}{8760^{*}CF^{*}PC} \quad (1)$$

where the terms are defined as:

- *CAPEX:* Capital expenditure [€/kW];
- *OPEX*: Annual operational expenditures [€/year];
- *PC*: Plant capacity [kW];
- *CF*: Capacity factor [%];
- *crf*: Capital recovery factor [%], calculated as

$$crf = \frac{i(1+i)^{n}}{(1+i)^{n} - 1} \quad (2)$$

in Equation (2), the term i represents the interest rate and n refers to the plant's lifetime considered.

The LCOE formulation has been specifically arranged in Eq. (1) to facilitate a parametric investigation of cost variations as a function of the capacity factor. Unlike conventional static analyses that aim to define a single LCOE value based on fixed energy production, the objective of this approach is to characterize time- and CF-varying LCOE ranges. This methodology accounts for simultaneous fluctuations in both market-driven costs and operational performance, as further discussed and illustrated in Fig. 7.

The calculation of the LCOE enables a holistic assessment of the technology's economic sustainability in the medium and long term, as it synthesizes investment costs, operational efficiency and the adopted financial strategy into a single, comparable metric.

2.3. Employment estimation model

The employment impacts of offshore wind technology in Italy have been analysed using an employment estimation model derived from multiplier models. These multiplier models are, in turn, derived from national accounts and input-output tables. These models facilitate the quantification of jobs generated throughout the entire supply chain, encompassing not only the primary activity of plant construction or management, but also related sectors and induced consumption.

Three different employment effects have been evaluated, distinguishing between direct, indirect and induced jobs. The former specify roles that are directly linked to the primary activity (e.g. design, construction, installation, operation and maintenance) [65]. Indirect effects relate to jobs created along the supply chain, i.e. in sectors producing the intermediate goods and services necessary for implementing the project (e.g. manufacturing, logistics, steel and electrical components) [66,67]. Lastly, induced effects refer to jobs generated by the increased disposable income of workers employed in the first two categories [68]. This increased disposable income leads to increased demand for goods and services in local sectors such as retail, catering, transport and household services.

To quantify the impact of industrial policy and offshore floating wind capacity on total employment, the methodology adopts sectoral employment coefficients, integrated with national Input-Output (I-O) matrices. In this framework, Type I and Type II multipliers derived from the official ISTAT (Italian National Institute of Statistics) tables are utilized. Specifically, Type I multipliers are applied to estimate the combined direct and indirect employment, whereas Type II multipliers are employed to capture the total socio-economic impact, including direct, indirect, and induced effects. The general formula can be summarized as follows:

$$Jobs_{total} = Jobs_{direct} + Jobs_{indirect} + Jobs_{induced} \quad (3)$$

where:

$$Jobs_{direct} = I^{*}C_{sector} \quad (4)$$

$$Jobs_{indirect} = I^{*}(I - A)^{-1\,*}C \quad (5)$$

$$Jobs_{induced} = (W^{*}MPC)^{*}C_{consumption} \quad (6)$$

Here, the term C_{sector}, W and MPC stand for the sectoral employment coefficients, the labour compensation [69] and the marginal propensity to consume [70,71], respectively. The $(I - A)^{-1}$ term stands for the Leontief matrix inverse [72]. This refers to the inverse matrix used in input-output models to calculate the total output required to meet a given level of final demand for goods and services, while taking into account intersectoral inputs. The national input-output tables are provided by ISTAT [73] and Eurostat [74]. These datasets provide a standardized aggregation of Italian economic sectors based on the NACE (Nomenclature des Activités Économiques dans la Communauté Européenne) classification codes [75], ensuring consistency with European statistical standards. $C_{consumption}$ points at the employment coefficients of consumer sectors. This value indicates the number of jobs generated by spending one million euros in various consumer sectors [72].

In Equation (4) I stands for the total investment depend on the total costs of the plants and the national production capacity rates. Therefore, different scenarios have been assessed, whereby different national technologies production policies have been evaluated, by envisaging the impact on the total FTE.

This approach enables the estimation of both the direct jobs attributable to the construction and operation of a plant and the overall economic spin-offs in terms of the production and local supply chains.

The conversion from shipyard to industrial energy hub involves the establishment of a long-term contract with the port authority; therefore, the selection of a specific area of the port suitable for the construction of dedicated components, their assembly and then their installation. Doing so would create long-lasting and sustainable jobs. Furthermore, it would kick-start the economy, possibly opening the possibility of exporting these components to other countries. This would therefore build the offshore floating wind industry in Europe. In analytical terms, defining the variables:

- N_f = number of projects completed in the time T
- $Jobs_t$ = temporary jobs generated for a project (no FTE)
- $Jobs_d$ = permanent jobs generated by an industrial hub (FTE)
- C = average costs of setting up a traditional construction site for a project
- C_{hub} = average costs for the construction and management of an industrial hub
- R = revenues generated by national projects
- R_{exp} = revenues generated by the export of components

The traditional construction site jobs during the years can be expressed through Equation (7), in which each project generates jobs proportional to the duration of construction and linked to the function $\delta_{i,T}$. The latter can assume a value of 0 in the event of the site being decommissioned, or 1 otherwise [76].

$$Jobs_{trad}(T) = \sum_{i=1}^{N_f} Jobs_t(i) \cdot \delta_{i,T} \quad (7)$$

The total cost, under traditional conditions, is calculated as [77]:

$$C_{trad} = \sum_{i=1}^{N_f} C \quad (8)$$

On the other hand, the total costs related to construction and management of industrial hub is calculated as [78]:

$$Jobs_{hub}(T) = Jobs_d \cdot T + \sum_{i=1}^{N_f} Jobs_t(i) \quad (9)$$

where $J_d \cdot T$ represents permanent FTEs, independent of individual projects and therefore of individual construction sites. In this condition, the total costs can be expressed using Equation (10):

$$C_{hub}(T) = C_h + \sum_{i=1}^{N_f} C_{marg}(i) \quad (10)$$

Here, $C_{marg}(i)$ is the marginal production cost for each project, which is lower than the traditional cost thanks to economies of scale. In this condition, therefore, total revenues are expressed by Equation (11):

$$R_{hub}(T) = R + R_{exp} \quad (11)$$

The industrial-energy hub becomes preferable to the traditional construction site when the following inequalities (12) and (13) are valid:

$$Jobs_{hub}(T) > Jobs_{trad}(T) \quad (12)$$

$$R_{hub}(T) - C_{hub}(T) > R - C_{trad} \quad (13)$$

that is, when this guarantees more sustainable employment and a positive economic balance thanks to economies of scale and exports. A traditional shipyard involves temporary and intermittent jobs, as indicated in the report (14):

$$Jobs(T) \propto N_f \quad (14)$$

An industrial-energy hub brings long-term jobs and benefits linked to economic multipliers by introducing the linear growth component, corresponding to stable and sustainable jobs with T ($Jobs_d \cdot T$), as indicated in relation (15):

$$Jobs(T) \propto Jobs_d \cdot T + N_f \quad (15)$$

The model developed to achieve the objectives of this research is based on these formulations and this innovative approach.

2.4. Social acceptance

The quantitative assessment of the social impact associated with the installation of offshore wind farms off the Italian coast was conducted through a sophisticated methodology predicated on a structured questionnaire and a stated preference approach [27]. In the current European energy landscape, characterized by the ambitious targets of the Green Deal [7] and the REPowerEU plan [79], the development of offshore wind energy, particularly through floating technology, represents a strategic priority for achieving collective decarbonization and energy independence. Within this framework, Italy occupies a crucial position in the Mediterranean basin, acting as a potential hub for renewable energy production. The choice of a stated preference methodology is specifically designed to elicit public preferences for non-market goods, such as landscape quality and ecosystem services, which lack conventional price signals but are central to the public acceptance of large-scale energy transitions across the European territory [80].

