The local socio-economic impacts of offshore wind farms

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Abstract: The offshore wind farm (OWF) industry is of growing importance, particularly in Europe. However, the local socio-economic impacts of OWF projects have received little attention compared with biophysical impacts. Yet, they have the potential to be significant for the regeneration of declining coastal communities. Drawing on findings from academic and industry literature, from a review of ESs (Environmental Statements) for OWFs and from particular case studies, the paper found differential coverage of social and economic impacts, and differences between predicted and actual impacts, by stage in project life. For example, the ES predictions substantially overestimated local offshore construction stage economic impacts, but underestimated other elements of the OWF lifecycle, including onshore construction, and especially the 20-25 years of the operation and management stage. The Aberdeen (Scotland) case study showed the importance of the engagement strategy of the developer. Drawing on the major Hornsea projects, off the coast of Yorkshire (England), the research also highlighted the positive and cumulative impacts of scale and hub status, where a programme of large OWFs can have important local impacts. The research identified some factors leading to the identified outcomes, including the changing size and location of OWF projects, the relevant legislative and regulatory context behind the decision-making processes for OWF projects, and the responses and relationships of stakeholders involved in the process. The key role of monitoring impacts is an underpinning issue and a requirement for the more effective assessment of impacts.

1. Introduction: why research the local socio-economic impacts of offshore wind farms?

Offshore wind is a major and rapidly evolving renewable energy industry. This is particularly so in Europe, and especially in the UK where it is a vital element in the transition to a low carbon economy. There is also growing interest and development activity in this sector in many parts of the world. In Europe, the growth has been particularly rapid from 2010 onwards, and the momentum from 2020 onwards is likely to be even greater.

Offshore wind farms (OWFs) are normally large projects, and increasingly very large projects, in terms of Megawatt capacity (1000 MW upwards), spatial footprint (400 square kilometres upwards) and development expenditure (2 billion pounds/dollars/euros upwards). Such projects usually require specific planning and assessment procedures in advance of development consent. The environmental impact assessment (EIA) process is designed to '*identify, predict, evaluate and mitigate the biophysical, social and other relevant effects of proposed development proposals prior to major decisions being taken and commitments made'* (IAIA 2009 p1). For OWFs, the focus of EIA activity, and the content of resulting Environmental Statements (ESs), has been on biophysical impacts, especially on birds, marine mammals and fishing (e.g. RPS 2014). There has been much less content on impacts on the human environment, and impacts on local and regional coastal communities adjacent

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to the projects. These are the “people effects” of development actions, and cover a range of social, health and economic impacts.

Table 1 provides an overview of some current socio-economic issues associated with the development of major projects (see Vanclay 2002 for a comprehensive review). Socio-economic impact assessment (SEIA) seeks to identify impacts of development actions on people, and who benefits and who loses; it supports the inclusion of the needs and voices of diverse community groups in project planning and decision-making. Some authors refer to social impact assessment rather than socio-economic impact assessment. Some see it as a separate field of study, a separate process (Arce-Gomez et al. 2015; Esteves et al. 2012; Vanclay, 2020). Others, including the approach taken here, see it as an integral part of EIA, providing the essential “human elements” complement to the “biophysical” focus of many ESs that is relevant to all stages of a project’s lifecycle. International legislation and guidance reflects such integration, for example in IFC/World Bank performance standards (2012/2017), and the amended EU EIA Directive (2014). An increasing concern by developers to secure a ‘social license to operate’ from the project host community (Boutilier 2017) is another important driver.

Table 1: SEIA and types of socio-economic impacts

Guidance Consultation ↓	*Key EIA steps*	*SEIA*	*Range of socio-economic impacts*
	Screening ↓ Scoping ↓ Baseline studies ↓ Impact prediction and assessment ↓ Mitigation & enhancement of impacts ↓ Monitoring	↓	*Economic:* • local employment content • local procurement-supply chain • direct, indirect and induced impacts • GVA and GNP • Other local business effects (eg tourism, fishing) *Social:* • demographic • housing • other local services (eg health, emergency services) • socio-cultural (eg community cohesion) • distributional effects

Yet, for OWFs, there can be scepticism about the importance of socio-economic impacts on host communities, especially when the OWF may be many kilometres off the coast (Haggett, 2008, 2011; Alem et al. 2020). For some observers, such OWFs are ‘out of sight, out of mind’, and any impacts may be ‘gone with the wind’. However, some OWFs are near the coast, and all OWFs have onshore components, including sub-stations, cabling and impacts on harbours and other local infrastructure and businesses. Such impacts may be of growing significance for coastal and remote communities, which may be suffering from the decline in traditional industries, such as shipbuilding, fishing and tourism. OWF developments may have the potential to contribute to the regeneration of such communities, but how can such potential be fulfilled sometimes in the context of community opposition (Hattam et al. 2015; Jenkins et al. 2016; Mabon et al. 2017)? This article examines the local significance of the socio-economic impacts of OWFs, factors influencing significance and take-up, and on ways to improve local potential. It draws on findings from academic and industry literature, from ESs for OWFs and from particular case studies. It seeks to differentiate between predicted and actual impacts, by stage in project life, as well as between social and economic impacts. Whilst the focus is on UK OWFs and communities, there is reference to practice in other EU states. The following section sets out the research approach, followed by a brief review of the nature of the OWF industry in the UK and EU. There is then an examination of specific research approaches and findings for the three main research elements. The article concludes with a summary of research findings and their determinants, and guidance for how stakeholders – developers, consultants, local communities and various levels of government -- might address better the local socio-economic impacts of OWFs.

2. Research approach

The research was part of a Vattenfall/EU scientific research programme to understand the wider environmental impacts of offshore wind projects. The European Offshore Wind Deployment Centre (EOWDC) in Aberdeen funded and facilitated the research. The programme supported in-depth research and monitoring in a real-time environment on four biophysical impacts topics, plus this socio-economic impacts topic. The Impact Assessment Unit (IAU) at Oxford Brookes University undertook the project between 2017 and 2020 (IAU 2020). OWF developments may have the potential to contribute to the socio-economic regeneration of local coastal communities, but a key research question is can such potential be achieved in practice for the benefits of such communities?

