Journal of Cleaner Production 379 (2022) 134859

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Social acceptability of a wind turbine blade facility in Kingston upon hull

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ARTICLE INFO

Handling Editor: Zhifu Mi

Keywords:
Renewable energy
Offshore wind energy
Local community impact
Employment
Social acceptability
Blade facility

ABSTRACT

In November 2016, Siemens Gamesa started construction of its £310-million, off-shore wind turbine blade assembly facility in the city of Kingston upon Hull in the UK. This paper adopted a mixed method approach, that is, maps, charts and tables and meta analysis to investigate the social acceptability of local residents to such investments using feedback from three residents' surveys conducted over a period of nearly 3 years. The study is a first of its kind as it presents a real case study of social acceptability of a large manufacturing facility, located close to a residential area, that significantly changed the landscape of the area. The findings indicate that residents on the whole favour such investments because of the economic opportunities. For instance, over 1000 direct jobs were created with the Office for National Statistics reporting a growth of 4.2% in Kingston upon Hull's economic output in 2016–2018. Similarly, Demos-PwC Growth for Cities Index 2018 ranked it, the third-most improved UK city to live and work. However, there were some concerns especially from those living close to the facility regarding issues like noise from ships docking and loading during the night and the obstruction of the scenery of the estuary by an erected sound barrier. The study also shows that it is important for the investors to work closely with local stakeholders and residents to maximise the returns whiles minimising the negatives.

1. Introduction

In 2011, the United Kingdom (UK) government introduced the new comprehensive Electricity Market Reform (EMR) to boost energy generation through renewable sources with the EMR geared towards meeting three main policy objectives (Electricity Market Reform, 2011):

- Decarbonisation of electricity generation
- Continuing security of supply
- Maintaining affordability

This announcement coupled with the Crown Estate announcing in 2010 the 3rd round of nine offshore wind farm zones gave the Humber region of the UK, a unique opportunity since three of the development zones are situated close to the Humber estuary. In addition, the Renewable Obligations (RO) – a market-based mechanism to incentivise generation of electricity from renewable energy sources – provided favourable conditions for investors.

The Humber region, especially the area around the city of Kingston upon Hull, has experienced a lot of deprivation over the past few decades following the collapse of the fishing industry resulting in persistent intergenerational welfare benefit dependency. Thus, the local authorities of Kingston upon Hull City Council (KHCC) and East Riding of Yorkshore Council (ERYC) together with the private sector sought hard for opportunities to revive the local region. Offshore wind development presented a great opportunity. In this regard, Green Port Hull (GPH), a sector-focused private/public partnership, launched in 2010, secured a £25.7 million Regional Growth Fund (RGF) funding in October 2011 to promote investment in the renewable sector, to train and upskill workers and to help ready development sites for offshore wind related businesses in the East Riding and Kingston upon Hull region. This served as a catalyst for the £310 million investment by Siemens Gamesa and Associated British Ports (ABP) for the redevelopment of Alexandra Dock in the port of Kingston upon Hull for the construction of the world-class wind turbine blade facility (Green Port Hull, 2010).

Siemens announced that the investment would, "provide a huge boost to the UK's offshore wind industry and the Humber region". The perception from the locals was generally very positive, given Siemens Gamesa's commitment to creating 1000 jobs with 90% of the hiring to be within 30 miles radius of the facility (The Guardian Online, 2016).

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https://doi.org/10.1016/j.jclepro.2022.134859
Received 6 January 2022; Received in revised form 2 September 2022; Accepted 21 October 2022
Available online 27 October 2022

This paper goes beyond what currently exists in the literature by undertaking a detailed study of peoples' perception/attitude towards new offshore wind developments during the construction, operational and post-operational phases. In addition, the study adopts a holistic approach by doing a social, economic, and environmental impact assessment of the renewable industry in the region. It presents the results by adopting a mixed method to investigate the social acceptability of Siemens Gamesa blade assembly facility and GPH's effort to drive the renewable energy industry in the region. Three residents' surveys were conducted over three years (2016–2018 inclusive) to capture the wider impact with the view of informing further renewables investment and influencing policy.

Following the introduction, a literature review of social acceptance of wind energy is given in section 2. Section 3 covers an overview of GPH and the blade assembly facility with section 4 covering the survey methodology. Data analysis and interpretation are presented in section 5 and concluding remarks in section 6.