The survey instrument was developed through an iterative process to ensure that the core dimensions of the public debate were accurately represented. The implementation followed a rigorous procedural flow, involving a sample of 500 Italian citizens reflective of the national population in terms of geographical distribution and educational background. To ensure data quality, the survey was administered online, targeting respondents across various macro-regions including the South and Islands, the Centre, and the North. A detailed breakdown of the sample's geographical distribution, gender, and education levels, compared with national benchmarks derived from ISTAT data [81–83], is provided in Table 1. This geographical stratification is essential to capture the heterogeneity of preferences, particularly distinguishing between those residing in coastal municipalities and those in the hinterland. The survey commenced by informing respondents that their participation was instrumental in mapping national perceptions toward offshore wind. A preliminary phase of the survey was dedicated to collecting detailed demographic and socio-economic data, which is crucial for a subsequent segmentation of the sample [84]. Following this, specific data were gathered on participants' behavioural patterns, including the frequency of their coastal visits and their prior experience with wind farms (both onshore and offshore), as well as their baseline attitudes and expectations. This information is critical for establishing a baseline and controlling for pre-existing knowledge and potential biases in the subsequent choice analysis [85].

The analytical framework of this study relies on a dual approach. First, an attitudinal analysis was conducted to investigate public perception through specific dimensions, such as local economic impact, environmental consequences, and visual integration, evaluated on Likert scales to identify general trends and consensus levels. Following this, the sample's level of familiarity with FOW technology was formally assessed. Second, the core investigative phase utilized a Discrete Choice Experiment (DCE) to analyse the structure of public preferences [86]. This methodology is a multi-attribute valuation technique based on Random Utility Theory, which assumes that individuals choose the alternative that provides them with the highest personal benefit. By forcing respondents to choose between different hypothetical scenarios that vary in their characteristics, the DCE allows for the precise estimation of the relative importance and statistical weight given to each single attribute of the project.

Furthermore, the methodology applied in this study is highly standardized and modular, making it perfectly replicable at a national level for any other European territory. By adjusting the attributes and visual stimuli to local geographical and socio-economic specificities, this DCE framework can serve as a universal tool for European policymakers to assess social acceptance and harmonize energy development with local landscape preservation. These attributes were selected to quantify the trade-offs among a multi-attribute set of potential impacts, selected to represent the core dimensions of the public debate. These encompass negative externalities such as visual disamenity and perceived ecological consequences for marine flora and fauna; socio-economic effects on

Table 1
Socio-demographics of sample and population.

Variable	Category	Survey Sample (%)	Italy (ISTAT %) [81–83]
Gender	Male	63.0 %	48.7 %
	Female	37.0 %	51.3%
Age (years)	18–30	55.1 %	15.1 %
	31–45	21.1 %	23.4%
	46–65	22.4 %	27.5%
	65+	1.4 %	34.0%
Education	Secondary (High School)	21.1 %	46.1 %
	University (Degree or higher)	77.5 %	29.4%
Geography	North	23.0 %	45.7 %
	Centre	45.0%	19.8%
	South & Islands	32.0%	34.5%
Coast	Reside along the coast	29.9 %	43.0%

local tourism and fishing activities; and positive externalities including regional job creation and contributions to national decarbonization energy targets.

The core investigative phase utilized a series of high-fidelity visual aids consisting of photorealistic renderings [87,88], as shown in Fig. 4. These images, meticulously crafted to depict offshore wind farms by day and by night at varying sizes and distances from the coast, are instrumental in providing a tangible representation of the potential aesthetic change, a technique critical for mitigating the hypothetical bias often encountered in stated preference studies. This multi-faceted methodology allows for a realistic assessment of individual perceptions and preferences, generating a rich dataset purpose-built for subsequent econometric modelling aimed at understanding the structure of public preferences and quantifying the trade-offs among the project's different attributes [89].

2.5. Techno-economic assumptions

The techno-economic modelling is predicated on a reference FOW farm architecture with a nominal capacity of 500 MW. While multi-gigawatt projects are prominent in long-term strategies, 0.5 GW scale was deliberately selected as a methodologically scalable baseline, reflecting the typical capacity of a single development phase for projects currently approaching Final Investment Decision (FID) in Europe [90]. This approach ensures that cost and performance estimations are anchored in more reliable, near-term data, thereby mitigating the substantial supply chain, vessel availability, and financing uncertainties inherent to pioneering gigawatt-scale deployments. The model employs next-generation wind turbine generators (WTGs) with rated power capacities in the 15-18 MW class, a selection aligned with the current technological frontier defined by platforms like the Vestas V236-15.0 MW [91] and the Siemens Gamesa SG 14-236 DD [92]. The deployment of such high-capacity turbines is a cornerstone of LCOE optimization; for a 500 MW farm, it reduces the unit count to approximately 28-33 turbines, which in turn curtails manufacturing, installation, and long-term operational expenditures per megawatt when compared to models in the 10-12 MW class. The park's spatial configuration assumes an inter-turbine spacing of seven rotor diameters (7D), in accordance with the optimised configuration in Ref. [56]. Tighter spacing would reduce inter-array cable costs; however, it would also induce significant wake-effect losses, thereby diminishing the AEP. Conversely, wider spacing would incur prohibitive cabling costs and lease area fees. The 7D standard is thus a widely accepted compromise to maximize the site's economic yield over its operational lifetime.

In regard to the foundation technology, a semi-submersible platform fabricated from high-strength steel was selected. This choice is substantiated by its market dominance and high TRL 8-9, which de-risks project execution. Its key logistical advantage lies in its compatibility with a wide range of port infrastructures for quayside assembly, obviating the need for the extreme water depths required by spar buoys, and its excellent hydrodynamic stability, which maximizes turbine availability by minimizing weather-related downtime.

The offshore substation is similarly conceived as a floating semi-submersible structure, positioned 1.5 km from the park. These technological assumptions are situated within a defined geographical context: the FOW is hypothetically located 50 km from the coastline at a site with a 300-m water depth and a conservative annual average wind speed of 7 m/s. This combination is representative of emerging deep-water markets such as the Mediterranean, where the 50 km distance mitigates visual impact concerns, a critical factor for social acceptance, while the 300-m depth is well beyond the 60m limit for fixed-bottom structures but not so extreme as to require unproven mooring technologies. The power export system utilizes a High Voltage Alternating Current (HVAC) connection, as it circumvents the substantial capital expenditure of the onshore and offshore converter stations required for High Voltage Direct Current (HVDC) systems [93,94]. While HVAC entails higher electrical losses, these remain economically acceptable at this distance and are significantly outweighed by the upfront capital savings.

Finally, to ensure a holistic cost assessment, an onshore grid connection distance of 10-30 km from the cable landing point is assumed, a parameter that accounts for the often-significant costs of right-of-way acquisition and terrestrial civil works.

The key technical parameters adopted for this analysis are summarized in Table 2; the majority of these values were derived from a formal stakeholder elicitation process.

3. Results and discussion

This study aims to provide an integrated assessment of FOW development in Italy, quantifying its economic, employment, and social impacts. The analysis focuses on national value creation, combining techno-economic indicators (CAPEX, LCOE), a sectoral input-output model for employment, and a social perception survey. The socio-

Table 2
Key technical parameters adopted for the analysis.

Parameter	Value	Unit	Source
Standard plant capacity	0.5	GW	Technical Elicitation
Turbine capacity	15	MW	[95,96]
Inter-turbine spacing	7* Rotor diameter	m	[56], Technical Elicitation
Plant layout	Grid		Technical Elicitation
Site depth	300	m	Technical Elicitation
Anchoring system	Drag anchor		Technical Elicitation
Distance from shore	50	km	Technical Elicitation
Distance site - substation	1.5	km	Technical Elicitation
Number of substations	2		Technical Elicitation
Average wind speed	7	m/s	[97]
Interest rate	3	%	Technical Elicitation
Farm Lifetime	25	years	[98]

Fig. 4. Photorealistic renderings shown in the survey [87,88].

economic potential depends on industrial policy and domestic supply chain development, making the optimal FOW strategy one that balances competitive LCOE with maximized local benefits through supply chain localization.

Section 3.1 presents the economic analysis (CAPEX breakdowns, LCOE sensitivity). Section 3.2 examines employment impacts by project phase (construction, O&M) and job type (direct, indirect, induced). Section 3.3 analyses public perceptions of advantages and disadvantages, while Section 3.4 quantifies the socio-economic implications of the NCEP (2.1 GW) and RED II (3.8 GW) targets under different localization scenarios. Section 3.5 concludes with key findings, emphasizing the transition from temporary construction to permanent industrial hubs and comparing results with existing employment studies.