The literature review provides a systematic overview of academic, industry and government literature on socio-economic impact assessment methodology and mitigation/enhancement methods, a specific examination of socio-economic impacts of OWFs, and all with particular reference to such impacts in Scotland. The focus is on literature largely published over the 10 years to 2020. Sources were identified both from a broad Google search of key words, and from important websites including, for example, *Tethys* developed in 2009 by the Pacific Northwest National Laboratory to support work on renewables by the US Department of Energy.

ESs for OWFs set out the predicted impacts of project construction, operation and decommissioning, with approaches to mitigating adverse effects and enhancing beneficial effects. The aim of the research is to identify and explain the coverage and significance of local socio-economic impacts (SEI) in ESs for recent large OWF projects in the UK and in various EU states. It also seeks to identify the relative coverage of (i) social, (ii) economic and (iii) other impacts (e.g. cumulative) in the stages of the OWF lifecycle, and evolving approaches to methodology, mitigation, enhancement and monitoring, and overall good practice.

The third part of the research undertakes a number of case studies. The EOWDC (Aberdeen) project provides the most detailed study. Through monitoring of the project over its lifecycle to date, the research seeks to provide a robust evidence base of actual socio-economic impacts - particularly at the local and regional level - and so help to reduce uncertainties in future assessment practices. Such monitoring is currently a weak area in EIA, especially for socio-economic impacts (Pinto et al. 2019). The research compares actual impacts, as far as possible, with those predicted in the project ES. However, as the EOWDC is a small OWF, with only 11 turbines and output of 96.8 MW, the research also includes two comparative studies of larger projects. The Beatrice project off the NE coast of Scotland, has a capacity of 580MW and the Hornsea OWF array off the Yorkshire coast of England, which includes Hornsea 1-4, and which provide an example of a major OWF programme, has a potential capacity of 7 Gigawatts (GW). These studies use largely desk-based research.

Throughout the three stages, the research seeks to explain, as possible, the factors leading to identified outcomes. These factors include, for example, the nature of the project including size and location. There is also the relevant legislative and regulatory context behind the decision-making processes for OWF projects, and the responses of key stakeholders involved in the process. Key stakeholders include the developers and their consultants, various levels of government and their agencies, and members of the local communities. Of central importance is the dynamics between the stakeholders. Some writers have commented on unbalanced power relationships, with the developer as pre-eminent (Kerr 2017, Jorgenson et.al. 2020). However, such power relationships are not fixed, and the research seeks to explore how they may be changing, and makes recommendations on future changes.

3. The dynamic OWF industry

Wind is a rapidly increasing energy sector; in Europe it increased from 2.5 GW in 1995 to over 140GW capacity in 2015 (EWEA 2016). Most of this capacity was initially onshore wind energy, but the offshore sector has been growing apace since 2000, especially in the North Sea (EC 2020). The UK is the global leader in offshore wind energy generation. At the end of 2019, it had almost 10GW in 40 OWFs, making it the nation with the single largest operating capacity in the world (Higgins and Foley 2014; Wind Europe 2020; Table 2). The forecast is for this capacity to grow to 40GW by 2030, with up to £50bn infrastructure spend (BVG 2016, Crown Estate 2019). The UK government's 10-point plan for a Green Industrial Revolution (Nov 2020) added further reinforcement, with the advancement of offshore wind capacity as the number one priority in the green energy transition.

Table 2: Number of offshore wind farms, MW capacity and number of turbines connected at end of 2019, per country

Country	Number of Wind Farms Connected	Cumulative Capacity (MW)	Number of Turbines Connected	Net Capacity Connected in 2019	Number of Turbines Connected in 2019
UK	40	9,945	2,225	1,760	252
Germany	28	7,445	1,469	1,111	160
Denmark	14	1,703	559	374	45
Belgium	8	1,556	318	370	44
Netherlands	6	1,118	365	0	0
Sweden	5	192	80	0	0
Others	9	114	31	8	1
Total	110	22,072	5,047	3,623	502

Source: adapted from Wind Europe (2020)

The OWF industry is also a technologically innovative industry, with rapid developments in turbine size, cabling and control systems. There has been a rapid fall in the unit cost of delivering UK offshore wind, as exemplified by the fall in the Contract for Difference (CfD) price for offshore wind projects in 2017 (BEIS 2019). Yet there is a concern that as an industry the UK offshore wind energy sector should take the delivering of UK content and economic success more seriously.

Many other countries worldwide are now recognising the potential of offshore wind energy, with particular growth in China and SE Asian states. China is expected to reach around 36GW of capacity by 2025 (Rystad Energy 2020).The US also announced (March 2021) a major goal of generating 30GW of offshore wind by 2030. The US Government argues that this growth in capacity will lead to over 44,000 workers in offshore wind by 2030 and nearly 33,000 additional jobs in communities supported by offshore wind activity (US Government, 2021). However, there is acknowledgement that much of the construction supply chain will be from the EU in the early build-up period (Reuters 2021).

4. Evolving literature and reports

Findings from the academic and industry literature review highlight some of the opportunities and challenges emerging on the assessment of the socio-economic impacts of OWFs. Alem et al. (2020) in their meta-analysis of literature on socio-economic impacts of OWFs found limited evidence to acknowledge the employment benefits in the local economy and social change in the community due to projects. They also note the importance of setting up monitoring mechanisms to provide evidence on actual impacts.

Our literature research found a clear focus on economic impacts, especially jobs and Gross Value Added (GVA) of the offshore element of the OWF construction stage. There is very little coverage of the OWF onshore element, and of social impacts. The 'local' in local content can mean different things covering a range of spatial scales from host community local authority area to the whole of the UK; indeed much of the UK economic research to date has been on a largely national government driven focus on the UK level. Even here, a key finding is of major economic leakage from the UK economy (Table 3). This leakage is greatest for the capital expenditure/ construction (CAPEX), with only c30% of expenditure staying in the UK; in contrast, c75% of the operational and maintenance expenditure (OPEX) stage stays in the UK, and it is estimated this could be worth 7000 UK jobs in 2020 (RenewableUK 2017; BVG 2015). UK content is also high for the development/planning stage (DEVEX), again at c75%.

