



Spatial distribution of economic benefits from offshore wind development: case studies of Poland and the United Kingdom

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Abstract. This paper compares Poland's emerging offshore wind market, with the United Kingdom, the European leader in the sector, to explore how economic benefits from offshore wind are distributed spatially. The Spatial Economic Benefit Analysis (SEBA) method was applied and refined by integrating an economic dimension, enabling the estimation of contract values and their geographical allocation. The study covers 18 projects, linking supply chain actors with contract packages to assess spatial concentration. Results show that supply chains tend to cluster: in the UK, a mature industrial belt has developed around the southern North Sea, spanning the British, Belgian, Dutch, and Danish coasts, serving both British and international markets. In Poland, Tier 1 contracts are largely secured by foreign firms, though domestic actors are visible in coastal and metropolitan clusters. With further Baltic development, Poland could become a regional supply hub if policy support improves.

Keywords: offshore wind, local content, spatial distribution, supply chain, coastal regions, SEBA.

Introduction

Europe's transition to renewable energy and enhanced energy security has accelerated offshore wind deployment. The United Kingdom leads Europe in this sector, with 52 operational offshore wind farms representing over 15.9 GW of installed capacity (The Crown Estate, 2025). In contrast, Poland is embarking on its offshore wind journey, with its first 1.2 GW offshore wind farm (OWF) scheduled for grid connection in 2026 and an ambitious target of nearly 6 GW installed capacity by the end of 2030 (Adamiec, 2023). While offshore wind implementation is crucial for energy security and the transformation of Europe's energy mix, it also raises important socioeconomic considerations regarding the distribution of economic benefits, especially concerning local content creation (Glasson et al., 2022; van der Loos et al., 2022).

This paper analyzes the spatial economic benefits of offshore wind projects in Poland and the UK by comparing supply chains at various development stages and assessing the contribution and regional distribution of domestic companies' activities. The comparative perspective between the mature UK market and the emerging Polish case highlights differences in supply chain configuration and the factors shaping these patterns (World Bank Group, 2021)

Analyzing spatial patterns of economic benefits from offshore wind farms in Poland and the UK remains a significant research challenge, particularly given the limited literature on sectoral distribution and maritime clusters in renewables. The task is particularly

difficult in countries at an early stage of development: in Poland, with no operational offshore wind farm in the first half of 2025, the sector is still emerging, but expected to expand rapidly in the coming years (Adamic, 2023). Thus, besides an ex-post view of the UK, a forward-looking perspective is adopted for Poland.

The growth of offshore wind energy creates new types of economic activities, but its effects are unevenly distributed, depending on supply chain structures and the capacity of domestic firms to participate (Biniek, 2017). Essentially, this involves determining whether the economic advantages generated remain localized to coastal regions, extend nationally, or reach beyond to areas furnishing the necessary spatial and infrastructural resources for offshore wind energy development (Saunders et al., 2020). This research seeks to geographically address these benefits through a detailed analysis of supply chain localization and regional economic integration within the offshore wind sector in Poland and UK (Stebbins et al., 2020; Kosek et al., 2025).

In this context, the concept of local content, understood as the proportion of national and regional entities participating in offshore wind projects, encompassing the supply of components, engineering services, logistics, operational, and maintenance activities, becomes critically important. Van der Loos et al. (2022) argue that local content is an outcome of the interactions between public policies, industrial strategies and global value chains, which rarely facilitate complete localization. Therefore local governments are looking for strategies to maximize the local economic benefits from such projects, even though they might initially be limited in contexts with scarce pre-existing industrial capabilities (Allan et al., 2020). Local governments shape the economic landscape of offshore wind by setting legal and financial conditions to attract investment and by promoting the localization of supply chains and regional industrial growth (Poulsen & Lema, 2017; Kahouli & Martin, 2018).

This complexity requires a detailed examination of supply chain structures to assess local economic integration. It also aims to identify opportunities to enhance domestic participation by focusing on how sector maturity and industrial capabilities in Poland and the UK shape spatial patterns of economic benefits.

The offshore wind supply chain is not static – it evolves alongside the maturity of the sector and the policies supporting its growth. The UK case demonstrates that a well-developed supply chain, reinforced by the Offshore Wind Sector Deal, can gradually increase the share of local content, with the ambitious target set at 60% by the end of 2030 (UK Government, 2025). In contrast, Poland, while only beginning its offshore wind development, can draw on the UK's experience in shaping sectoral agreements and mapping supply chains (*Offshore Wind Sector Deal*, 2021). The UK is a mature reference point; Poland is pre-operational. In the UK, more than 25 years of development have established the country as a European leader and a reference point for actively shaping supply chains with significant domestic participation (UK Government, 2025). Poland, by contrast, has not yet commissioned a single offshore wind farm, but aims to become a regional leader with up to 18 GW of capacity planned by 2040 (Ministry of Climate and Environment, 2021).

This study addresses the challenge of assessing spatial economic benefits in a sector that is still in an early phase. The novelty of the approach lies in applying and adapting the Spatial Economic Benefit Analysis (SEBA) tool to measure the potential impacts of offshore wind development at a stage when no operational capacity yet exists in Poland. By geolocating supply chain actors and linking them with estimated contract values, the method

enables an ex-ante assessment of how the sector may evolve. The analysis quantifies the participation of domestic companies in the offshore wind supply chain and interprets it in relation to key factors shaping its structure and regional distribution. In doing so, the paper proposes a framework for assessing the economic impacts of industries in formation, offering insights into current conditions and future trajectories.

Theoretical background

The Blue Economy has been increasingly recognized as an important driver of regional development, generating both direct and indirect spillover effects across multiple sectors of the economy (Jenniches, 2018; Zaucha, 2018; Czermański et al., 2024). Land-sea interactions (LSI) provide a useful analytical perspective for understanding how maritime activities are linked to inland economic structures (Kidd et al., 2019; Zaucha, 2019; World Bank, 2022).