3.1. Economic impact

The economic impact was evaluated by first structuring the project's CAPEX, integrating data from literature, industry reports, and direct stakeholder consultations to establish a robust cost basis and subsequently calculate the LCOE.

3.1.1. CAPEX per component and OPEX

A detailed component-level cost analysis, breaking down each major technological package, was conducted to define the short-term CAPEX range, with total values of 4.85 M€/MW (minimum) and 5.91 M€/MW (maximum) obtained from the sum of individual component costs. It is important to emphasize that these CAPEX figures are not predefined assumptions but represent primary results derived from the stakeholder elicitation and the processing of survey data, according to the methodology detailed in Section 2.1. The higher estimate reflects stakeholder inputs identifying it as a precautionary average CAPEX for first-of-a-kind projects in an immature market, accounting for supply chain inefficiencies, logistical bottlenecks, and the absence of economies of scale.

Beyond this short-term perspective, a medium-term scenario of 4.13 M€/MW was developed to represent a future stage of technological and supply chain maturity. As shown in Fig. 5, the CAPEX composition across scenarios reveals non-proportional cost variations, highlighting the influence of technological progress on overall expenditure. This detailed breakdown identifies the main cost centres and provides a transparent foundation for the techno-economic analysis, clarifying how financial and procurement risks are concentrated in the most capital-intensive components.

In the Minimum CAPEX Short-Term scenario, Turbine Manufacturing is the largest cost centre, representing 32.1% of total CAPEX, followed by Foundation Manufacturing (23.9%), the Offshore Substation (16.5%), and Installation (8.0%), while mooring systems, cables, and development contribute smaller shares (Fig. 5).

In the Maximum CAPEX Short-Term scenario, costs increase non-proportionally, reflecting the distribution of technological risk. Foundation Manufacturing shows the largest rise, from 1.16 to 1.71 M€/MW (+46.55%), due to the lower maturity and greater manufacturing uncertainty of floating substructures. This component is also highly sensitive to steel prices, which fluctuate with global raw material costs (iron ore, coking coal), energy prices, and supply-demand dynamics. In contrast, the more mature Turbine Manufacturing remains relatively stable, increasing by only 4.06% [99]. Consequently, the project's cost structure is expected to shift significantly in the High-Cost scenario.

The comparison between the Minimum Short-Term and Medium-Term CAPEX scenarios highlights a 14.8% overall cost reduction driven by technological maturity. Turbine Manufacturing costs are expected to decrease by 22%, while Foundation Manufacturing costs are projected to fall by 23%.

The projected cost reduction for foundations is reinforced by a potential material shift toward hybrid concrete and steel substructures [100], expected to be cheaper than all-steel designs. While this balanced decrease could reshape the project's cost structure, the turbine will remain the largest cost centre. Despite overall savings from industrialization and economies of scale, turbines and foundations will continue to dominate both financial and technological risk management. This detailed analysis highlights how the relative weight of key cost centres evolves with technological maturity, emphasizing that financial and procurement risks remain predominantly concentrated in less mature, capital-intensive components such as the floating foundation.

Fig. 6 depicts short-term CAPEX uncertainty across the main components of the floating offshore wind project, with the blue bars representing potential cost escalation ranges. The figure highlights that the greatest uncertainty lies within the most capital-intensive and least mature technological packages.

Foundation and Turbine manufacturing costs show the greatest variability, though for different reasons. Foundation costs range widely, from 0.9 to over 1.7 M€/MW, due to low technological maturity and fabrication risks typical of pre-commercial stages. In contrast, turbine cost uncertainty stems from market volatility and a supply chain adapting to the growing demand for next-generation large models.

Future cost reductions will stem from scaling up WTGs to the 20-25 MW class, with some manufacturers in China already developing models up to 26 MW [101], and the industrialization of substructures For

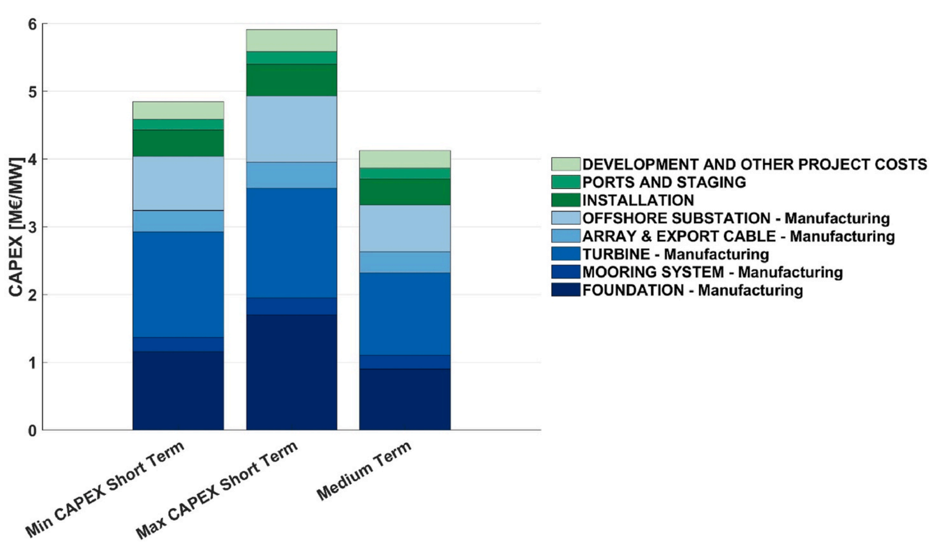

Fig. 5. Total value of the CAPEX for three scenarios per component.

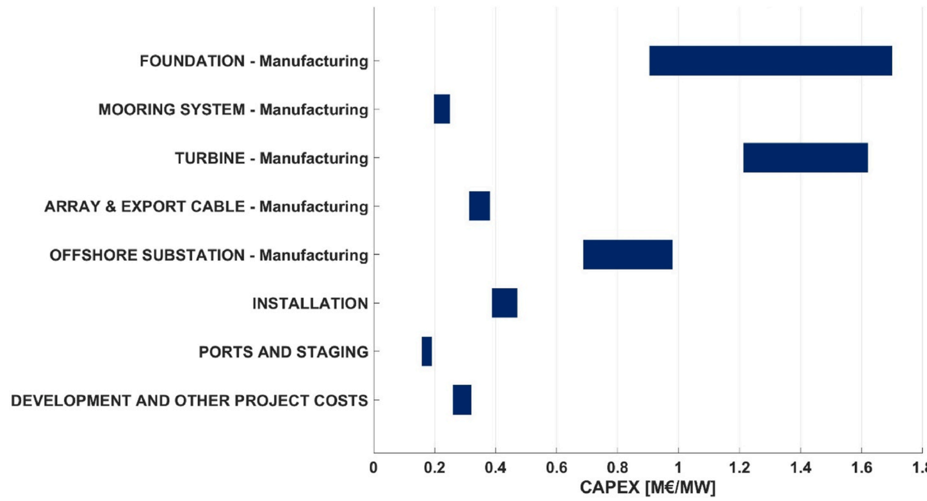

Fig. 6. Short-term CAPEX uncertainty for main floating offshore wind components (blue bars show cost ranges).