Table 3: Activities, costs and average UK content by stage of OWF life cycle

Main stages	*Key activities*	*Costs involved for a 1GW OWF*	*Est % UK content 2017*
DEVEX (development expenditure)	Early pre-construction, planning, assessment and consenting activities	Estimated at c£120m (c£50m for assessment and consenting). Up to 5 years.	73
CAPEX (capital expenditure)	Main construction activity, which includes offshore and onshore work.	Roughly ca. £2-3bn. Up to 3 years. Major area for cost efficiencies.	29

OPEX (operational expenditure)	Training, logistics, transfer vessels, monitoring and maintenance.	Estimated at c£75mpa. O&M lifecycle is 20-25 years.	75
DECEX (decommissioning expenditure)	Removal of offshore and onshore infrastructure. Alternative may be repowering of OWF.	Estimated at c£300m.	
TOTEX (total expenditure)		IAU roughly estimated at c£4bn (undiscounted) over full project lifecycle.	48

Source: Adapted from BVG (2019); RenewableUK (2017) and IAU estimates from recent projects.

However, whilst there is outsourcing of much of the offshore construction from local areas, there is more local potential with the onshore work (e.g. sub-station connections; local port improvements) (Oxford Economics 2010). In addition, the impacts of multiple OWF developments can be cumulative, and can be a catalyst for port development and other supply chain activities (e.g. assembly and, in some cases, fabrication facilities). The availability of a hub port, with modern facilities for large-scale rigs and set down areas is very important for developing major supply chain economic benefits. Dutch ports such as Vlissingen and Ijmuiden provide good examples.

A Capital Stocks analysis, which assesses the impact on wellbeing by changes in stocks of capital (e.g. health), was undertaken for the UK Crown Estate by Hattam et al. (2015) (Table 4). It suggests that the impacts of OWFs on financial, manufactured and human capital are primarily positive (also SSE 2016). For the human capital stock, they identify positive impacts on employment (direct, indirect and induced), and on skills and wages. The literature review identifies increasing use of modelling; particularly using an Input–Output (I-O) approach (Ladenburg et al. 2005). However, this "top-down" approach has limitations. The key to effective I-O analysis is the currency and level of disaggregation of the underpinning tables. Unless an up-to-date I-O table exists for the host area under study, start-up costs may be too great, with recourse to adaptation from national and regional tables (Alem 2020). Partly in response, there are some hybrid and "bottom-up" approaches, making good use of the actual details of the project and the host economy (BVG/UHI 2017). Monitoring of actual, rather than predicted local impacts, is essential for better planning, assessment and management of impacts in the interests of the local community. Yet monitoring has been very limited to date, with a few rare exceptions, such as the Scroby Sands and Robin Rigg projects (SQW 2011, EON 2011). A key factor is that it has not been a mandatory element in the EU EIA process until recently (EU 2014). There is now an initiative to improve monitoring in terms of UK content, but this still leaves a large gap in terms of monitoring at more sub-national scales (RenewableUK 2015).

Table 4: Capital Stocks Analysis -- some socio-economic impacts of OWFs

Capital Stock	Summary and direction of change
Human capital (e.g. skills and education)	**Positive impact:** • Creation of direct jobs in construction, O&M of OWFs, plus indirect jobs in supply chain, and induced employment. **Impact unclear:** • Mental health impacts are uncertain but may be influenced by falling house prices [-ve], transient work force [-ve] and energy from green sources [+ve].

Social capital (e.g. social networks)	**Mixed impact:** • Generally strong support for OWF re environmental impact, job creation and local economic growth. • Opposition concerns over potential fall in property values (re perceptions of less attractive seascape) and wildlife impacts. • Community funds can have positive impacts, but some view them as bribes. **Impact unclear:** • Evidence is anecdotal but suggests tourism continues with some new opportunities (e.g. boat trips to OWFs). • Effects on view and restorative nature of seascape could affect engagement with coastal environments and ultimately health. **Positive impact:** • Formation of opposition and supporter groups builds relationships and social capital within communities.

Source: Adapted from Hattam et al. /Crown Estate (2015)

The social element of SEI is a relatively new but expanding field and methods to analyse social impacts are developing all the time. There is recognition of the need for both technical and participatory approaches to SEI, in order to capture the complexity and nuances of potential social impacts on communities (Arce-Gomez et al. 2015; Mabon et al. 2017). Early community engagement is crucial to lessen the impact in relation to anxiety, which in turn has a positive effect on the social impacts of an offshore development (Gray et al. 2005; Vanclay 2012). It is interesting to note that five of the seven steps in the 2015 IAIA guidelines on social impact assessment refer to the pre-operation phase (Vanclay et al. 2015). It is also important to ensure sustained engagement throughout the project's lifetime, in order to mitigate or avoid longer-term social impacts (Mabon et al. 2017). Such engagement can contributes to equity and justice issues, with communities feeling engaged in decision-making about their future (Jenkins et al. 2016; Aitken et.al. 2016).

Research also demonstrates the importance of taking into consideration culturally meaningful aspects, which might have impacts on community attitudes and perceptions (Ellis and Ferraro 2016). Although these are more challenging to assess, they are crucial to understanding a community's response to an OWF where the cultural importance of seascape can play an important role in shaping responses (Wiersma and Devine-Wright 2014). Gee and Burkhard (2010 p350) use the concept of cultural ecosystem services to explore the relationship with coastal communities and OWFs; these services include 'non-material benefits which people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation and aesthetic experiences'. For example, people coming to the sea wanting to enjoy an un-degraded coastal setting may feel an emotional loss of the open horizon and feel a sense of being limited.

Visual impact is a key issue for public attitudes to OWF projects. Ladenburg's (2009) study of two offshore wind farms in Denmark showed that people with experience of OWFs located far from the shore have a more positive perception of their visual impacts than those with experience of OWFs located closer to the shore. Wiersma and Devine-Wright (2014) similarly conclude that coastal residents and tourists generally prefer wind turbines to be located at greater distances from the coast. However, research has shown there is not a straightforward correlation between acceptance of wind turbines and their distance from the shore (Haggett 2011; Westerberg et al. 2013; Glasson, 2017a).

Overall, research indicates that OWFs have a positive impact on well-being, although this is less so for the specific impacts on social capital (Hattam et al. 2015). Mitigation and enhancement methods, such as offering community benefits are also seen as positive, although they can also be interpreted as 'bribes' to the community (Kerr, 2017; Glasson, 2021). Research suggests that emphasising the community benefits, rather than benefits to individuals, will garner greater support for future developments. To conclude, there is an emerging literature on the social impacts of OWF developments, but there is a need for more work in particular in relation to the potential impacts on the sense of community and belonging (Langbroek and Vanclay 2012).