Evidence from Poland demonstrates the scale and uneven distribution of such impacts: the national blue economy was estimated at EUR 12.9 billion, with an output multiplier of 1.86, meaning that each euro invested generated an additional 0.86 euro in other sectors (Mogila et al., 2024). While over 75% of direct effects are concentrated in coastal regions, indirect and induced benefits also allocate to central and southern regions, reflecting strong interregional linkages and the role of manufacturing and services. These findings highlight the clustered yet interconnected nature of the blue economy and underline the need for methodological approaches capable of capturing not only sectoral, but also spatial dimensions of its development. This perspective is especially relevant for emerging maritime industries such as offshore wind, where direct local economic effects remain largely unmeasured.

The economic benefits of offshore wind energy are increasingly recognized as crucial not only for regional development, but also the social acceptance within the local community. However, how these benefits are spread across different locations depends on several factors. These include the maturity of the domestic offshore wind sector, the capacity of local supply chains and the implementation of public policies that promote local content (Sylvest, 2020; World Bank Group, 2021).

Jenniches (2018) emphasizes that the regional economic effects of renewable energy technologies, including OWF, are significant in terms of job creation, gross value added (GVA) and the development of local industrial ecosystems. The job creation effect is widely recognized in the literature with several different approaches to better estimate the number of jobs created from wind energy development (Kahouli & Martin, 2018; Aldieri et al., 2020). Although offshore wind investments generate benefits such as new jobs, existing methodologies do not allocate them geographically. Moreover, economic outcomes extend beyond direct and indirect employment effects. The input-output (I-O) methodology is commonly used in order to better understand the blue economy sector (Mogila et al., 2021). In the context of offshore wind development there has been an I-O model created by Allan et al. (2020). According to the study, for the UK offshore wind sector, each £1 million spent locally can generate over £1.5 million in GVA and create more than 10 full-time equivalent (FTE) jobs, but this multiplier effect depends strongly on the level of local content and the geographical distribution of suppliers (Allan et al., 2020).

Economic benefits derived from offshore wind energy manifest not only offshore, but also and frequently more significantly, onshore. The deployment of new OWF projects necessitates complementary onshore activities, including installation, logistics, maintenance and infrastructure management, which collectively stimulate demand for local goods and services (Díaz & Guedes Soares, 2020). This connection is captured by the concept of land-sea interactions, which, according to Kidd (2019), have both functional and institutional aspects, making them vital for effective spatial and economic planning (Tocco et al., 2024)

Local content could be classified as an economic outcome of land-sea interactions, as the distribution of benefits depends on the location of installation ports, manufacturing facilities, transmission networks, operation, and maintenance centers (Glasson et al., 2022; van der Loos et al., 2022). These elements give rise to specialized offshore wind service hubs, around which investments and employment opportunities tend to concentrate (Markard & Petersen, 2009; Poulsen & Lema, 2017). The economic impact of increasing local content in offshore wind developments has been less widely studied, yet it remains a crucial factor in maximizing the benefits for the host economy (Allan et al., 2020).

In assessing the economic benefits of OWFs, the concept of local content is of central importance. This term refers to the share of national or regional companies and resources in the delivery of offshore projects, but its definition is neither standardized nor universally applied in the international context. BVG Associates (2015) proposed a comprehensive methodology for measuring local content in the UK offshore wind sector, based on the valuation of contracts, tier-level supply chain segmentation (tiers 1-3) and geolocation of suppliers. While local content is recognized on the national level within the country's economy, there is currently a lack of standardized methodology to assess the distribution on the regional level.

Furthermore, the capacity to retain economic value within a region is significantly influenced by the availability of port infrastructure, industrial facilities and a skilled workforce equipped to support offshore projects (Crowards et al., 2023). Consequently, less developed markets typically exhibit a greater dependence on foreign suppliers and expertise. As the sector matures and consistent new investments enable private capital to fund supply chain infrastructure in a particular region, the proportion of local content tends to increase (World Bank Group, 2021).

In the UK, socio-economic impacts of offshore wind are assessed through mandatory Supply Chain Plans, which commit developers to domestic value creation and are later verified against contracting outcomes and achieved local content (Glasson et al., 2022). In Poland, although developers must submit Supply Chain Plans under the CfD scheme, these contain no binding local content requirements and follow no unified methodology. As a result, data on domestic participation are self-declared, unverified and fragmented, with no national database for tracking economic impacts such as job creation or gross value added.

There is growing academic interest in measuring the spatial distribution of economic benefits from offshore wind energy (OWE). For this purpose, Weig and Schultz-Zehden (2019) proposed the Spatial Economic Benefit Analysis (SEBA), which integrates quantitative and spatial analyses to localize economic gains. SEBA provides a useful framework for assessing spatial impacts of offshore wind projects, particularly in emerging markets such as Poland.

The SEBA methodology links supplier locations, business activities and contract values to represent economic benefit flows spatially. It has been applied to offshore wind and other maritime sectors such as fisheries, oil and gas, seabed mining, tourism and shipping, demonstrating its value as a planning tool within Maritime Spatial Planning (Weig & Schultz-zehden, 2019). Its pioneering application in the German offshore wind sector revealed coastal concentration, inland industrial linkages and the international nature of supply chains, while also showing that ownership structures affect domestic participation. However, its broader use remains limited by scarce economic data. Addressing this gap, the present paper applies SEBA in an ex-ante perspective to offshore wind in Poland, in comparison with the mature UK market.

Materials and methods

The aim of this study was to examine the spatial distribution of economic benefits from offshore wind energy (OWE) development in Poland and the United Kingdom by analyzing supply chain value and its distribution. This study refines the SEBA methodology by identifying specific companies within offshore wind supply chains and estimating the value of contracts for individual projects. This makes it possible to link economic value to spatial patterns and to improve the analysis of regional economic impacts. The enhanced method also supports a more reliable assessment of local content. It provides a basis for policy discussions on how to strengthen domestic participation in offshore wind development (Allan et al., 2020).