2. Literature review

The social impact of the Siemens Gamesa blade facility, as part of offshore wind farms development, cannot be studied without considering the public acceptance of wind energy (offshore and onshore) as a whole. The existing literature on social acceptance of offshore wind energy does not split the building blocks of these megaprojects or focus on different stages of the project's lifecycle. The opinion of the local community regarding the blade facility cannot be studied like other factory construction projects. Here, the clean energy target and its sustainability together with the general role of offshore wind energy in climate change are likely to influence the views of residents on the blade facility. Job creation opportunities, pollution, and the impact on local community development are deemed to be general attributes of the social impact of developing manufacturing facilities. We would therefore proceed by undertaking a review of the social acceptance of both onshore and offshore wind energy projects to shed light on the key influential factors that should be considered for this study.

2.1. Public acceptance of onshore wind energy

The social acceptance of wind energy has received a lot of attention in the literature with scholars addressing it as either a constraint or driver for the renewable energy sector. Wüstenhagen et al. (2007) explained sociopolitical, community, and market acceptance as three dimensions of renewable energy innovation acceptance. The authors observed that public and community acceptance from the viewpoint of consumers, investors, and intra-firm are studied more in the literature than market acceptance. In another review on social acceptance, Fast (2013) concluded there are complex social responses to renewable energy like territory, landscape, and other geographical concepts and Rand and Hoen (2017) highlighted the impact of socioeconomic factors on wind energy. However, environmental concerns, closeness to wind farms, and distance to turbines could be opposition drivers. The authors stressed that the application of research findings in practice and policy is limited. Batel et al. (2013) argued that choice of "acceptance" and "support" for assessing the public's opinion about low carbon energy infrastructure is essential as "support" implies a more favourable position and active role of communities rather than a passive and tolerating role conveyed by "acceptance".

Jobert et al. (2007) also studied the local acceptance of wind energy in France and Germany using five case studies. The study classified factors into two categories: institutional factors including regulations and incentives and site-specific factors such as local economy, geography, local actors, and project management. In a survey conducted among 919 citizens in five Swiss rural areas with potential wind projects, Walter (2014) concluded that although positive public general attitude towards wind energy plays an essential role, it cannot guarantee a high local acceptance rate. A Similar survey that investigated the acceptance factors of wind energy in Germany (Langer et al., 2018) identified acceptance factors like process-related factors, personal characteristics, perceived side effects, and technical/geographical issues. A review conducted in European countries regarding the community acceptance of wind energy identified and emphasized six essential factors (technical features of the projects, environmental, economic and social impacts, contextual factors, and individual characteristics) in community perception of onshore wind energy development (Leiren et al., 2020).

2.2. Social acceptance of offshore wind energy

The research on public acceptance of offshore wind energy is growing considering the rapid pace of its development. Haggett (2011) noted that the role of the public should be included in offshore wind energy development particularly when considering the potential wider impacts of energy security, employment, and investment. However, the difficulty is in properly engaging diverse groups. In this regard, Devine-Wright (2008) argued that studying the public acceptance of renewable technologies requires a hybrid research approach (qualitative and quantitative) to highlight the complex nature of beliefs regarding these technologies. Other studies also stated that as offshore wind energy could be considered as a newcomer in energy technologies, the public may express a positive attitude towards it (Kaldellis et al., 2016). But the real social acceptance could be measured in the massive expansion and development of the wind farms in shallow zones. Firestone et al. (2012a, 2012b) focussed on the public acceptance of offshore wind energy through time. The authors argued that though concerns regarding the impact of offshore wind farms on boating and fishing could influence public support, energy independence could change the attitude of those opposed to it. In another study, Firestone et al. (2012a) conducted a survey of residents near two wind farms. The public support came from the willingness for energy independence whereas those who opposed it were concerned about the fishing and boating impacts. Similarly, Portman (2009) discussed the essential role of involving the public in the assessment of offshore renewable energy facilities. The authors noted that effective communication via transparency and accessibility, broad-based inclusion through fairness and proactivity, prioritisation via boundary definition and cumulative consideration, flexibility and openness, and early identification and unbiased presentation could lead to successful public participation. Cohen et al. (2014) provided a critical review of public acceptance of energy infrastructure including wind farms. They proposed future research should focus on developing the procedure for facilitating the negotiation between the public and developers.