5. Socio-economic content of Environmental Statements

The examination of the socio-economic content of UK ESs concentrated on OWFs of 50MW and over, thus excluding some of the early small projects; it also included only ESs undertaken from 2010 onwards. This time-period includes the rapid growth of UK OWF activity, with 22 projects ranging in size from 50 to 2400MW. The bulk of the ESs were under the English National Infrastructure Planning regime (HMG 2008), and most are now in operation or under construction. A contents assessment was undertaken of each ES against a template covering the research aims (coverage of key economic and social impacts, methods used, mitigation and monitoring), and the results were coded (e.g. predicted construction jobs per OWF MW capacity).

All UK ESs include a section on socio-economic impacts, but there is considerable variation in length of coverage, and much more coverage of economic than social (a ratio of about 5:1). ESs clearly recognise variations in impacts over the project life cycle; most include both construction and O&M stages, and increasingly the decommissioning stage. By far the most attention is for the offshore activities of the construction stage. This is unfortunate as onshore activities can have important local socio-economic impacts. A set of National Policy Statements (NPSs) for energy projects (Department for Energy and Climate Change 2011) includes socio-economic impacts, and provide broad guidance on ES content, with more coverage of economic than social impacts. There is a recognition of the importance of monitoring and the role of evidence, but in comparison with biophysical impacts (e.g. on seabirds and cetaceans) which have regular follow-up requirements, actual monitoring in practice is very limited.

The ES economic focus is on employment especially, and on supply chain and GVA impacts. There is also coverage of some related sector impacts, especially tourism and fishing for offshore works, and agriculture for the onshore cable route; these may be in separate ES chapters. The scenario approach, usually low/medium/high, is the most popular prediction approach used to allow for uncertainty. Such uncertainty relates in particular to (i) port location, especially for construction, (ii) amount of UK supply chain content, and (iii) the evolution in OWF technology (e.g. in the rapid growth in turbine size -- now up to 15MW). Predicted employment figures can vary widely between scenarios, making life difficult for decision makers and host authorities. For example, for the Beatrice OWF, total local job predictions varied from 400 -1800 for the construction stage and from 3200-6000 for the total O&M stage, for low and high scenarios (Arcus 2012, 2015). There is also the issue of what is local and/or regional in terms of economic impact. Where there is specification, the focus is on adjacent coastal local areas. The literature indicates some merit in differentiating between local areas (e.g. 60-minutes local commuting area and wider regional catchment for the construction stage), and a narrower local authority area for the O&M stage (Glasson, 2017b).

Most economic predictions build in multiplier impacts, with direct impacts on employment and GVA having indirect (supply chain) and induced (e.g. retail expenditure of project staff) impacts. Multipliers vary between ESs, but are generally about double the original direct impacts. Notwithstanding uncertainties and ranges in predictions, it is possible to identify a range of predicted potential local and regional employment impacts for total construction and for each O&M year, using a job per project MW approach (Table 5). Although O&M employment numbers may be low, especially compared with construction, the various O&M activities are usually much more accessible to local people, and have a life of 20-25 years. The ESs largely assess construction stage economic impacts as positive, but of medium/ minor significance; for the O&M stage, impact assessment is almost always seen as of positive but minor significance. In addition, some ESs note that OWF development can boost local/regional confidence providing a positive impact on the development potential of an area. Mitigation and enhancement measures focus largely on the positive enhancement measures, emphasising local training and upskilling measures, supply chain events and protocols for local businesses. Increasingly, such measures may require a specific Employment and Supply Chain Plan. The Hornsea example, discussed later, involves the developer working with local authorities/ agencies, and business organisations, to support education, training and supply chain initiatives for the Humberside area. This is a recent requirement by regulators on developers following the formal examination process.

Table 5: Some OWF ES employment prediction 'rules of thumb'—jobs per project MW size

- These figures include Direct plus Indirect and Induced employment.
- *For total Construction Full Time Equivalents (FTEs)*, forecast jobs per MW range from c 0.2 (local area /low impact scenario), to c0.5 (local area /medium impact scenario) to c1.5 (regional area /medium impact scenario).
- *The annual O&M FTE per MW* over the 20-25 year life of the project is much less, and may be c0.15-0.2 per MW for a regional area /medium impact scenario, although some forecasts appear to be (unrealistically?) much lower than this.
- Whilst there is some commonality in the use of the Direct plus Indirect & Induced employment approach, there is *considerable variation in the multiplier ratios* used (i.e. D: ID+INDU). These vary from 1:0.3 to 1:1.5, with the mean being around 1:1 (i.e. double the direct impact) although we should expect variations reflecting the relative potential of OWF host coastal economies to provide supply chain support.

Source: IAU (2020)

Several ESs discuss potential project impact on other economic sectors, especially tourism and fishing. For the construction stage, the ESs assess the impacts on tourism as negative, and of minor and occasionally medium significance. Analyses tend to draw on previous studies of the impacts on tourism of both onshore and offshore wind farms; these tend to show little impact on tourists' destination decisions (SPR 2019). There are fewer mentions of the negative impact on fishing from the construction stage; where mentioned they are seen as minor negative. The findings are similar for the O&M stage, although there is occasional mention of the potential value of OWFs as a tourism attractant.

The coverage of *social impacts* in ESs for OWFs is disappointing, with many having little coverage at all. Some briefly mention social impacts, especially potential construction workforce impacts on housing and local services. A few go further with content on demography, housing and local services, and on local quality of life. However, even in such cases there is normally little depth with respect to specific issues; for example impacts of projects on cost of housing, community wellbeing (noise, increased vehicular movements, diversions etc), and community cohesion (Chadwick and Glasson, 2017). Yet there may be local community concern about potential housing price devaluation associated with visible projects (Alem et al 2020). Overall, there appears to be a general assumption by developers and their consultants, across small and large, and older and recent projects, that social impacts are not important. As such, EIA scoping exercises generally underplay them. The recent scoping exercise for the major Hornsea 4 project provides a clear example of limited coverage of social impacts (Orsted 2018).