The methodological framework was structured in three stages. Stage 1 examined the spatial location of offshore wind farms and service ports. Stage 2 focused on mapping supply chain contracts and estimating their economic value for each individual project. Stage 3 extended the analysis to the broader geographical distribution of entities across the entire offshore wind sector, providing the structural context for understanding supply chains. The analytical tool was refined in line with the direction proposed by Weig and Schultz-Zehden (2019) and this modification represents a significant improvement of SEBA. In this revised framework, contract values were not only mapped spatially, but also linked to their estimated economic weight, allowing for a more precise assessment of capital flows and their territorial footprint within national and regional economies. The three-stage analytical procedure is illustrated in Figure 1, which presents the methodological framework developed for this study as an adaptation of the Spatial Economic Benefit Analysis concept.

First, offshore wind farms in Poland and the United Kingdom were identified for analysis. The selection aimed to include relatively recent investments that could provide insights into the current status of both markets. The projects examined represent four different stages of development: (1) development phase, when preparatory work is undertaken; (2) pre-construction phase, preceding the start of offshore works; (3) construction phase, when installation activities at sea are ongoing; and (4) operational phase, when the wind farm is fully connected to the grid. The decommissioning phase was not considered within the scope of this study.

In 2021, Poland introduced a support mechanism in the form of Contracts for Difference (CfD), which compensates the gap between the market electricity price and the fixed strike price of approximately EUR 72/MWh. All seven projects that successfully secured Polish CfD

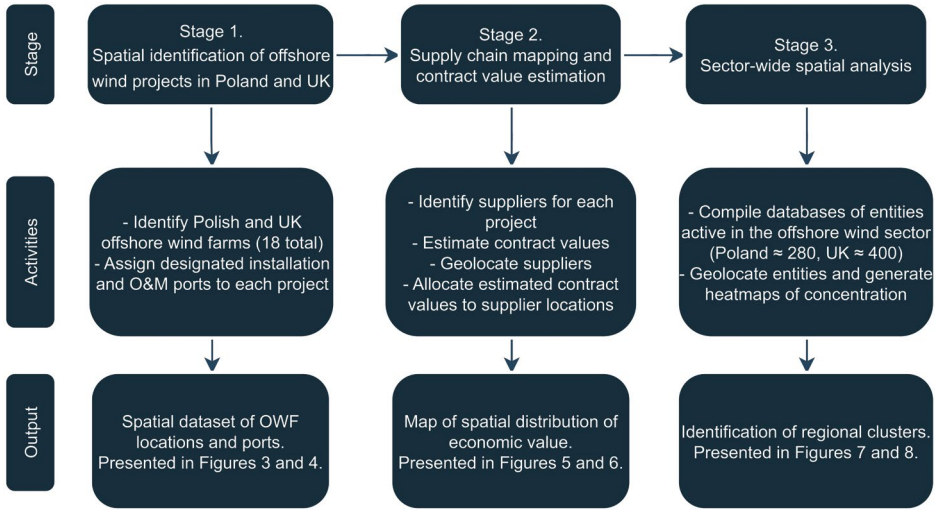


Fig. 1. Methodological framework of the study based on the adapted Spatial Economic Benefit Analysis (SEBA) approach

support were included in the study. The Polish projects selected for analysis are presented in Table 1, together with their basic characteristics. The expected Commercial Operation Date (COD) was estimated based on the announcements by Ministry of Climate and Environment. A key feature of the analysis is the identification of the designated operations and maintenance (O&M) port, which represents a major center of economic benefits throughout the O&M phase of the project (Kaiser & Snyder, 2013; Kosek et al., 2025).

By the end of 2024, a total of 52 offshore wind farms were in operation in the UK, with a combined capacity of almost 16 GW (The Crown Estate, 2025). For the purpose of this analysis, eleven of the most recent projects were selected. The selection focused primarily on projects commissioned in 2023 or later, as well as those currently under construction or in the development phase. The UK projects selected for the analysis, together with their basic characteristics, are presented in Table 2.

Table 1. Polish offshore wind projects selected for the analysis

Project	Total Power (MW)	Developers	Status	COD	Operation & Maintenance Port
Baltic Power	1,140	PKN ORLEN, Northland Power	Under construction	2026	Port of Łeba
Baltica 2	1,498	PGE, Orsted	Pre-construction	2027	Port of Ustka
Baltica 3	1,045	PGE, Orsted	Pre-construction	2030	Port of Ustka
Bałtyk II	720	Equinor, Polenergia	Pre-construction	2027	Port of Łeba
Bałtyk III	720	Equinor, Polenergia	Pre-construction	2027	Port of Łeba
BC-Wind	399	Ocean Winds	Development	2027	Port of Władysławowo
F.E.W. Baltic II	350	RWE Renewables	Development	2030	Port of Ustka

Source: Current offshore wind farm projects (Ministry of Climate and Environment, 2025).

Table 2. UK offshore wind projects selected for the analysis Project

Project	Total Power (MW)	Developers	Status	COD	Operation & Maintenance Port
Dogger Bank A	1,200	SSE Renewables, Equinor, Vårgrønn	Under construction	2025	Port of Tyne
Dogger Bank B	1,235	SSE Renewables, Equinor, Vårgrønn	Under construction	2026	Port of Tyne
Dogger Bank C	1,218	SSE Renewables, Equinor, Vårgrønn	Under construction	2027	Port of Tyne
Hornsea 3	2,852	Ørsted	Development	2028	Port of Grimsby
Berwick Bank	4,100	SSE Renewables	Development	2030	East Lothian
Sofia Offshore Wind Farm	1,400	RWE Renewables	Under construction	2026	Port of Grimsby
East Anglia 3	1,400	ScottishPower Renewables	Under construction	2026	Port of Lowestoft
Neart na Gaoithe	450	EDF Renewables, ESB	Operational	2025	Eyemouth Harbour
Inch Cape	1,080	Red Rock Power, ESB, SDIC	Under construction	2027	Port of Montrose
Seagreen	1,075	SSE Renewables, TotalEnergies	Operational	2023	Port of Montrose
Moray West	882	Ocean Winds	Under construction	2026	Buckie Harbour

Source: Offshore Wind Report 2024 by The Crown Estate UK (2025).