In addition, social acceptance of offshore wind energy was investigated through the analysis of two types of acceptance: siting of projects and general acceptance (Teisl et al., 2015). The authors highlighted that the evaluation of costs and benefits of renewable energy by people could influence their acceptance level. Hence, transparent communication and training the public in areas related to renewable technologies development play an essential role in social acceptance. A study by Bush-Hoagland (2016) recommended that for facilitating offshore wind energy planning, the public should be moved to an informed position rapidly. They concluded that public education plays an essential role in the social acceptance of offshore wind energy projects. A related study in the US (Firestone et al., 2009) concluded that when offshore wind power is deemed transformative, there is significant support even for residents near the first developments, who inherently take more risk. Similarly, Landeta-Manzano et al. (2018) studied the role of the community in wind turbine expansion and observed the safety of workers, as well as local direct and indirect employment, play an essential role in community acceptance. Key challenges relating to large onshore wind turbines were also addressed (McKenna et al., 2016) with the authors concluding that public acceptance is reduced when you have larger tower heights

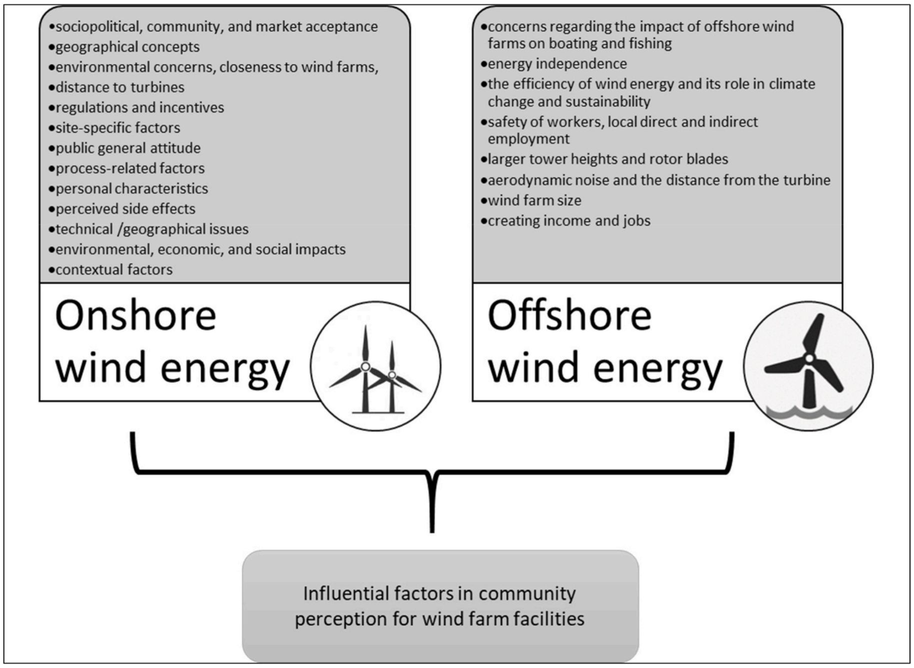

Fig. 1. The influential factors in public acceptance of wind energy from literature review.

and rotor blades. The aerodynamic noise and the distance from the turbine play an essential role in this perception. Moreover, the noise would be a critical element in the future as the low-frequency noise could lead to stress and headache.

The synthesis of this review reveals the essential factors contributing to public acceptance of offshore wind energy projects. Therefore, in determining the influential factors in the development of large-scale facilities, both variables in onshore and offshore wind energy development should be considered. It should be noted that there are some similarities between the two research contexts. However, a comparative synthesis can highlight the essential factors that should be integrated into the study when focusing on the social acceptance of facilities in offshore areas. Fig. 1 summarizes these factors.

To the best of our knowledge, the detailed analysis of social acceptance during the construction, operation, and post-operation phases of offshore wind energy facilities is not addressed in the literature. This research takes a step forward into empirical studies on the role of local communities in developing renewable energy infrastructure by studying the social acceptance of a blade manufacturing facility.