Assessment methodology for social impacts is largely descriptive and qualitative, building on baseline studies of local demographics and economic conditions, with a predominant use of professional judgement and comparative studies. In several studies, there is little evidence of the role of public participation to assess social impacts; yet this is important for socio-economic issues and a requirement under the English national infrastructure regime (DECC 2011). This can marginalise community input, and may in part explain the limited social content. A more positive recent trend is the provision post ES/examination/decision of a Community Benefits Fund (CBF) to support local communities. Approximately 75% of UK OWFs, in operation or under construction since 2010, have such funds, or plan to introduce them (Glasson 2021). The Crown Estate (2019 p11) regards such schemes as *'now well established as an integral part of OWF development – signifying the positive relationships being built between operators and the local communities within which they operate'.*

The review of EU ESs included 13 projects, in five countries (Denmark, Netherlands, Belgium, Sweden and Ireland), ranging in size from 50 to 752MW.There was an assessment against the same template used for the UK studies. Findings clearly indicate that socio-economic impacts (especially employment, GVA, wider economic development and supply chain, demography, housing, local services and community wellbeing) are less well covered than in the UK ESs. This may be a function of the more all-encompassing integrated approach to EIA topics in the UK, where socio-economic impacts are not separated out from the EIA as a whole, plus the perceived importance of such projects to economically problematic coastal areas.

Where there is coverage, EU ESs also include more on economic than social impacts. Key economic topics considered are tourism and commercial fishing, plus some limited coverage of shipping, traffic and employment. There is little use of quantitative methods, such as I-O analysis. The coverage of social impacts is minimal. As for the UK, the focus is on the impacts related to the offshore construction and O&M stages. Typical mitigations for economic impacts include timing of work to avoid the tourist season; financial compensation (fishing and agricultural) and turbine placement to allow fishing boats and recreational boats access; plus restricted working hours during construction. The strategic context and process leading up to their production can also affect the content of ESs. All EU countries have a legal requirement to create marine spatial plans (MSP) which may include renewable energy plans, subject to strategic environmental assessment. Belgium provides an example where all ESs followed the outline of topics for consideration based on guidance from the MSP and had the same format, with decisions regarding acceptable impacts largely addressed at strategic level.

6. Monitoring and auditing the EOWDC/Aberdeen OWF

The Aberdeen OWF is a small wind farm with 11 turbines, 96 MW capacity, located only 2km offshore, developed by Vattenfall (Figure 1). As a demonstration project, it is innovative in terms of technology (turbine size, foundations, and cabling and control systems). It has offshore and onshore elements. The latter includes a sub-station at Blackdog and a 7.5 km cable route to the system connection at Dyce. The project ES (DTZ 2011) predicted economic impacts of c300 local (c750 Scotland) construction job years and c650 local (c750 Scotland) O&M job years (i.e. 150 local pa construction, and c25-30 local pa for O&M life). The ES also predicted c£16m GVA local (c£40m Scotland) for the construction stage and c£20m local (£23m Scotland) for the total O&M stage. There were hardly any ES social impact predictions, with impact of construction on public footpaths being a rare exception. The project became operational in 2018 and annually produces electricity to power c80, 000 homes, generating the equivalent of 70% of Aberdeen's domestic electricity demand.

Figure 1: Location of the EOWDC (Aberdeen) OWF 2 km off the NE Scotland coast

Source: Adapted from AOWFL (2010)

The research approach undertaken by the team included regular meetings/telecoms with Vattenfall project staff; the collection of monitoring data on a regular basis from developer and contractors (e.g on contracts' spending, and employment); workshops with representatives of local authorities/agencies and with the local Belhelvie Community Council to explore evolving project impacts and responses, and community surveys through the project lifecycle to identify actual impacts (IAU 2020). The ES (DTZ 2011) uses inner (Aberdeen and Aberdeenshire), wider (Scotland), and UK study areas. The focus here is on the inner and wider areas. There was good data from Vattenfall contracts spending, onshore tier 1 (main) contractor contracts data and sub-station workforce survey, community responses to a proposed Community Benefits Fund,various community surveys and press coverage of the project over its lifecycle. Data for the offshore construction stage activities of the two main tier 1 contractors was more aggregated.

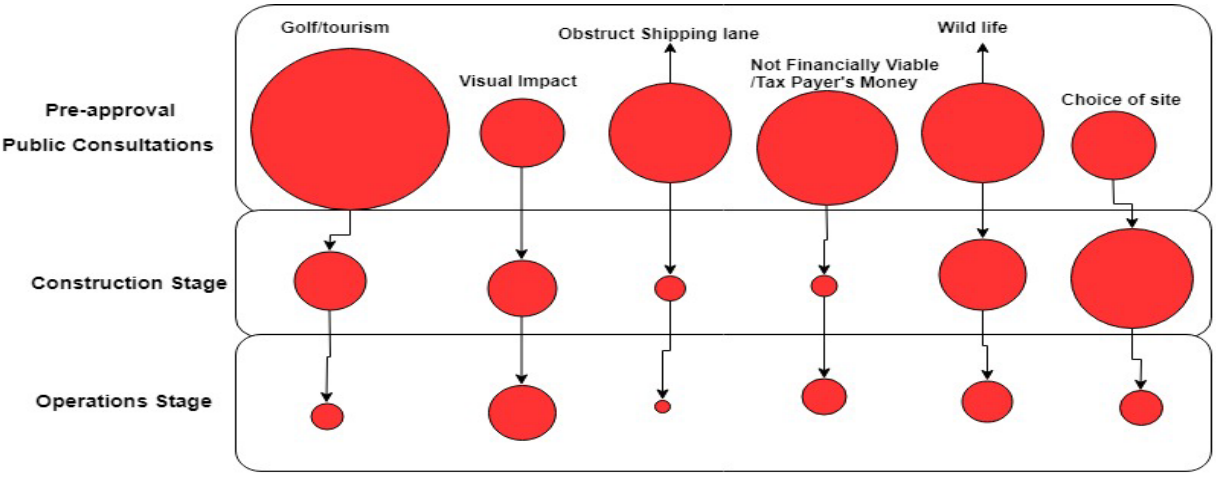
The project performed well against economic impact predictions for onshore construction and for the early O&M stages of the project life cycle -- stages that tend to be underplayed in ES documentation, but which are important for local economic benefits. For example, our sub-station survey work indicated employment levels well above those predicted, with roughly 60% of workers from the inner area and the rest from the wider Scotland area. The O&M stage is particularly significant in terms of the high local percentage of the total economic impacts, over a 20-25 year life. The actual expenditure of around £100m, and about 800-1000 FTE jobs, over the project life, both exceeded predictions.