In total, 18 offshore wind farms with a combined capacity exceeding 22.7 GW were selected for analysis. Each project was mapped and associated to its operations and maintenance (O&M) port.

The second stage of this research involved identifying entities participating in the supply chains of the analyzed wind farms and where possible, allocating the value of their contracts. Supply chain plans, the 4C Offshore database and public announcements were reviewed to obtain information on awarded contracts. Each supplier was geolocated according to its registered headquarters. Estimated contract values were assigned exclusively to Tier 1 suppliers responsible for complete component or service packages. Due to limited transparency and the scarcity of publicly available financial data on value of service or component delivery, the methodology developed by BVG Associates was adapted. This approach made it possible to assess contract values for identified suppliers using Levelized Cost of Energy (LCOE) benchmarks.

The Levelized Cost of Energy (LCOE) represents the constant unit cost of electricity that equalizes the present value of all costs with the present value of electricity produced over the lifetime of a project, using a given discount rate (typically the Weighted Average Cost of Capital, WACC). Expressed in today's prices and excluding tax and inflation, it reflects the lifetime average cost of electricity generation. LCOE is widely employed to compare the economic performance of different generation technologies and locations (Johnston et al., 2020).

$$LCOE = \frac{\sum_{t=1}^n \frac{I_t + M_t}{(1+r)^t}}{\sum_{t=1}^n \frac{E_t}{(1+r)^t}} \quad (1)$$

I_t – Investment expenditure in year t

M_t – Operation, maintenance and service expenditure in year t

E_t – Energy generation in year t

r – Weighted Average Cost of Capital (WACC)

n – number of years.

The cost of each offshore wind farm was estimated using BVG Associates' assumptions on the expected Levelized Cost of Energy (LCOE). The average investment cost was set at EUR 2,737,000 per MW of installed capacity (CAPEX), with an annual average operating expenditure of €97,800 per MW (OPEX) (BVG Associates, 2025).

Costs were disaggregated by category and the estimated value of each category was used to approximate the contract value of the corresponding supply chain package. Developers typically contract Tier 1 suppliers for main components and services, who then subcontract to Tier 2 and Tier 3 firms. As detailed cost data are available primarily for Tier 1, values were estimated mainly at this level and to a lesser extent for lower tiers, which were mapped, but only partially quantified.

The SEBA methodology was refined by adding a value-based dimension to the spatial mapping of supply chain actors. As shown in Figure 1, the largest costs relate to turbines and installation, with turbine manufacturers also holding long-term service contracts, concentrating both CAPEX and OPEX in a few firms. For geographical allocation, operational expenditures were assigned to the location of the service port. This refinement allows the method to capture not only the territorial distribution of suppliers, but also the concentration of economic value among specific actors and regions.

Stage 3 extended the analysis beyond project-specific supply chains to capture the wider industrial context. Companies active in the offshore wind sector were identified through industry databases: in Poland from marinepoland.com and in the UK from the Offshore Renewable Energy Catapult's 'wind' database, filtered to include firms with revenues above EUR 10 million. Each company was geolocated by its registered address,

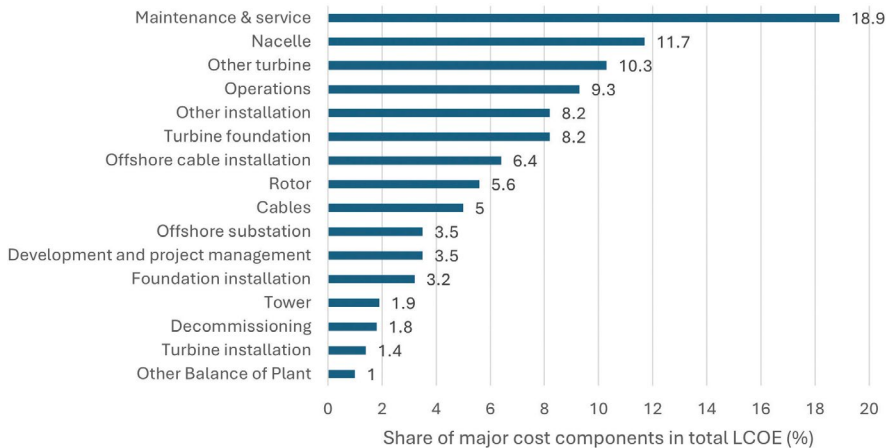


Fig. 2. Share of each major cost component in total Levelized Cost of Energy (LCOE), expressed as a percentage of total project costs, based on BVG Associates (2025)

producing datasets of about 280 entities in Poland and 400 in the UK. This allowed the creation of maps to analyze spatial concentration and identify potential regional clusters of offshore wind activity.

The analytical framework developed for this study involves several methodological limitations that should be acknowledged. The estimation of contract values was based on indicative expenditure assumptions rather than on actual financial data, as detailed contract-level information is typically not disclosed publicly. This introduces a degree of uncertainty regarding the distribution of economic value among suppliers. In addition, information on subcontractors operating at Tier 2 and Tier 3 levels was often unavailable, which may lead to an underestimation of local benefits where secondary suppliers are spatially clustered. Furthermore, in cases where contract data were missing or where projects had not yet reached the contracting phase, the method did not include predictive allocation of potential future benefits, thus making it more reliable for retrospective than for prospective analysis. Finally, the allocation of contract values was assigned to the registered headquarters of each supplier. For international companies with multiple production sites or subsidiaries, this approach does not yet capture the geographic dispersion of manufacturing activities. Despite these limitations, the method produced results that are sufficiently consistent to support interpretation and to draw conclusions about spatial and economic linkages in the offshore wind sector.