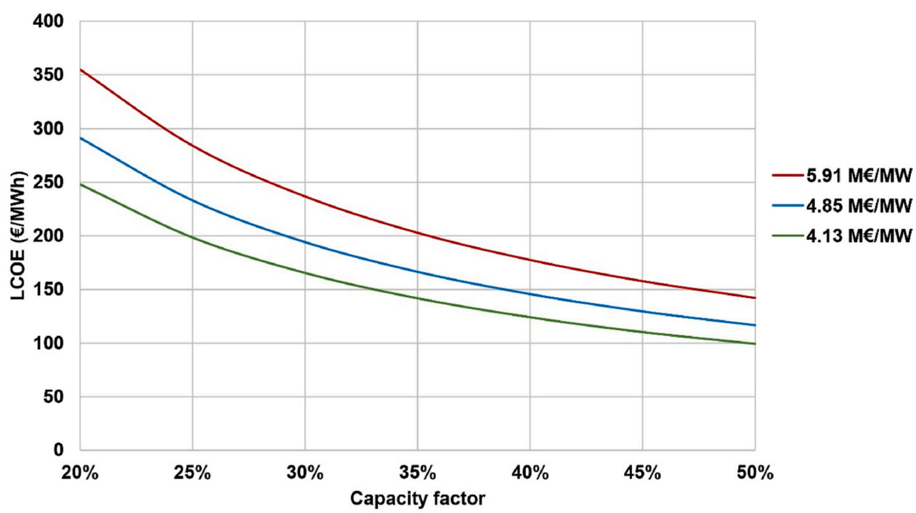

Fig. 7. Levelized Cost of Electricity by changing capacity factor in the three CAPEX scenarios.

foundations, this requires shifting from complex, bespoke designs to standardized modular systems enabling faster, assembly-line production with less specialized labour. A moderate 14% cost decrease (from 0.800 to 0.688 M€/MW) is also expected for floating substations, driven by greater market competition and platform standardization.

In contrast, some cost centres are considered inelastic. Subsea cable costs (0.314 M€/MW) are expected to remain stable due to dependence on volatile copper and aluminium markets, while installation costs (0.389 M€/MW) are unlikely to decrease because of anticipated bottlenecks in the specialized vessel market, keeping day rates high. Overall, this indicates that industry-wide cost reductions will primarily depend on industrializing core floating technology packages, whereas external market factors will limit savings in other supply chain segments.

In addition to capital expenditures, the analysis evaluated the OPEX to determine the long-term economic sustainability of the FOW sector in the Mediterranean context. Based on the stakeholder survey and expert elicitation conducted for this study, the annual OPEX for a 15 MW turbine is estimated to range between 1.8 and 2.0 million euros. Considering a projected project lifetime of 25 year, the cumulative OPEX accounts for approximately 31-37% of the total CAPEX. This result is consistent with current academic literature and industrial benchmarks, which identify a similar cost distribution for floating offshore wind projects in their pre-commercial and early commercial stages [102–104].

The significant weight of OPEX, representing nearly one-third of the initial investment, underlines the critical importance of the operational phase in defining the LCOE. An OPEX-to-CAPEX ratio of 31-37% suggests that cost-reduction strategies must extend beyond component manufacturing to encompass the development of resilient, localized maritime logistics and specialized maintenance infrastructures. Specifically, the transition towards "energy hub" models could facilitate substantial cost savings through the centralization of operations and the integration of automated monitoring systems, thereby reducing the logistical complexities and high vessel day-rates associated with deep-water environments.

3.1.2. *LCOE in short and medium term*

Building on the three CAPEX scenarios defined in Section 3.1.1 (short-term: 4.85-5.91 M€/MW; medium-term reference: 4.13 M€/MW), the LCOE has been assessed. In Fig. 7, the LCOE by changing the capacity factor in the three CAPEX scenarios has been depicted. The analysis has been carried out in a wide range of capacity factors in order to generalise the analysis to the broad context of mediterranean area.

In the Italian context, current capacity factor can usually be considered within a range of 25-40%, with 30-35% as a typical range for present-day sites.

In the short term, the LCOE falls in the range of 150-280 €/MWh, with average values (capacity factor around 30-35%) ranging from 170 to 240 €/MWh. In the medium term, reflecting progressive industrial learning and partial supply-chain maturation, the LCOE is expected to decline to a plausible range of 125-200 €/MWh, with mean values around 140-165 €/MWh. These values refer to the 500 MW reference plant, therefore scale effects (positive and negative) may shift outcomes outside these bands. Overall, short-term uncertainty remains high due to the limited number of commercial-scale FOW projects and the immaturity of installation and port logistics. Furthermore, the capacity factor remains the primary lever in the short term for reducing the LCOE.

Recent international reports and scientific literature are consistent with the LCOE values identified in the present work. According to IRENA [59], contemporary FOW projects exhibit LCOE values higher than 200 USD/MWh, with a potential reduction up to 100 USD/MWh in the medium term and LCOE values around 67 USD/MWh achievable by 2050.

According to DNV's Energy Transition Outlook [105], the global average LCOE for FOW is around 390 USD/MWh today, with a long-term reduction pathway toward about 100 USD/MWh. For a recent bottom-up benchmark, the NREL 2022 Cost of Wind Energy Review estimates around 145 USD/MWh for floating compared with 95 USD/MWh for fixed-bottom reference cases [106].

In Ref. [107], an optimization of FOW system configuration in different sites in the mediterranean area has been carried out. The results further highlight the strong CF-sensitivity of costs. Across multiple locations, LCOE ranges from 80 €/MWh (in exceptionally high producibility sites, with capacity factors higher than 50%) up to 195 €/MWh.

Taken together, these sources indicate that, while meaningful cost reductions are expected as the FOW industry scales and standardizes, a cost gap versus fixed-bottom offshore is likely to persist through the medium term, particularly at sites with modest capacity factor values and under constrained supply-chain conditions.

3.2. Employment impact

The quantitative analysis of employment impact from Italian FOW development reveals distinct job creation profiles across the project lifecycle. The initial Construction and Installation (C&I) phase, in particular, represents a primary driver for large-scale employment, quantified at 14.4 kFTE per installed gigawatt. This substantial labour demand stems primarily from the manufacturing, fabrication, and assembly processes associated with capital-intensive components. Consequently, the employment of specialized engineering and welding is anticipated in the fabrication of floating foundations, the high-voltage electrical systems production and export cables, in addition to the precision assembly of wind turbine nacelles and blades. A deeper analysis of the C&I phase employment composition, as shown in Fig. 8, reveals that "Installation & Development" (43.5%) constitutes the largest single share of the total. In this context, the logistical, managerial, and development activities are found to be as, or more, labour-intensive than discrete manufacturing segments, such as "Foundation - Manufacturing" (25.6%).

Furthermore, indirect employment is the main and most significant component, accounting for approximately 52% of total job creation, compared to about 27% for direct jobs and 21% for induced employment. This indicates a substantial multiplier effect capable of disseminating throughout the national economy and stimulating associated sectors (e.g., steel manufacturing, naval engineering). The realization of this multiplier effect, however, is contingent upon the capacity and maturity of the domestic industrial ecosystem. Currently, robust port infrastructure is identified as a critical prerequisite, despite its minimal direct FTE representation in the data. Accordingly, the 14.4 kFTE/GW forecast relies fundamentally on the readiness of these enabling infrastructures.

An additional consideration emerging from this distribution concerns the resilience of employment generation. A structure largely driven by indirect jobs suggests that the overall socioeconomic impact may be more sensitive to supply chain disruptions, international market dynamics, and industrial competitiveness. Conversely, it also implies greater scalability: as industrial activities expand, the employment effect can grow nonlinearly, reinforcing the strategic importance of long-term industrial planning and stable investment frameworks.

The predominance of the indirect share underscores a pivotal conclusion: without a strong domestic supply chain, the majority of the employment value would be externalized. Therefore, the capacity of the national industrial fabric is the primary determinant in capturing the full economic benefit.

The O&M fundamentally differs from the transient, high-intensity C&I employment profile. It establishes a paradigm of stable, long-term labour, projected to sustain approximately 1 kFTE per installed GW annually for the asset's 25-30 year operational lifetime, as shown in Fig. 9 [108]. The local economic benefit of this phase in intrinsically linked to the geographic fixity of its core activities, such as vessel operations and on-site corrective maintenance, which provide durable employment for coastal communities. This geographic dependency, however, is not absolute; functions such as onshore remote monitoring and diagnostics are potentially geographically independent and thus susceptible to centralization or outsourcing. Furthermore, the aggregated O&M composites diverse roles, from specialized technicians to port-side logistics, without disaggregating the required skill profiles. Accordingly, the realization of high-value local employment is contingent upon the availability of pre-existing, specialized skill base within the host region.