3. Survey methodology and data

This section discusses the survey design, population and sample size, the survey instrument, and the study variables that informed the construction of the three residents' survey questionnaires. It further discusses the data collected through the surveys together with the analytical technique and key findings.

3.1. Survey design

The main purpose of the surveys was to help GPH to gain an understanding of the local residents' sentiment about how the blade facility affected them and also the wider impact of renewable energy initiatives in the region. We chose survey as the preferred method of data collection as it was the easiest way of reaching a wider audience. The target group was identified with input from the stakeholders (GPH

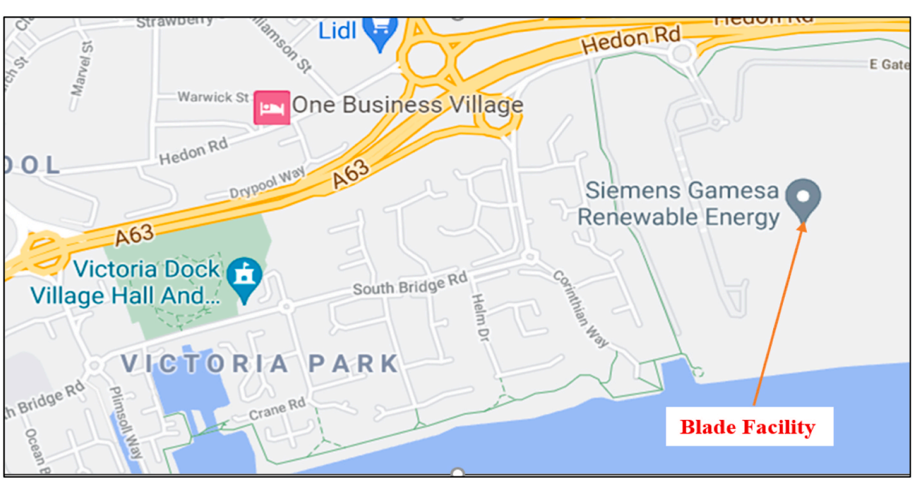

Fig. 2. Survey area: Immediate surroundings of blade facility [Victoria dock village and Marfleet ward].
Source: Google Maps

Table 1
Distribution of How Long Respondents have lived in the Green Port Hull area.

Category	Key Variables	Measure of Key Variables O = Open ended; C = Closed ended	First Survey	Second Survey	Third survey
Demographic/ Background	Postcode/Resident Identification	[O] Street Postcode (eg. HU9 1PQ)	✓	✓	✓
	Household Size	[C] Whole number [eg 1, 2, …]	✓		
	Gender breakdown	[C] Select one [Male or Female]	✓		
	Age breakdown	[C] Under 16; 16–24; 25–34; 35–44; 45–54; 55–64; 65 and over	✓	✓	✓
	Education level	[C] Standard education classification [Primary, Secondary/Vocational, Tertiary, Other]	✓		
	How long lived in GPH area	[C] Months/Years [0–3; 4–6; 7–12; 13-18; 19–36; 3–5; 6–10; Over 10; Always lived in the area]	✓	✓	✓
Social/Economic	Occupation	[O] Respondent to specify	✓	✓	✓
	Current Employment status	[C] Employed, Unemployed, Inactive [student, retired, carer, discouraged]	✓	✓	✓
	Whether work locally or out of town	[O] Respondent to specify	✓		
	Property Ownership	[C] Select one [Rent, Own, Other]	✓		
	Whether region has Skills Set/ Capable Workforce	[C] Select one [Yes or No]		✓	
	Life satisfaction	[C] Scale 0–10 [0 = "not at all" and 10 = very satisfied, happy, anxious, worthwhile]	✓	✓	
	Happiness Level		✓	✓	✓
	Anxiety Level		✓	✓	✓
	Feeling worthwhile		✓		
	Safety level in area	[C] Scale of 1–5 [1 = very safe; 2 = quite safe, 3 = a bit unsafe; 4 = very unsafe; 5 = I would not go out]	✓		
	Trustworthiness of people	[C] Scale of 1–5 [1 = very trustworthy; 2 = quite trustworthy, 3 = a bit trustworthy; 4 = very untrustworthy; 5 = I would not trust my neighbours]	✓		
GPH/Siemens	Awareness of Green Port Hull (GPH) & Activities	[C] Select one [Yes or No]	✓		✓
	Whether GPH beneficiary	[O] Respondent to specify	✓		
	Awareness of Siemens involvement in Hull	[C] Select one [Yes or No]	✓		✓
	Whether impacted by Siemens Presence	[O] Respondent to specify	✓	✓	
	Whether GPH region on track to meet its aspiration	[C] Select one [Yes or No, Please provide details …]			✓
Environment	**Local community impact of Siemens Investment**: traffic, noise, parking, air quality, wildlife, Hull Landscape	[C] Select one [Increase, Decrease or Constant, with details where applicable]	✓	✓	✓