Results

The spatial-economic examination of the offshore wind energy sector in Poland and the United Kingdom, employing an enhanced SEBA methodology, shows distinct patterns in sectoral concentration and the distribution of economic value. The findings encompass four analytical layers: the location patterns of all identified sectoral entities within analyzed economies, the mapping of contracted suppliers for representative offshore wind projects, the estimated economic value of Tier 1 contracts and a cross country comparison of structural and geographic characteristics. The territorial distribution of the Polish offshore wind farms is presented on Figure 3.

In Poland, the planned offshore wind farms are located within the Exclusive economic zone of the Baltic Sea, in the corridor north of Łeba and Ustka, about 20-30 km offshore. The location reflects favorable wind conditions, shallow depths of 20-50 meters and short transmission distances, which reduce costs of cabling and grid connection. From the perspective of logistics, the main installation ports are Gdańsk and Gdynia, both equipped with infrastructure for handling and pre-assembling large turbine components such as nacelles, towers and foundations.

For the long-term operational phase, dedicated operations and maintenance (O&M) ports have been assigned to specific projects. Among them, Ustka and Łeba play a pivotal role: each has already been designated as the base for three offshore wind farms and this number may increase with further projects in the future. Władysławowo is also preparing to host one project, while additional capacities may emerge as the sector grows. On the map, projects marked in grey indicate early-stage developments not included in this analysis. Each analyzed project has been assigned a colour, which also corresponds to its designated O&M port marked with the same colour in the legend.

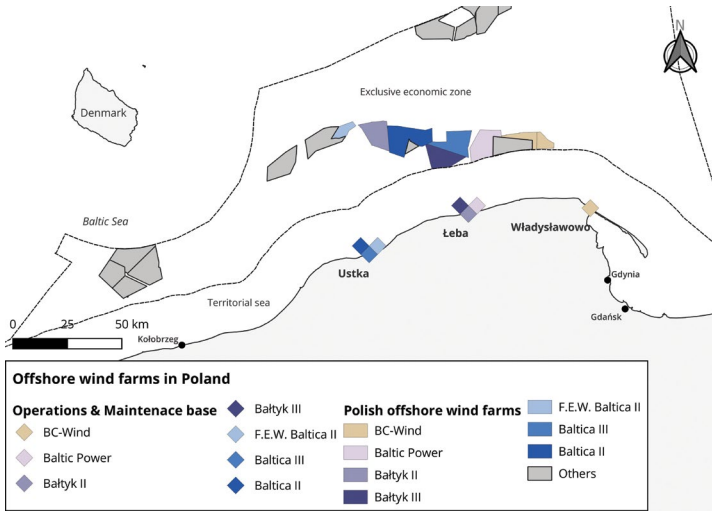


Fig. 3. Polish offshore wind farms location based on Spatial Information System of the Maritime Administration (SIPAM), www.sipam.gov.pl

Figure 4 shows that offshore wind farms in the United Kingdom tend to form several distinct clusters rather than being evenly distributed across the North Sea. These clusters reflect both favourable environmental conditions and areas designated by administrative decisions such as Crown Estate leasing rounds.

Three major offshore wind zones can be identified in the UK. The first is in Scotland, where projects such as Seagreen are located further offshore in the northern part of the North Sea. The second is the Humber region in central-eastern England, around Grimsby, which serves as the main base for large-scale developments including Hornsea and Dogger Bank. The third is situated off the southern coast near Suffolk, where the East Anglia projects are concentrated. Each of these clusters is supported by dedicated operations and maintenance (O&M) ports, creating regional service hubs. This spatial pattern reflects a mature market structure characterized by the coexistence of several regional maritime clusters.

Stage 2 of the analysis focused on the value of contracts allocated within the supply chains of the selected offshore wind projects. Figure 5 and 6 present the spatial distribution of suppliers linked to the analyzed farms. Each project is shown with a distinct colour, corresponding to its supply chain, while the size of circles reflects the estimated value of the awarded contracts. This visualization illustrates both the geographical spread of contractors and the relative scale of their participation.

The spatial distribution of supply chain entities involved in Polish offshore wind projects reveals the dominant role of countries with long-standing offshore wind experience, such as Denmark, Belgium and Netherlands. This indicates that sectoral maturity and industrial capacity are currently more decisive in shaping supply chains than geographical proximity to project sites. Major turbine suppliers: Vestas and Siemens Gamesa, anchor high-value contracts around their European headquarters, reflecting the international concentration of technological competences. At the same time, a regional cluster of domestic firms is emerging along the Polish coast, particularly around designated service

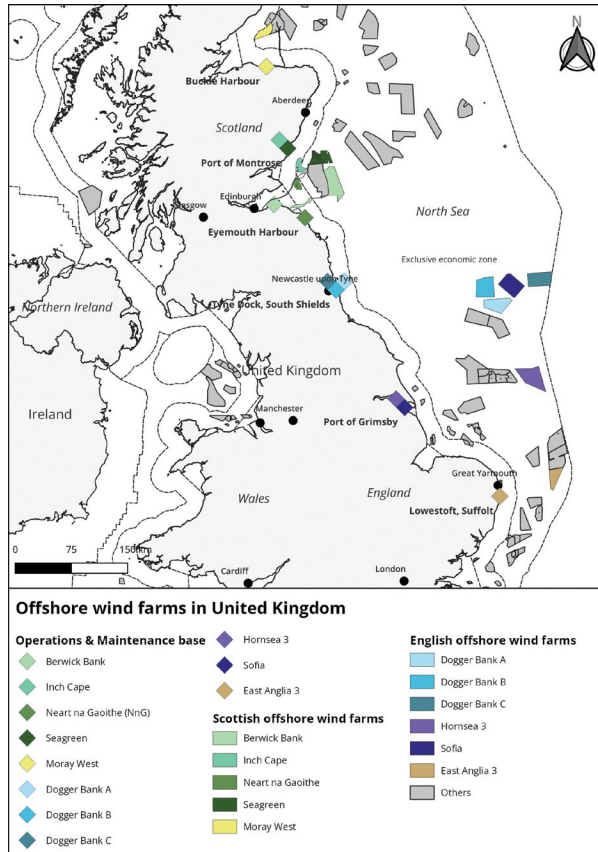


Fig. 4. UK offshore wind farms location based on the Offshore Wind Map, www.thecrownestate.co.uk and Crown Estate Scotland Spatial Hub, www.crown-estate-scotland-spatial-hub-coregis.hub.arcgis.com