In contrast, the local and Scotland wide economic benefits from the major offshore construction appear to be very limited, and much less than predicted. For example, at peak, there were around 500 construction personnel, mainly located offshore on installation vessels. The average offshore construction workforce over the construction period was around 200. A broad mix of nationalities was involved, with vastly more other Europeans (80%) compared with British (10%) and other nationalities (10%). Dutch personnel constituted about 50% of the peak workforce, reflecting the nationality of the key offshore construction stage contractor. The Scottish contingent was very small. One caveat to the findings may be the small nature of this project and the short construction period. As such, a large percentage of the personnel came from outside the local area and were already employed and experienced. Whilst most workers were on relatively short-term contracts for this project, the parent companies likely contracted many of them for much longer-term employment. The project also used established component production facilities from outside Scotland. However, even so, actual local impacts are low and well below those predicted in the ES documents. This leakage of the main offshore construction stage benefits is a major concern to local, regional and national authorities. The Scottish Energy Minister noted at an offshore wind summit in Edinburgh in early 2020 – '*Scotland is the ideal location for offshore wind, but recent projects have not delivered the significant economic opportunities we want to see for Scottish businesses'* (Scottish Government 2020*).* Under new measures recently agreed between the Scottish Government and the Crown Estate Scotland, developers will have to agree on supply-chain commitments when applying for offshore wind leases.

Community views of the project during the consenting and pre-construction stage included some elements of 'resistance' due to uncertainty over the number, size and location of the turbines, but others expressed views which sought to 'get on board' with the project. These differing views (possibly exaggerated by the media) did result in some loss of social cohesion within the communities during the pre-construction and construction stages, but this was less of an issue into the early O&M stage. However, for this stage some responses on visual impacts used the word ‘surprise’ in relation to the size of the turbines and their closeness to the shore, and a number of qualitative comments indicated some conflicted viewpoints e.g. *‘not great for the seascape, but the renewable energy is necessary’*. Indeed, the biggest ‘feeling’ in relation to the windfarm was that it was ‘*good to see clean energy being generated’* (80%).

One of our activities analysed the public perception of the project and the narratives formed around press reports, newspaper articles, social media comments, and the public consultation for the project, starting with pre-approval public consultations, and then through the stages of the project life cycle. Overall, this provided an interesting window on key project themes in the public media. For example, there was an early-orchestrated campaign against the project because of its proximity to a Trump Organisation golf course. Other factors include the relative decline in Aberdeen’s role as a major oil and gas capital for Europe, and the global drive to transition to more renewable energy. Figures 2 and 3 seek to represent the shifts in positive and negative themes across the project life to date. The figures show the decline in the importance of the negative themes after the pre-approval stage, whereas the positive themes, remained strong. Whilst this may partly reflect the effects of ongoing information, mitigation and enhancement measures from the EIA process, it also indicates a general goodwill towards the project from the local community.

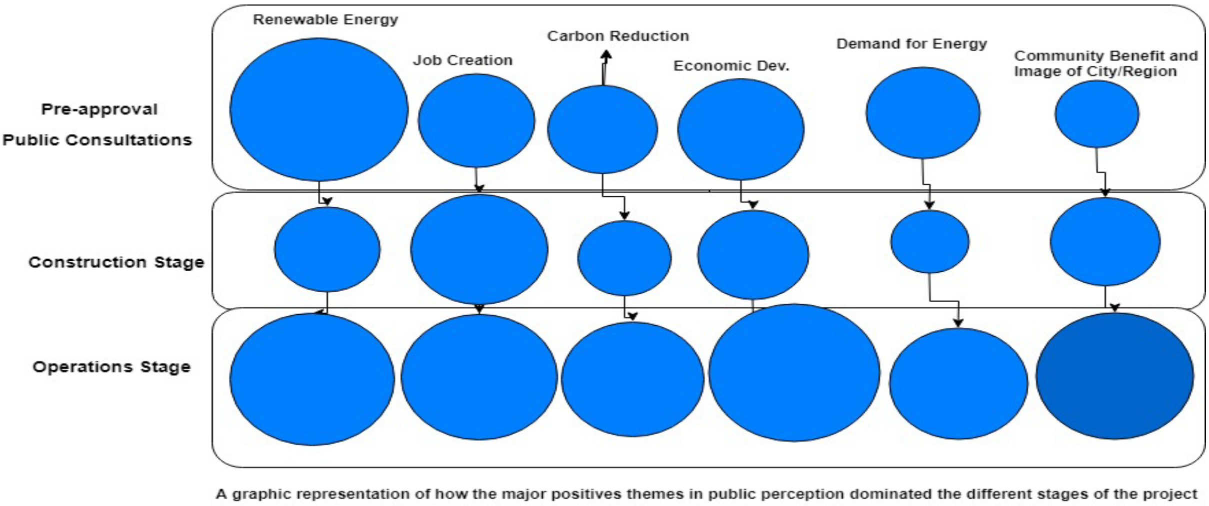
Figure 2: Showing the spread and degree of dominance of negative themes across all stages of the project (shape sizes indicate the frequency of mention of the issues identified by individuals and in media).*



A graphic representation of how the major negative themes in public perception dominated the different stages of the project

** The shapes represent a balanced combination of individual responses, especially at pre-approval (eg n=70 for golf/tourism objections), and word length media coverage, across all development stages.*

Figure 3: Showing the spread and degree of dominance of positive themes across all stages of the project (as for Fig 2).



Source: IAU 2020.

Of importance for the management of social and economic impacts is the engagement strategy of the developer.There is evidence of much good practice in the Vattenfall approach, well managed by the project's Local Community Liaison Officer, throughout the project life cycle. The introduction of the EOWDC Community Benefits Fund (CBF), known as the *Unlock our Future Fund,* is another important feature of long-term community engagement, building on pioneering Scottish Government CBF guidance (Scottish Government, 2018). The Aberdeen CBF supports community and environmental projects with up to £150,000 pa over 20 years, for the whole of Aberdeen City and Aberdeenshire, with a 10% pa ring-fenced amount for the sub-station location of Blackdog (Glasson 2021). Recent projects include for example air source heat pump systems for community buildings, and electric vehicle for free-of-charge and accessible transport to those who cannot afford public transport. Table 6 summarises some good engagement practice drawing in particular on the Aberdeen experience. Further recommendations on good practice are set out in the concluding section of Vanclay and Hanna (2019), including for example to 'be fair, act in good faith, and be perceived as being transparent, honest and genuine', in addition to 'encouraging and supporting community-led monitoring and evaluation of potential impacts'.