Source: Surveys of residents in Kingston upon Hull, 2016–2018

and Siemens Gamesa) who commissioned the impact assessment. Our goal was to track changes over time and a repeated cross-sectional research approach was adopted in conducting three residents' surveys over a three-year period. These coincided with the ending of construction phase (First Survey, August – October 2016), beginning of the operational phase (Second Survey, March – May 2017), and one year after the beginning of the operational phase of the facility (Third Survey, June – August 2018). Furthermore, the surveys focussed on residents dwelling in residential accommodation (Victoria Dock Village and Marfleet ward) in the immediate area surrounding the blade facility. Fig. 2 shows the area covered by the surveys.

For our sampling technique, we used google map to identify the residential accommodation in the catchment area of the blade facility. In this regard, these data sources (ONS/Nomis population estimates/Population Census; local population data sources; Postcode map) were used to get an idea of the number of houses/streets in the Victoria Dock Village and Marfleet ward. Since the houses in the two wards were not too many, we decided to target a resident from each of them.

Appropriate measures were put in place to reduce error, bias, and anonymity such as capturing only postcodes to avoid identification of individuals, distributing questionnaires online through a link and aggregating and summarising results. The questions were designed in line with other national surveys such as Office for National Statistics (ONS)/Nomis (travel to work type questions), British Household Survey (household type questions), and Annual Population Survey (well-being type questions).

The Online Surveys (formerly Bristol Online Survey) web tool was selected and used because in addition to the excellent design capabilities, it was also cost-efficient and saved a lot of time and effort especially in administering and collecting feedback by receiving results in real-time. It provided also an easy and convenient way for respondents to complete the surveys, ensuring anonymity and objectivity. In addition, it was easy to distribute the link by email, WhatsApp or Facebook as well as being smartphone/tablet friendly.

3.2. Population and sample

The main objective of the first survey was to ascertain the impact of the construction of the blade facility on individuals residing within a 2 km radius of the facility. By virtue of their location, these individuals would feel the impact first. In addition, it was projected that there might be a social and economic transformation of the surrounding area (e.g. change in property prices, noise, traffic, air impact, and wellbeing) as a direct impact of the investment (Akella et al., 2009; Green Port Hull, 2010; International Renewable Energy Agency, 2017). Hence our sample was limited to the local wards of Marfleet and Victoria Dock which fall directly within the demarcated area. For most of the Victoria Dock area, the local councillors and the housing estate both had a mailing list and a facebook page and they offered to distribute the survey through these mediums. Marfleet ward, however, did not have a mailing list and two researchers went from house to house on selected streets to administer the questionnaire. A similar exercise was also carried out in the Victoria Dock area for those not on the mailing list. The questions focused on one principal household person though some demographic questions were targeted at other household members.

The second survey, coincided with the beginning of the operational phase. The stakeholders wanted to capture the impact of this event and the questions were revised to have a more environmental focus (local community impacts of air, traffic, noise, scenery and offshore wind energy) while preserving most of the previous social and economic questions for consistency. The third survey, was done about one year after the beginning of the operational phase of the facility (post-operational phase) and had questions more focused on the impact of the facility on people's quality of life but again maintained some fundamental social and economic type questions.

3.3. Survey instrument

The surveys were purposely designed to not only assess the immediate impact of the blade facility on the residents of the local area but to also gauge the wider impact of the GPH initiatives to boost the renewable industry in the region. Following research and ethics guidelines, the questionnaires had a covering letter outlining the purpose of the survey, the consent and participation of the residents, how the information gathered would be used in line with UK Data Protection Act 1998/ General Data Protection Regulation (GDPR) and stored securely in password protected computers. The questions were divided into various categories: demographic, economic, social, and environment/ sustainability.