and installation ports such as Łeba, Ustka, and Gdynia. These entities, though engaged mainly at lower tiers of the supply chain, are positioned to expand their role in logistically sensitive operations, including installation, maintenance, and component delivery, where distance to offshore sites becomes a key factor of efficiency.

Stage 2 of the analysis for the United Kingdom focused on the distribution of supply chain entities and their contract values (Fig. 6). As in the Polish case, each project is represented with a distinct colour and the size of the circle reflects the estimated value of the corresponding Tier 1 contract.

The map again confirms the dominance of turbine manufacturers Vestas and Siemens Gamesa Renewable Energy, whose headquarters in Denmark and northern Spain concentrate the largest contract values. Both companies supply turbines for UK projects, which is why their headquarters appear clearly on the map as major contract locations. At the same time, the UK case shows a substantial involvement of domestic companies. There is a dense concentration of suppliers along the British coastline, particularly in regions adjacent to the main clusters of offshore wind farms. This spatial pattern reflects

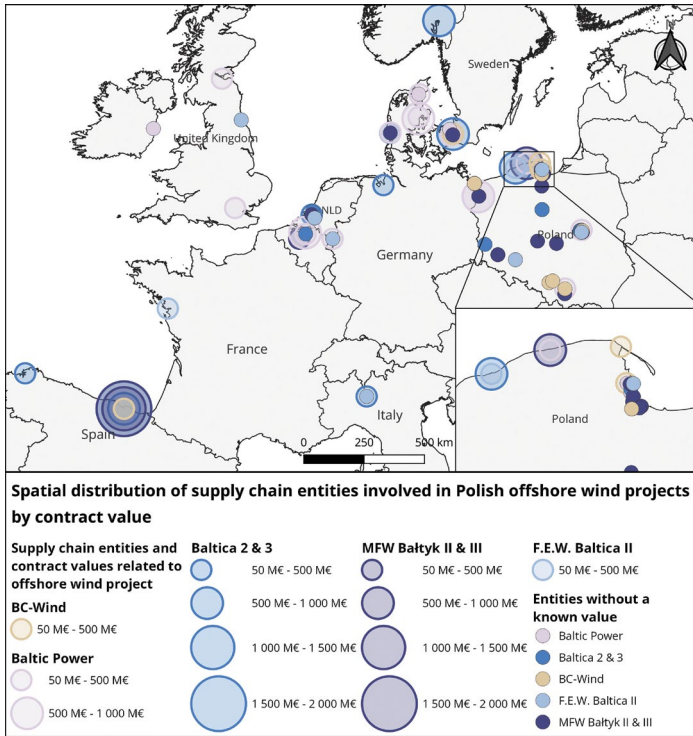


Fig. 5. Spatial distribution of selected Polish offshore wind projects’ supply chain, based on 4C Offshore (4C Offshore.com, 2025) database and public data published by offshore wind project developers

how traditional maritime regions, previously linked to oil and gas, shipbuilding, and port logistics, have adapted to the ongoing energy transition. Their existing infrastructure and location advantages enable them to integrate into the offshore wind value chain. In addition, clusters of Dutch and Belgian firms extend the spatial footprint of the supply chain across the southern North Sea. Together with British and Danish suppliers, they form a continuous industrial belt around this maritime area, which effectively functions as an integrated supply chain hub for the offshore wind sector.

The Stage 2 analysis highlighted both the international dimension of supply chains and the visible presence of domestic firms, particularly in coastal regions. These findings illustrate how contract allocations shape the geography of offshore wind development, but they do not capture the full sectoral potential. Therefore, Stage 3 examines the wider offshore wind industry in Poland and the UK, mapping companies that could become part of project supply chains as the sector continues to expand.

Further analyze considers the wider geography of the offshore wind sector in Poland beyond the contracts already awarded. Figure 7 presents a heatmap based on 280 entities identified from the industry database. The map highlights patterns of geographical concentration by marking locations with a high density of firms active in the offshore wind supply chain. This visualization makes it possible to identify regional clusters and to distinguish the main centers of activity within the national context.