Table 6: Good practice community engagement—from Aberdeen project

Affected communities should be engaged at the earliest stage possible, to achieve a 'social license to operate'. This will hopefully minimise negative social impacts and maximise local community benefits. An eight–part plan for developers to achieve such engagement can include: • *Appoint a Local Community Liaison Officer (LCLO) or equivalent;* • *Participate early in community workshops / focus groups to scope potential key issues;* • *Engage regularly with the community throughout project stages;* • *Utilise engagement opportunities provided by community groups (eg parochial/community councils);* • *Fund support for engagement activities in development and construction stages, and a CBF for O&M stage ;* • *Survey community views of development impacts at key stages in the project lifecycle, including focus on key impacted groups (eg. specific settlements close to onshore works; wider community of interest; specific potentially impacted industries, such as fishing and tourism);* • *Monitor media coverage of views on project impacts; and* • *Produce regular publicly available monitoring reports on the project and its local and regional impacts.*

Source: IAU 2020

7. Comparative studies: the example of the Hornsea OWF array

The Hornsea projects (1-4), when fully developed, will constitute one of the largest clusters of OWF energy worldwide, with about 900 very large turbines, with c7GW of power (1.2 + 1.4 +2.4 + 2.0 GW). Hornsea 1 is currently the largest operational OWF in the world; Hornsea 2 is under construction; and Hornsea 3 and 4 are at various stages of planning and assessment. They are located up to 100km offshore in part of the North Sea where there are many large OWFs at various stages of development. They lie off an industrialised coast, including the ports of Hull, Grimsby and Immingham. These projects provide an example of OWF development on a large scale, with potential for substantial supply chain development, associated production/fabrication initiatives, and cumulative impacts.

All the Hornsea ESs have substantial content on socio-economic impacts, focusing on construction stage economic impacts (Smartwind 2013, 2015a; Orsted 2018a, 2018b). The scenario predictions display great variability. Cumulatively, the projects do however provide a set of substantial overlapping socio-economic impacts, with the medium scenarios for H1 and H2 each of c1000 local construction jobs pa, and H3 double that number. The O&M stage is also significant cumulatively, with estimates of local jobs pa under a medium scenario of 308(H1), 450(H2) and 620(H3), giving well over 1000 jobs pa combined over lifecycles. This analysis is reinforced by a strategic overview of the economic impacts of Dong/Orsted and other OWF developments on Humberside provided in a document to the Planning Inspectorate examination of the H2 project (Smartwind/Regeneris 2015); this indicated about 400 continuing O&M jobs from H1 alone.

Our comparative research was predominantly desk-based and, unlike the Aberdeen project, did not have access to detailed contract information. However, through monitoring of the placing of 93 major H1 OWF construction contracts it was possible to gain some indication of spatial distribution. This approach is limited in terms of comprehensiveness, accuracy of spatial implications and, of course, contracts vary greatly in value, but it is rich in terms of actual contracts placed, many of which are clearly beneficial to the UK and to local economies associated with the project (IAU 2020). However, much of the heavy infrastructure – especially turbines and foundations – is manufactured overseas in mainland Europe (especially Denmark, Netherlands and Germany), although there is some UK presence. The UK appears to have a substantial involvement in cabling, and a substantial consultancy role, with about 75% of those contracts. Overall, the UK may have about 50% of the total number of contracts, but it is not possible to ascertain value from this information. It is difficult to identify local Humberside contracts, but they are likely to be no more than c10-15% of the total number, and in value – this is likely to be much less. There are also many more small local sub-contracts for goods and services not reflected in this analysis of major contracts.

The Dong/Orsted strategic overview report also notes the critical significance of a pipeline of projects in providing a sustainable economic benefit. '*In order for the offshore wind sector to have a sustainable economic benefit in the Humber Region a series of investments over a long period is critical. The nature of the sector is such that there is a large level of activity during the construction phase including manufacture and installation of components (typically over one to three years), followed by a smaller, sustained level of activity in the ongoing O&M*

of the wind farm. This means that a one-off wind farm development in an area would have limited sustained economic impact, because workers based temporarily in the area, who would move on once the construction was completed, would deliver most of the local construction phase activity. In the Humber, however, the group of wind farm developments over 10+ years has provided the area with the opportunity to establish a stronger foothold in the sector, secure inward investment and enable local businesses to access supply chain opportunities' (Smartwind/Regeneris, 2015). Examples of a growing local supply chain include -- Siemen's £310m turbine factory in Hull, with c1100 new direct jobs; the Able Marine Energy Park, a £450m Humber port facility particularly for offshore wind; and Orsted's £200m OWF O&M servicing base in Grimsby Docks, with a further 200 jobs. In combination, the OWF developments and linked onshore investments all enhance the identification of the Humber as a major OWF hub.

Specific Hornsea projects' social impacts information is not easily available, other than overlaps with economic impacts. These include for example education and training initiatives, as set out below:

- University of Hull new Masters programme in renewable energy;
- Hull College Digital and Green Energy Centre providing relevant qualifications and support for local business growth into the renewable energy sector;
- An £11m investment in the University Technical College (UTC) in Scunthorpe specialising in engineering and renewable energy; and
- Support in the Regional Growth Fund for 380 local apprenticeships in priority sectors, including renewable energy.

There is also a CBF initiative, the East Coast Community Fund, which distributes c£465,000 pa to help a range of local community and environmental initiatives for each of the next 20 years. Whilst the fund is likely to increase in size with more Hornsea projects coming on stream, it is still a much smaller scheme per MW than the Aberdeen CBF scheme.

The net effects, both directly from project construction and from the supply chain, with indirect and induced impacts, is a boost to local employment, and a reduction in unemployment, with important knock-on social and welfare benefits for communities in the Humber area, a coastal area which has been facing many socio-economic challenges. Overall, such OWF developments appear to have contributed to a raising of confidence and aspiration in both the public and private sectors on Humberside, with one reflection being Hull's success in winning the competition to be the 2017 UK City of Culture.