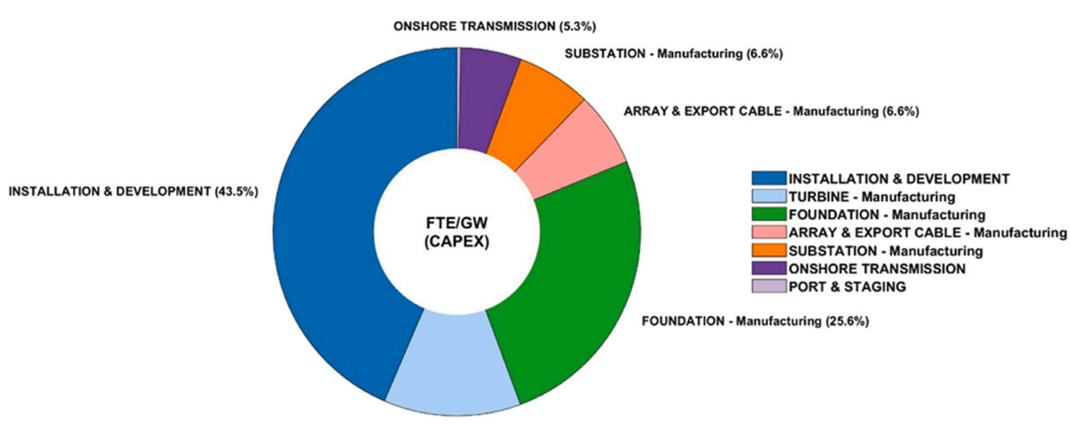

Fig. 8. FTE/GW referred to supply chain component.

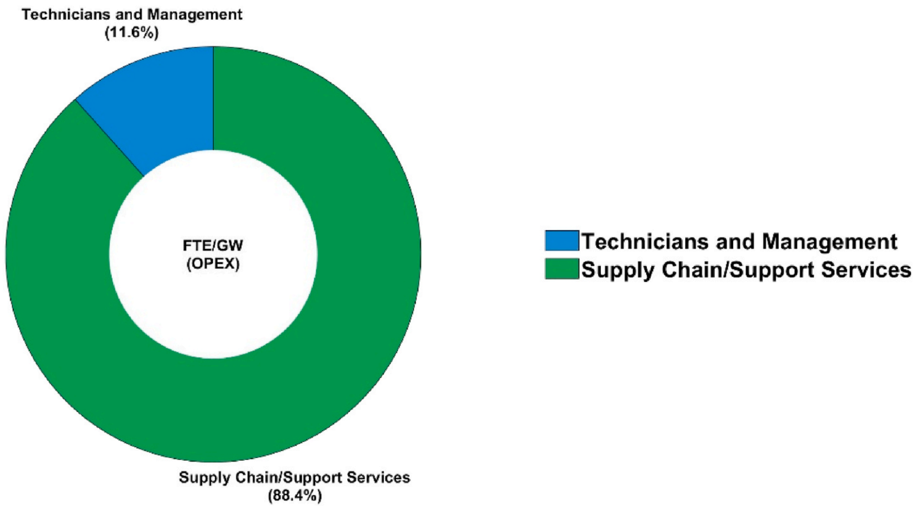

Fig. 9. Annual FTE/GW (referred to operation and maintenance) per phase.

The results delineate a biphasic employment impact across the project lifecycle. An initial, large-scale but temporary labour demand during the construction phase is subsequently replaced by a smaller, stable and long-term, operational workforce. These projections, however, are interpreted as a modelled potential, representing an upper-bound scenario. In this context, the actualization of these figures is directly dependent on the degree of national content achieved. This term encompasses the strategic localization of the entire value chain, from raw material processing to advanced manufacturing. Accordingly, a coherent and proactive industrial strategy is the central policy lever required to anchor the full spectrum of economic benefits domestically. Such a strategy is essential to ensure that Italy's energy transition also serves as a powerful engine for national industrial development and long-term, skilled employment.

3.3. Social acceptance

To investigate public perception and the social acceptance of offshore wind energy, a quantitative survey was designed and administered to a sample of 500 participants. The analytical framework adopted a two-fold approach: a descriptive attitudinal analysis to identify general perceptions and a DCE to quantify the statistical weights and trade-offs driving the final decision-making process. The investigation focused on three key dimensions:

- local economic impact, quantified as permanent jobs created;
- potential environmental impacts, described through the implementation of specific mitigation measures;
- the visual integration with the marine landscape.

The first phase of the analysis utilized Likert scale parameters (1-to-5) to evaluate individual perceptions. Fig. 10 presents a detailed assessment across ten dimensions, visualized through box plots where medians indicate prevailing opinions. Results show a clear contrast between positive perceptions of economic and air quality impacts and a more cautious or negative view of environmental effects. The most positively perceived impacts are “Tourism and economic activities” and “Property values”; the latter shows a narrower interquartile range (IQR), denoting strong consensus, while Tourism exhibits a wider IQR, reflecting more polarized opinions. Overall, the most favourably rated dimensions are economic (employment, tourism, and property values), consistent with findings by Parton et al. [109].

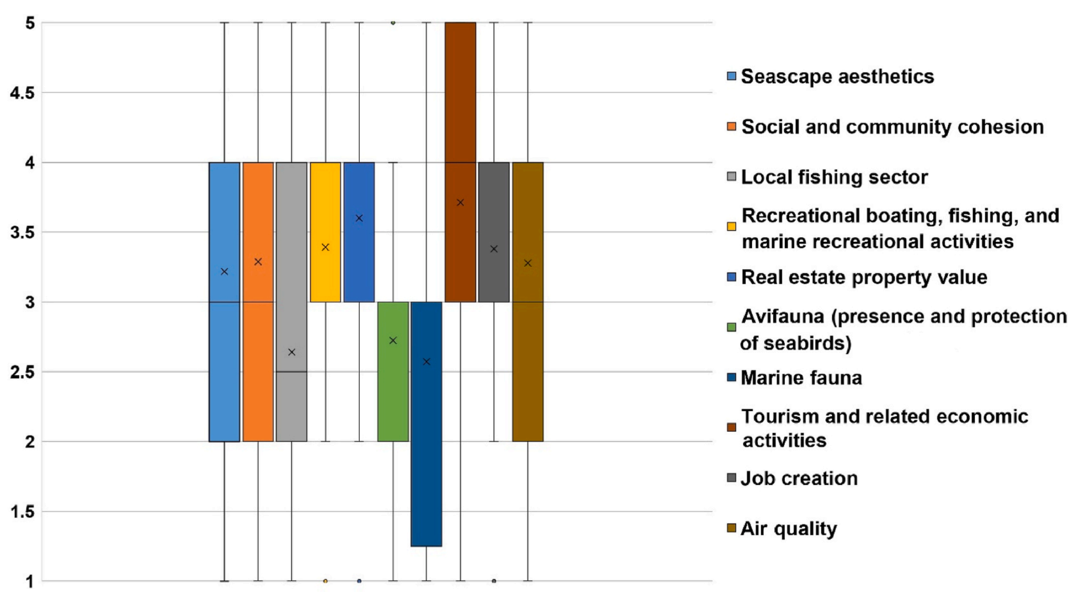

Fig. 10. Survey's results.

Conversely, the impacts on the Local Fishing Sector, Marine Fauna, and Avifauna are perceived as negative, with median scores below 3.0. Both Local Fishing and Marine Fauna display a large IQR, indicating substantial uncertainty and limited consensus, a pattern consistent with scientific findings highlighting both negative effects (e.g., displacement) and positive ones (e.g., artificial reef benefits) [110]. The aesthetic impact on the marine landscape is neutral but characterized by wide dispersion, revealing that visual concerns are highly dependent on contextual factors such as project location and distance from the coast [109]. The aesthetic impact on the marine landscape is likewise neutral but characterized by wide dispersion, revealing polarized opinions. This suggests that visual impacts, though contentious, are not uniformly perceived as negative and depend on contextual factors such as project location. As demonstrated by Parton et al. (2024) [109], siting projects farther offshore can foster greater public agreement, emphasizing distance ad a key determinant in mitigating visual impact concerns.