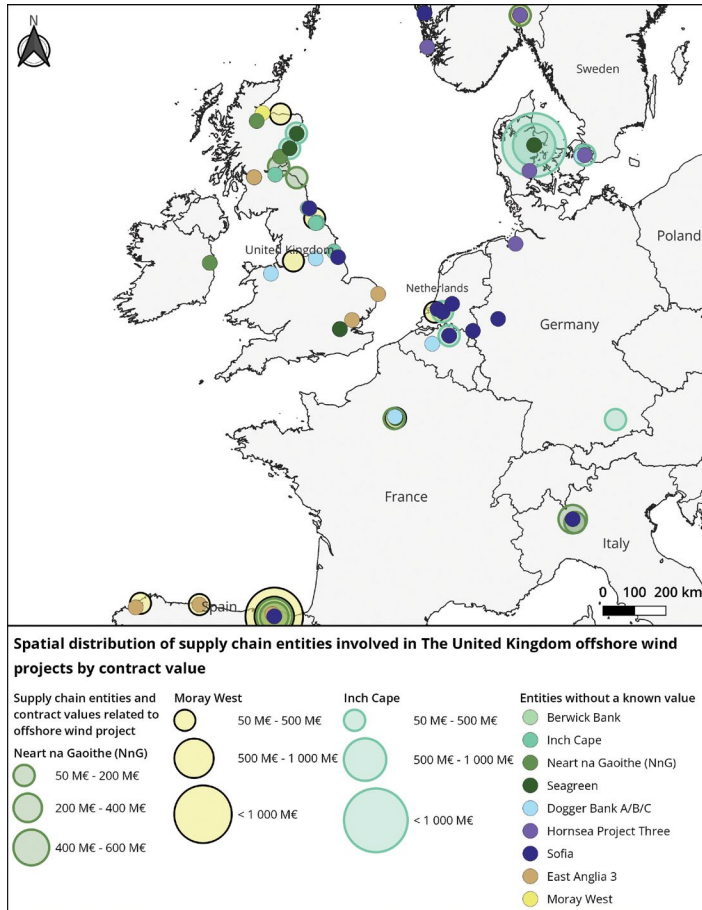


Fig. 6. Spatial distribution of selected UK offshore wind projects’ supply chain, based on 4C offshore database (4C Offshore.com, 2025) and data published by offshore wind project developers

Three such centers stand out. The Pomeranian region in Gdańsk forms the dominant hub, concentrating shipyards, fabrication facilities and the two installation ports. The West Pomeranian region in Szczecin builds on shipbuilding traditions and its proximity to German and Danish markets. A third hub is the Mazovian region (Warsaw), where company headquarters, engineering consultancies and financial services are located. This spatial distribution reveals a division between coast and inland: maritime regions provide industrial and port capacities, while Warsaw entities – project management and financing.

The emerging geography of the Polish offshore wind sector therefore mirrors, to some extent, the trajectory observed in the United Kingdom, where traditional maritime economies have evolved into integrated offshore wind clusters. In Poland, a similar transformation may occur as coastal industries and port facilities adapt their infrastructure and competences to serve the growing offshore wind market, embedding this new sector within existing maritime and industrial networks.

Stage 3 for the United Kingdom is based on 405 identified companies active in the offshore wind sector. Figure 8 presents their spatial distribution as a heatmap, highlighting the areas of highest concentration.

In contrast to Poland, where clustering is mainly coastal, the UK shows a more diverse geography with several distinct centers. Clusters are visible not only along the shoreline,

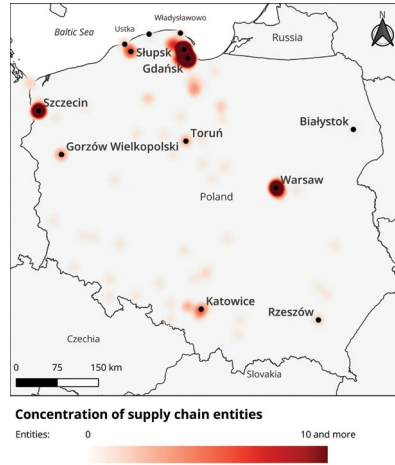


Fig. 7. Spatial distribution of Polish offshore wind sector supply chain based on marineportal.com offshore companies database

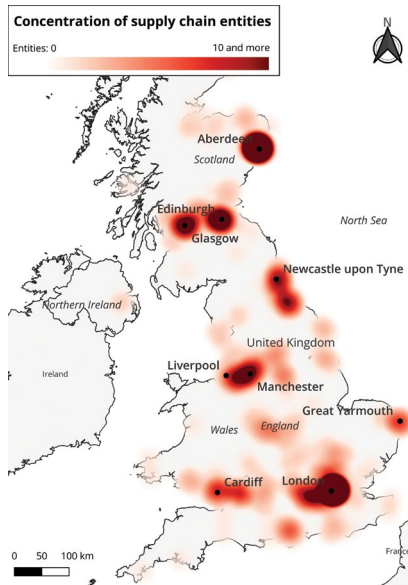


Fig. 8. Spatial distribution of UK offshore wind sector supply chain, based on offshore companies database (ORE Catapult, 2025)

but also inland, often around major urban and industrial centers. Notable examples include London, Manchester and Cardiff, where the concentration of firms may be linked to the broader industrial base, service sector capacities and the availability of skilled labour. In Scotland, strong clusters appear around Aberdeen, Glasgow and Edinburgh, reflecting both historical links to the oil and gas industry and the more recent growth of offshore wind. Coastal concentrations are still present, for example in Great Yarmouth and Newcastle, but inland clusters are equally prominent. The capital, London, stands out as one of the largest hubs, combining corporate headquarters, project management and financial services, underscoring the multi-layered character of the UK offshore wind sector.

Discussion

The results of this study provide several important observations regarding the geography of offshore wind supply chains and the distribution of economic benefits in Poland and the United Kingdom. By applying an enhanced SEBA method, spatial mapping was combined with estimated contract values, allowing analysis of both supply chain distribution and the scale of participation. This revealed patterns not visible in conventional, non-geographical supply chain analyses.

The geographical dimension of economic growth in marine areas has also been discussed in previous research, particularly in the context of estimating the value and use of maritime space. Earlier studies explored the concept of spatial rent generated by different marine activities, identifying the economic potential of specific sea areas and their adjacent coastal regions (Zaucha et al., 2020; Psuty et al., 2021). These analyses pointed out that the highest concentration of maritime value added in Poland was observed in the Gulf of Gdańsk, particularly around the Puck Bay area and the adjacent ports of Gdynia and Gdańsk, which together form the core functional region of the Polish maritime economy (Szejgiec-Kolenda et al., 2018; Zaucha & Matczak, 2018). Building on this perspective, the development of offshore wind energy and its associated O&M bases may introduce new terrestrial gateways servicing sea areas such as Łeba, Ustka or Władysławowo (Zaucha et al., 2020).