8. Discussion and conclusions

The ES reviews and the case studies reinforce many of the findings from the academic and technical literature, including for example the focus on economic rather than social issues, on offshore construction with broad ranges of impacts, and lack of monitoring. Key explanatory factors for such findings include the nature of the projects, including size and location. The fact that the projects are offshore, and often well offshore, has influenced developer attitudes to the relevance of local socio-economic impacts, and especially social impacts, and the assessment approach builds in much uncertainty on impacts for local areas. Developers have until recently been pre-eminent in the power relationships between the key stakeholders involved (developers and their consultants, various levels of government and their agencies, and members of the local communities).The legislative and regulatory contexts behind the decision-making processes for OWF projects have also been limited. Although the UK context encourages coverage of socio-economic impacts, implementation has been weak, especially regarding social impacts. Monitoring of socio-economic impacts by stakeholders, particularly by developers, has also been weak, partly in relation to the lack of mandatory requirements.

However, the various elements of the research also indicate some significant emerging issues and ways forward in recent years. There is a growing inclusion in project planning and assessment of the socio-economic impacts associated with the stages in the OWF lifecycle. This is particularly the case for projects in the UK, with a key focus on jobs and wider economic impacts; there is less coverage of these aspects in EU projects, where the key topics considered tend to be tourism, commercial fishing and shipping. Factors behind the growing importance may reflect some shift in the power relationships between key stakeholders, with government at various levels and local communities becoming concerned about the leakage out of economic benefits (Kerr 2017; Scottish Government 2020). Certainly, in the UK, the examination of recent OWF projects by the Planning Inspectorate now involves more emphasis on socio-economic impacts than was the case for OWF projects from 10 years or so ago. The issue of local impacts, and local content of projects, is becoming a more significant factor for developers to plan for, with a growing recognition from the research of the importance of 'a social license to operate' from the community (Boutilier 2017).

There is also the factor of the rapidly evolving nature of OWF projects themselves. Trends in this dynamic industry show that OWFs are getting much larger and becoming located further offshore. Some may question whether local socio-economic impacts will therefore become less important. However, all projects come ashore, they are supplied and serviced from coastal locations and indeed, as they become larger, so do the potential socio-economic impacts. There is growing recognition from national and local governments that OWF developments do have the potential to make important regeneration contributions to employment and general wellbeing in often deprived, and sometimes quite remote, coastal communities, as part of a focus on a green energy transition. However, there are some continuing issues.

The ES assessments show a clear focus on economic impacts, with varying considerations and ambivalent trends in assessment of social impacts. This partly reflects government guidance, plus developer perceptions that social impacts are of minor concern for OWF projects. The consideration of jobs and wider economic impacts via the supply chain is understandable, and easier to quantify than social impacts. However, even evidence on local economic impacts raises concerns, especially in relation to the major OWF offshore construction stage. To date it has been difficult to identify local impacts, with economic predictions in ESs often involving wide-ranging scenarios. Developers and their consultants have used arguments that in this new industry, with fast moving innovation, and uncertainty of main contractor supply ports, wide-ranging impact predictions are inevitable. Yet, now with more projects, and more identification of key ports, this should be less the case. The predictions can also substantially overestimate impacts, with major leakage of benefits to established international contractors. There is increasing government concern and response in countries with major OWF development/potential, as in the UK, that the industry should take the delivery of national and local content and economic success much more seriously. The Scottish Government, with Crown Estate Scotland, provides a positive example where developers will have to agree on supply-chain commitments when applying for OWF leases. The Hornsea project provides another example where there is a project requirement to deliver a local employment and supply chain plan working together with local agencies to support a range of local education/training and supply chain initiatives. This is becoming a requirement for developers in most new UK OWF projects.

Our findings show the relative importance, and often underestimation, of other elements of the OWF lifecycle, including onshore construction, and especially the 20-25 years of the O&M stage. There has been a focus in ESs by developers on the construction stage, and a perception that other elements of the project are of little local significance. The Hornsea projects provide an example of the positive and cumulative impacts of scale and hub status. A programme of large OWFs can make important socio-economic contributions in improving and sustaining the supply chain and enhancing key infrastructure - especially improved port facilities, which other industries may use. In this context, the Scottish Government has recently set out a plan for a £40m development of the port of Leith as a renewable energy hub on a 71ha site (Planning News 2021).

Social impacts are important and should be covered whatever the distance from the coast of the OWF. Likely to be more qualitative than economic impacts, they include demographic, housing, local services and wellbeing impacts. As for economic impacts, they should be for each project stage and spatial level. Visual impacts can be an important local concern for near coast OWFs, challenging deep-seated perceptions of seascape, although strong support for the clean energy transition may outweigh such concerns. Again, scale can be a significant factor in explaining the profile of social impacts. A programme of projects can provide noticeable impacts in the community, for example delivering educational/training opportunities and raising local area confidence. Of importance for the management of both social and economic impacts is the engagement strategy of the developer (Mabon et al. 2017; Vanclay and Hanna 2019).The Aberdeen project provides a good example of an engagement strategy over the lifecycle from pre-construction through to early O&M. There is also increasing use of Community Benefits Funds (CBF) for OWFs, which can deliver a wide range of locally focused socio-economic and environmental initiatives. Although the relative levels of funds for OWFs are currently smaller than for onshore projects, as for those projects OWF funds are likely to grow and be of increasing significance for local communities (Glasson 2021).

In conclusion, the research also illustrates the importance of monitoring of actual socio-economic impacts. As noted by Alem et al. 2020, this is a weak area in OWF EIAs and ESs. Lack of effective monitoring can mask the differences between predicted and actual impacts. Monitoring of socio-economic impacts in the construction and O&M stages is important to check both on predictions, and on the implementation of conditions. Pressure from governments/regulatory authorities at various levels, and indeed a self-interest from developers themselves in learning from experience for the next project, are all now pointing towards improved monitoring activity. In addition to individual project monitoring, because of the overlapping impacts of multiple projects in some areas (e.g. in the North Sea), there may also be merit in a periodic strategic level single developer multi-projects approach and/or a multi-developer/possible government approach to monitor cumulative impacts.

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