Fig. 11 indicates that perceived criticalities are primarily associated with technical and environmental factors. The logistical complexity of maintenance in marine settings and exposure to extreme weather emerge as major disadvantages, alongside potential impacts on the marine ecosystem, which most respondents view as a key barrier to acceptance.

High initial investment costs also contribute to cautious public attitudes. Conversely, the perception of the technology as still being "in development" is less prominent, suggesting general confidence in the maturity of wind technologies, though the public may not fully distinguish between bottom-fixed and floating systems. The presence of neutral or only mildly negative responses further indicates that concerns are not universally shared, implying that transparent, data-based communication and practical examples could effectively reduce perceived risks and enhance overall acceptance.

Fig. 12 highlights the main advantages perceived by the respondents. The most prominent benefit is the higher energy production compared to onshore installations, followed by the absence of land use and the reduction of visual and acoustic impacts. These perceptions are technically justified, as offshore wind farms operate in areas with stronger and more consistent winds, leading to higher capacity factors. Such benefits are crucial for development in densely populated regions, where land-use conflicts and NIMBY (Not In My Back Yard) attitudes often hinder onshore projects [111].

Additional advantages identified include the creation of a local industrial supply chain and greater energy production stability. The integration of wind farms with other maritime activities (e.g., aquaculture) is also seen positively, although with a greater uncertainty, reflecting the experimental stage of multi-purpose offshore platforms.

While the previous sections describe general attitudes, the Discrete Choice Experiment provides a rigorous quantification of the drivers of social acceptance. Fig. 13 illustrates the preference weights (utility coefficients, β) derived from the respondents' choices, revealing the "marginal utility" of each project attribute. The results of this analysis offer a decisive perspective on the public's decision-making structure. The Local Economic Impact (Coef: +0.60) and Visual Disamenity (Coef: −0.60) emerge as the two most influential drivers, possessing nearly identical statistical weight but in opposite directions. This suggests a perfectly balanced trade-off: for the average respondent, the negative utility caused by the alteration of the marine landscape is exactly compensated by the positive utility of local economic development and job creation.

Interestingly, while the attitudinal analysis (Fig. 10) showed significant concern regarding the Marine Flora & Fauna, the DCE results reveal a lower marginal utility for this attribute (Coef: +0.04). This indicates that, when forced to make a choice between different project configurations, participants prioritize tangible socio-economic benefits and aesthetic preservation over ecological factors. Similarly, the Tourism Disturbance (Coef: −0.28) shows a significant but secondary negative weight. The fact that the error bars for "Flora & Fauna" cross the zero line suggests that the impact of this dimension on final acceptance is less certain compared to the decisive roles of economy and landscape.

In conclusion, the dual analysis demonstrates that social acceptance for FOW in Italy is not a binary "yes or no" position, but a calculated balance. The replicability of this DCE framework across the European territory allows for the identification of specific "acceptance thresholds," where local economic compensation effectively mitigates the perceived visual and environmental costs of the energy transition.

3.4. Socio-economic implications of Italian targets

The deployment FOW in Italy entails major socio-economic implications, particularly regarding investment needs and employment creation. This study evaluates the capital and workforce requirements associated with two official national targets: 2.1 GW by 2030 (NCEP), and 3.8 GW (RED II decree).

Estimated investments range from 10.2 to 12.4 billion € for the NCEP target and 18.4-22.4 billion € for the RED II target, based on CAPEX values of 4.85 to 5.91 M€/MW, consistent with international benchmarks for first-generation FOW projects. The employment potential is significant: the construction phase could generate 30,000–60,000 FTE positions, depending on the deployment scenario, while the operation and maintenance phase would sustain a stable base of high-skilled jobs over the 25-30 years lifetime of the wind farms [108]. These long-term roles, focused on predictive maintenance, remote monitoring through Supervisory Control and Data Acquisition (SCADA) systems, and complex marine logistics, are well recognized in the literature as key drivers

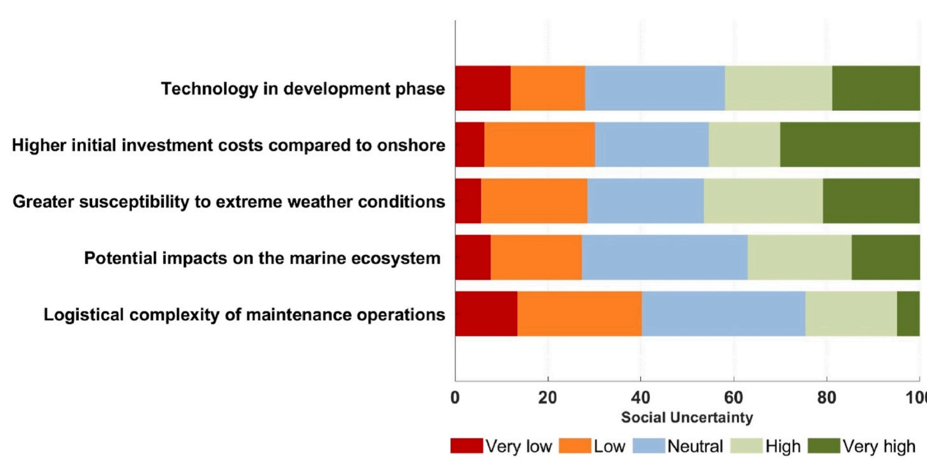

Fig. 11. Social uncertainties of FOW technology.

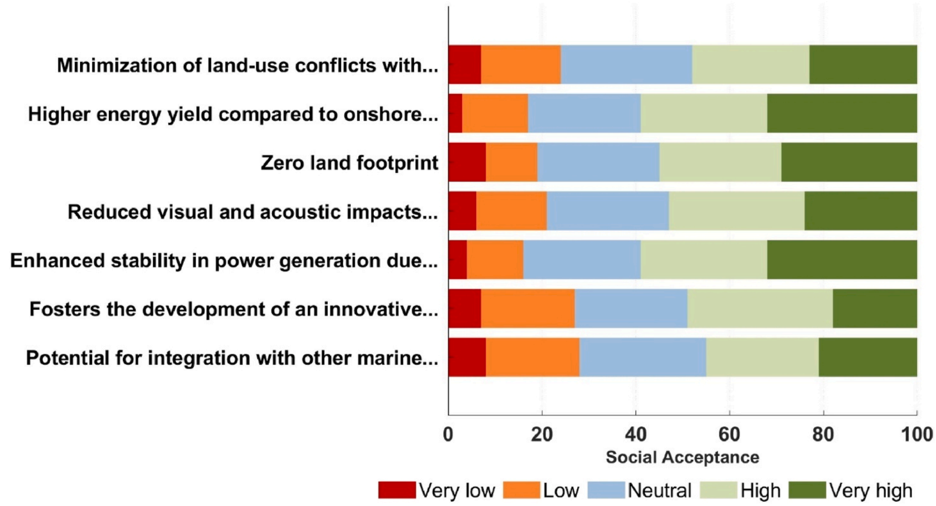

Fig. 12. Social acceptance of FOW technology.

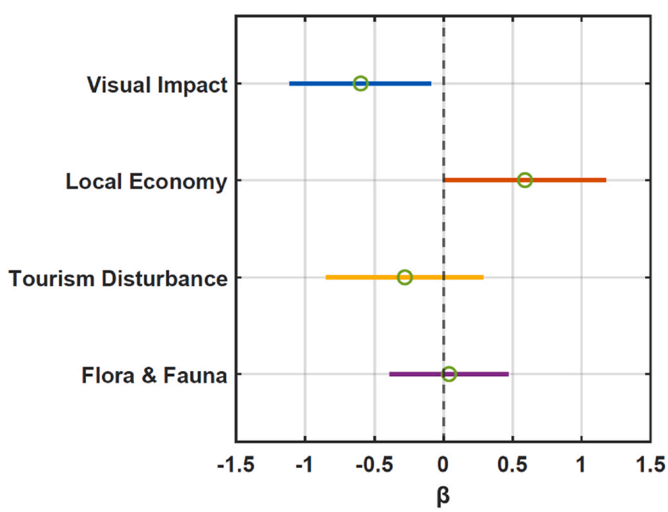

Fig. 13. Preference weights and utility coefficients for FOW attributes.

of regional industrial development.