The application of SEBA to the Polish offshore wind sector is novel. It is the first time the tool has been applied to a pre-operational market in direct comparison with a mature case such as the United Kingdom. Even without operational offshore wind farms, the analysis could indicate where supply chains are most likely to develop and show early signs of clustering. These concentrate along the Baltic coast, in designated O&M ports such as Łeba and Ustka, as well as in large coastal agglomerations traditionally linked to the maritime economy, including shipyards and related industries in Gdynia and Gdańsk in the Gdańsk Bay area and Szczecin on the western coast. Warsaw also emerges as an important center due to its role in project management, corporate headquarters and financial structuring. At the same time, the analysis shows that the supply chain at Tier 1 level remains strongly dependent on foreign suppliers, who secure the most valuable packages of components and services. This is particularly visible in turbine procurement, which in all projects is concentrated in the hands of two companies: the Danish firm Vestas and Siemens Gamesa Renewable Energy, headquartered in Spain. More broadly, most Tier 1

contractors originate from Western European countries, especially those clustered around the North Sea, reflecting the maturity of these industrial bases and their established position in the global offshore wind supply chain.

A similar concentration around the southern North Sea is visible in British offshore wind projects, but with a stronger presence of domestic firms. At the same time, international suppliers remain important, particularly those based in Belgium, the Netherlands and Denmark – countries with long-standing offshore wind industries. Together, these suppliers form a continuous belt of activity across the southern North Sea, which supports a large share of Europe's offshore wind capacity. Within the UK itself, this external input is complemented by a dense network of national firms. Clusters can be seen both along the coast, for example in Grimsby, Lowestoft, Montrose and Aberdeen or inland, around major industrial centers such as London, Manchester, Birmingham, Glasgow and Edinburgh. These locations illustrate the more advanced stage of the British supply chain, where coastal service ports and several independent inland hubs work together to address the sector's needs.

The observed differences between Poland and the United Kingdom point to the need to consider offshore wind supply chains through both spatial patterns and sectoral policy. In the United Kingdom, local content has been a central objective, reinforced by the Offshore Wind Sector Deal and mandatory reporting of supply chain plans (BVG Associates, 2015, 2021). These measures have contributed to a steady increase in the share of domestic participation with the current goal set to reach a 60% before 2030 (UK Government, 2025). At the same time, the tendency of suppliers to locate in geographical proximity has, over time, produced a dense industrial belt in the southern part of the North Sea. Supply chain concentration is strongest in countries with established offshore wind sectors, especially Belgium, Denmark and the Netherlands, while the UK stands out for the large share of domestic firms, reflecting both the scale of its sector and deliberate policy support.

In Poland, government efforts have so far focused primarily on creating the sector itself, with less emphasis on ensuring that local companies capture a significant share of value (Ustawa z dnia 17 grudnia 2020 r.). Local content is mentioned in strategic documents, but targets remain non-binding and reporting is declarative (*Offshore Wind Sector Deal*, 2021). Without stronger instruments and monitoring mechanisms, much of the economic value of offshore wind development may accrue to international contractors. Setting clear targets for local content, as in the UK's benchmark, should therefore be accompanied by a careful balance between strengthening the domestic economy and preserving competitiveness in order to secure further reductions in the LCOE of the offshore wind sector (Kuntze & Moerenhout, 2012; Bazilian et al., 2020).

From a policy perspective, several recommendations can be made. The offshore wind industry should be supported not only through market-stabilising mechanisms such as the Contract for Difference (CfD), but also through instruments that strengthen the capitalisation, technological upgrading and competence transfer of domestic suppliers. This may involve preferential financing, guarantees, or innovation grants aimed at improving the competitiveness of Polish and regional firms (Sawulski et al., 2018).

Equally important is the introduction of transparent standards for monitoring local content and for tracking the spatial allocation of economic benefits among main contractors and subcontractors. Although fixed national quotas are not feasible under EU

competition law, member states can still apply targeted industrial policies to support strategic sectors (Yoshizawa, 2021; Dermine & Patrin, 2024). Such measures would enhance domestic value capture and reinforce regional clusters within the maritime economy.

The analysis demonstrates the usefulness of the SEBA methodology for examining sectors at an early stage of development and for enabling cross-country comparisons. Applying this approach to Poland and the UK provided insights into supply chains and revealed spatial patterns of economic activity. The adapted approach improves understanding, but limitations remain: contract values were estimated using LCOE benchmarks and could be assigned mainly to Tier 1 suppliers. In reality, these values are distributed further across subcontractors at Tier 2 and Tier 3, which were mapped, but not valued. A logical next step in the development of SEBA would be to include contracts from a lower tier and allocate their values geographically, thereby offering a full picture of economic benefit flows and the actual scale of local participation.

Although SEBA focuses on the spatial distribution of economic benefits, the transformation of maritime space extends beyond economic processes. Offshore wind development directly affects the coastal landscape, introducing a visible change in seascape character that can influence the tourism potential of nearby areas. It may also create navigational challenges and interfere with the migration routes of marine species, adding to cumulative environmental pressures (Churski et al., 2022). Future applications of SEBA could therefore include these broader spatial and ecological dimensions to more fully reflect the impact of offshore wind on maritime space.

Offshore wind development in Europe is expected to expand further. While the North Sea will remain the central basin for the industry, the importance of other maritime areas, including the Baltic Sea, is set to increase (EU Baltic Sea Governments, 2022). This evolution is likely to generate demand for new regional supply chains, modelled on the dense network that has emerged in the southern North Sea. Owing to its strategic location and leading role in Baltic offshore wind development, Poland could become a key hub in building such a supply chain for this part of Europe. At present, the European supply chain already shows oligopolistic features at the Tier 1 level, particularly in turbine manufacturing and large installation packages. However, the growing demand for products and services across lower tiers creates opportunities for domestic firms to enter and expand. With an appropriate national policy framework, this could lead to the formation of local supply hubs that reach beyond national markets, contributing to a broader notion of 'European content' – an extension of the local content concept to the European scale (Polish Investment and Trade Agency, 2025).

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