The realization of Italy's employment potential from floating offshore wind depends largely on the national industrial strategy and the extent of supply chain localization (Fig. 14). Three scenarios were modelled to assess this effect. In the Reference Scenario, with 20% domestic turbine content and 70% localization in other components, around 14.4 kFTE per GW are generated nationally about 58% of total potential. In a Domestic Production Scenario, where localization increases to 60% for turbines and 90% for other components, the domestic employment share rises to 77%. Conversely, a High-Import Scenario, assuming 5% turbine and 40% other component localization, retains only 39% of potential jobs, leading to substantial economic leakage abroad, as shown in Fig. 15.

Component-level analysis highlights floating foundations as the segment with the highest industrial development potential, being material and labour-intensive, logistically complex, and suited to local production. The lack of a dominant global design standard offers room for new industrial players. Domestic manufacturing of foundations and related electrical infrastructure could generate over 3 kFTE per installed GW, lower project CAPEX, and strengthen Italy's position in the global FOW market.

Establishing a localized, resilient supply chain would maximize socio-economic benefits, boost energy security and innovation, and enable Italy to evolve from a technology importer to a European manufacturing hub. Given the early-stage maturity of the FOW sector, current policy and investment decisions will determine whether Italy achieves industry leadership or remains reliant on foreign supply chains.

3.5. Discussion

Building on the results presented in the previous section, the employment estimates were further examined in relation to comparable studies on FOW. The estimated number of full-time equivalent jobs related to FOW in Italy was compared with employment factors reported in earlier research. As shown in Table 3, these studies span different countries, reference years, and analytical approaches. Most rely on conventional shipbuilding, which reflect industrial frameworks that differ from the energy hub configuration explored in this study. In contrast, the energy hub concept offers a more integrated and spatially efficient structure for coordinating FOW-related activities. This perspective is particularly relevant for Italy, where the scarcity of port space represents a major constraint on large-scale offshore development. By reorganizing manufacturing and assembly within a coordinated hub, the model proposed here aims to optimize existing infrastructure while supporting a more resilient employment dynamic.

A comparison with the literature reviewed in Section 1.2 demonstrates how the employment estimates presented in Table 3 align with, and provide clarity to, a fragmented body of evidence. Prior research has yielded a broad spectrum of Employment Factors, frequently ranging from below 2 FTE/MW to over 40 FTE/MW. Such variability is primarily attributed to diverse methodological frameworks (e.g., Input-Output models, JEDI, or LCA-based assessments), the maturity of the investigated supply chains, and divergent assumptions regarding local content. However, the majority of existing studies focus on bottom-fixed offshore wind, national contexts with established industrial infrastructures (e.g., UK, France), or early-stage floating projects characterized by limited techno-economic granularity. This heterogeneity hinders cross-country benchmarking and necessitates methodological harmonization.

In this context, the present study contributes to the field by providing employment estimates for the Italian floating offshore wind sector that are explicitly coupled with a granular techno-economic model and various localization scenarios. The findings, yielding 14.4 FTE/MW during the construction phase and approximately 1 FTE/MW/year during operations, position this work within the upper range of international literature. This result is consistent with the high labour intensity inherent in floating foundation manufacturing and the current absence of economies of scale in pre-commercial markets.

Crucially, the analysis quantifies how employment benefits are

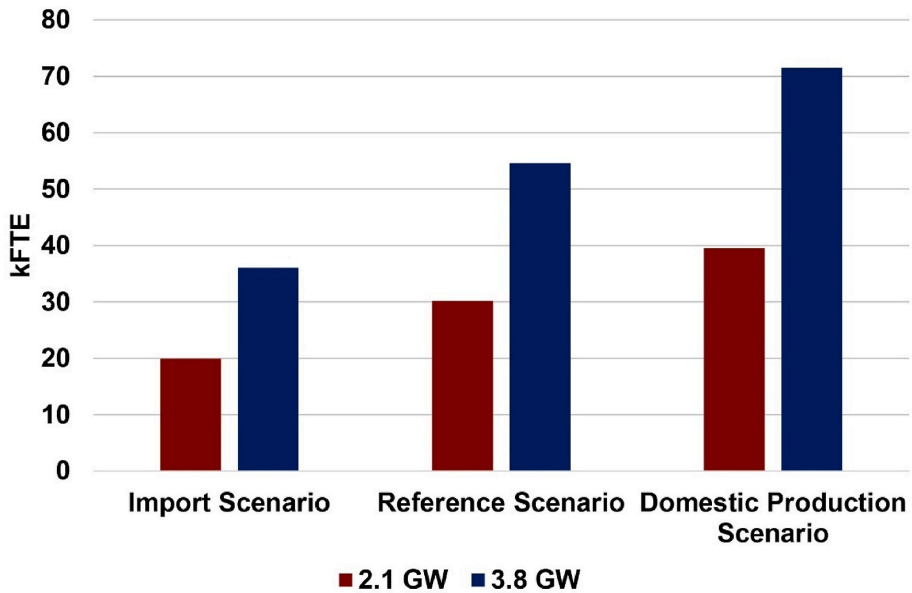

Fig. 14. Scenarios by GW investment.

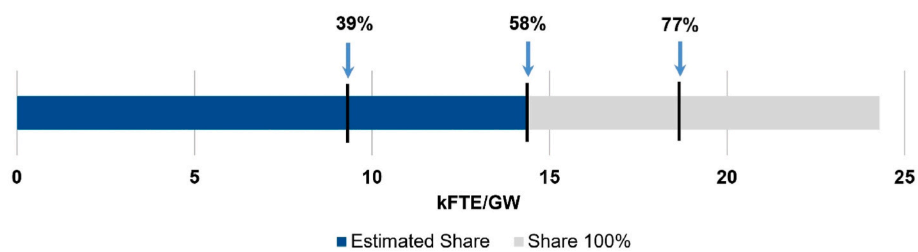

Fig. 15. kFTE/GW comparison between estimated share and total share.

strictly contingent upon industrial policy and localization strategies; depending on the degree of domestic supply chain involvement, Italy could retain between 39% and 77% of its total employment potential. This nuance is seldom captured in previous literature, where local content is often assumed as a static parameter rather than a modelled variable. Furthermore, recent techno-economic studies focused on the Mediterranean, such as Martinez et al. [50] and Benabadji et al. [58], have highlighted the spatial variability of LCOE across different sub-basins. While these studies primarily address cost metrics, they confirm that Mediterranean FOW operates under environmental and logistical conditions distinct from those of the North Sea, further justifying the need for country-specific socio-economic assessments.

The synthesis of Table 3 and the literature review identifies two structural research gaps: (i) a deficiency in socio-economic assessments tailored to Mediterranean deep-water contexts; and (ii) a lack of integrated models that simultaneously account for techno-economics, supply chain localization, employment impacts, and social acceptance. This study addresses these gaps by proposing an integrated framework that reflects the industrial and geographical specificities of the Italian case, while maintaining generalizability for other Mediterranean regions where floating technologies are projected to be a primary energy driver.

This comprehensive modelling approach highlights a fundamental trade-off that permeates the decision-making process in the offshore wind industry: the tension between maximizing local socio-economic returns and minimizing the final cost of energy. From the perspective of a farm developer, the primary objective is to ensure the project's financial bankability, which often leads to considering the procurement of major components, such as turbines or platforms, from highly competitive international markets like China. While such an approach can substantially lower CAPEX and increase the competitiveness of bids in auction-based systems, it simultaneously risks diluting the domestic economic impact, shifting the project toward the "Import" scenario where local benefits are confined to assembly and maintenance. In practice, this trade-off suggests that decision-making cannot rely solely on market-driven cost optimization if national industrial growth is a priority. Policymakers must therefore design procurement frameworks and auction criteria that value supply chain resilience and local job creation, potentially through non-price criteria that offset the immediate cost advantage of cheaper foreign imports. Furthermore, the logistical challenges of transporting massive floating substructures over long distances may provide a "natural protection" for local manufacturing, as the cost and carbon footprint of transoceanic shipping could partially negate the price benefits of offshore production. Ultimately, choosing between a lower-cost import strategy and a more expensive domestic one involves a strategic evaluation of whether the additional investment in the local supply chain serves as a long-term catalyst for national energy security and technological leadership in the Mediterranean basin.

4. Conclusions

The expansion of floating offshore wind energy in Italy represents a strategic opportunity to accelerate the national energy transition while fostering industrial development and employment growth. This study set out to assess the economic and occupational potential linked to the deployment of FOW and to explore the level of public acceptance toward this emerging technology, which may become a cornerstone of Italy's path toward energy autonomy. To address these objectives, a techno-economic analysis was conducted in collaboration with key

Table 3
EF in FTE/MW found in academic literature.

Country	Year of reference in the research	EF [FTE/MW]	Scenario/Phase	Ref.
Spain	2028 2030	5.70/ 1.63/ 0.43 2.07/ 2.76/ 3.81	High/Middle/Low (LCA + IO, full vs partial internal manufacturing)	[45]
Poland	2023	4.18/ 0.76/ 0.40	IO Model - High/Middle/Low; 16.9% internal manufacturing	[112]
France	2023	19.05/ 2.01/-	IO Model - 100% internal manufacturing chain	[112]
Australia	2025 2025 2025	1.5/ 13.68/ 0.9/0.28 1.4/5.3/ 0.38/ 0.08 8/15.6/-/ 0.2	Development/ Construction/ Manufacturing/O&M – JEDI model	[57]
Germany (EU ref.)	2009-2022	1.03-1.70	Direct Jobs EF evolution from 2009 to 2022	[113]
UK	2003-2015	19 - 7	Offshore wind employment ranges from 2003 to 2015	[37]
Ireland	2011	47 ÷ 3.9 9	Employment metrics - case study (onshore/offshore) Offshore-only report (national ref.)	[38]
UK	2015 2003-2008	10 (3.5) 10 (4.6)	Direct jobs for devices (foundations supply chain) Other report (construction-focused)	[38]
EWEA (EU avg.)	2011	6 ÷ 1.9	Offshore wind EU range	[38]
UK	2011	2 ÷ 0.5	O&M only - cumulative job creation	[38]
USA	2020	34.1 ÷ 1.18	Direct total (JEDI, 95 MW scenario)	[114]
		44.31 ÷ 2.05	Total including induced jobs	[114]
		4.3 ÷ 0.68	O&M annual total	[114]
UK	2009-2022	1.03-2.49	Net jobs EF evolution from 2009 to 2022	[55]
Italy	2028-2035	14.4/1	IO model - Development + Construction + Manufacturing/O&M	This study

stakeholders to estimate short- and medium-term costs and National investments. Furthermore, the potential employment impacts have been assessed, and a survey was carried out to investigate public perceptions and the degree of social acceptance of floating offshore wind technologies.

It is found that the total investment needed to achieve the FOW capacity targets of NECP (2.1 GW) and RED II (3.8 GW) range between 10.2 and 12.4 billion € and 18.4-22.4 billion, respectively. In light of such investments, it is anticipated that the construction and installation phase of 2.1 GW of floating offshore wind plants will yield between 30 and 33 kFTE, and up to 54-60 kFTE for 3.8 GW. The operational phase, which is to be spread over several decades, is estimated to contribute approximately 1000 FTE/year for each installed GW.

Techno-economic results indicate that short-term capital expenditure remains high, ranging between 4.85 and 5.91 M€/MW, with turbines and floating foundations representing the most significant cost centres. However, a medium-term reduction to 4.13 M€/MW is projected as the supply chain matures and industrialization scales up. Similarly, the annual OPEX is estimated at 1.8-2.0 million euros per 15 MW turbine, representing nearly one-third of the initial investment over the project's lifetime. This cost structure leads to a LCOE currently between 150 and 280 €/MWh in the short term, with the potential to decline to 125-200 €/MWh in the medium term, provided that capacity factors are optimised and industrial learning is achieved.

From a social perspective, the study reveals that public acceptance is driven by a delicate balance between perceived benefits and concerns. While there is strong support for the technology's contribution to decarbonization and regional job creation, concerns remain regarding visual impacts on the marine landscape and potential effects on marine ecosystems and local fishing sectors. The Discrete Choice Experiment specifically highlights that local economic impact and visual disamenity are the most influential factors in decision-making, suggesting that social acceptance can be fostered by siting projects farther offshore and ensuring that economic benefits are retained locally.

This assessment highlights and quantifies how strategic decisions regarding the structure of the production chain, along with the industrial and training policies adopted, influence the economic and social impacts of this emerging technology. The provision of employment benefits is contingent upon the capacity to internalise the production phases that exhibit the highest added value, such as floating foundations and electrical substations. Domestic industrial production has the potential to retain up to 77% of potential employment, in comparison to 39% of potential jobs in case of import-based scenarios. This implies that the development of a national supply chain is not only an industrial choice, but also a strategic choice for job creation.

In order to achieve this outcome, it is first necessary to launch an innovative industrial model, moving from a shipbuilding approach to a highly automated and robotised energy hub model. This automated, compact technological model can facilitate the transformation of the Italian limited port space availability into a competitive opportunity. In this particular context, it is of paramount importance that a segment of the supply chain can be initiated in the short term, leveraging the extant expertise within the Italian industrial sector.

The methodological approach proposed in this study integrates technical-economic models, employment analyses and social acceptability assessments into a single analytical framework that leverages dialogue with key stakeholders. The approach is replicable, transferable and adaptable to Mediterranean contexts, where port capacity, supply chain configuration and environmental constraints require tailor-made assessments. In fact, while there is a substantial literature and numerous existing plants for fixed-bottom offshore wind turbines, there is a significant gap for FOW, requiring the development of analyses to stimulate the emergence of new industrial supply chains in countries where the morphology of the territory prevents the widespread application of fixed-bottom turbines.

This work therefore provides a useful framework for policymakers and industrial planners to develop policies to support a new FOW supply chain. It also provides researchers with a practical reference base for future studies where the socio-economic inputs for this nascent technology remain difficult to identify and validate. The potential of floating offshore wind power to act as a structural lever for development in Italy is considerable. In the coming years, billions in investment, high added value and tens of thousands of jobs could be generated. However, this potential can only be unlocked if an integrated vision is established today, combining industrial policy, training, energy planning and infrastructure.

CRediT authorship contribution statement

Domiziana Vespasiano: Writing – original draft, Visualization, Methodology, Investigation, Data curation. **Lorenzo Villani:** Writing – original draft, Methodology, Investigation, Data curation. **Antonio Sgaramella:** Writing – original draft, Methodology, Investigation, Data curation. **Lorenzo Mario Pastore:** Writing – original draft, Methodology, Investigation, Data curation. **Davide Astiaso Garcia:**

Visualization, Supervision, Methodology, Data curation. **Livio de Santoli:** Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Nomenclature

AEP	Annual Energy Production
AWEA	American Wind Energy Association
C&I	Construction and Installation
CAPEX	Capital Expenditure
CF	Capacity Factor
CGE	Computable General Equilibrium
crf	Capacity Recovery Factor
DCE	Discrete Choice Experiment
EF	Employment Factor
FEF	Full Employment Factor
FID	Final Investment Decision
FOW	Floating Offshore Wind
FTE	Full-Time Equivalent
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
IQR	Interquartile Range
IRENA	International Renewable Energy Agency
JEDI	Jobs and Economic Development Impact
LCA	Life Cycle Assessment
LCCA	Life Cycle Cost Analysis
LCOE	Levelized Cost Of Energy
MSP	Maritime Spatial Planning
NACE	Nomenclature des Activités Économiques dans la Communauté Européenne
NECP	National Energy and Climate Plan
NIMBY	Not In My Back Yard
NREL	National Renewable Energy Laboratory
O&M	Operation and Maintenance
OPEX	Operational Expenditure
PC	Plant Capacity
RED	Renewable Energy Directive
SCADA	Supervisory Control and Data Acquisition
TRL	Technology Readiness Level
US-MRIO	US multi-regional I-O model
WTGs	Wind Turbine Generators

Data availability

Data will be made available on request.

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