A mixture of open-ended and closed-ended questions were used in the three surveys. Closed-ended questions were employed (example, employment status) with respondents given several independent choices to choose from. Similarly, ordered choices forming a continuum of responses such as Likert scales (scale from 0 to 10) and numeral ranges were employed for variables like wellbeing (life satisfaction, anxiety, happiness, worthiness) and age distribution respectively. We also used closed-ended questions with unordered choices (Dillman et al., 2014), allowing respondents to compare responses and select one (such as highest education level). In addition, since some of the questions lend themselves to varied responses, open-ended questions allowed us to capture further insight from residents (Dillman et al., 2014).

The questionnaires were distributed through the mailing lists of Victoria Dock ward councillors/Housing association and via their Facebook page together with face-to-face dissemination for those not on the mailing list over an average period of 3 months.

3.4. Study variables

The variables were informed by the scope of the impact assessment project and captured the background and demographic information required for analysis purposes. The questions were categorised into four main groups as can be seen from Table 1. The background and demographic questions and length of time the person lived in the area are also suitable for investigating whether there are unique differences between particular subgroups or whether interventions should be targeted at specific groups. For example, postcode mapping may reveal certain characteristics/issues associated with a particular area like Victoria Dock village.

The socio-economic variables helped in assessing the social and economic wellbeing of individuals in the local area and also highlighted the assistance they would need to improve upon their current status. The personal wellbeing of individuals is of paramount importance and often closely linked with people's employment status. For instance, current employment status shows whether a person is economically active (employed or unemployed) or economically inactive (retired, student, carer or long term sick). Generally, we expect people who are gainfully employed and able to take care of their needs to be more satisfied and happier than those not employed and struggling to make ends meet.

Environment related questions also covered topical issues like traffic, noise, air quality and scenery associated with the blade facility. Similarly, the impact of making and using offshore wind turbines was also assessed.

3.5. Survey data and responses

The data is drawn from the responses to the three residents' surveys. For the first survey, a 16-question questionnaire was administered during the construction phase of the blade facility, with 82 residents responding from the Drypool ward catchment area with a majority of them residing in the Victoria Dock housing estate. According to ONS 2011 Census data, the Drypool ward had about 2713 households with Victoria Dock having about 160 households with at least 1 household member. The second survey coincided with the beginning of the operational phase and a 17-question questionnaire was developed and administered with 63 residents responding and finally, a 18-question questionnaire was used in the third survey and yielded 61 responses from around the Victoria Dock village area. On the whole, the response rates were not as high as we would have liked but out of the three, it was highest for the first survey because a team also went out to specific areas of Victoria Dock to capture the information electronically, through tablets made available to residents by the researchers which allowed them to complete them independently, whereas for the second and third surveys we relied on mailing lists only. But overall, the responses are fairly indicative of general opinions of residents on renewable energy-based initiatives and investments. According to the councillors, during consultation sessions with residents, they voiced similar concerns to the responses captured by the surveys regarding issues like construction noise, dust and blockage of the scenery by the sound barrier.

Table 2
Chi2 Test for independence of Survey Samples.

Sample	Residents surveys 1, 2 and 3
Variable	Age Distribution
Null Hypothesis	There is no relationship between the samples
Chi2 test	Pearson chi2(10) = 7.0171 Pr = 0.724
Lrchi2 test	Likelihood-ratio chi2(10) = 8.0851 Pr = 0.621

Source: Surveys of Residents in Kingston upon Hull, 2016–2018

Table 3
Test between each sample and target population.

Sample and Population	Variable	Null Hypothesis	Chi2 test
Survey 1 and Population	Age Distribution of respondents for each sample and target population	No relationship between each sample and the target population	Pearson chi2 (7) = 1.3e+03 Pr = 0.000
Survey 2 and Population			Pearson chi2 (10) = 5.5e+03 Pr = 0.000
Survey 3 and Population			Pearson chi2 (6) = 112.4028 Pr = 0.000

Source: Surveys of Residents in Kingston upon Hull, 2016–2018

We performed a Chi-square test to ascertain whether the three survey samples were independent of each other. From the Chi-square and Likelihood ratio test results in Table 2, they are not significant at the 5% level so we fail to reject the null hypothesis that the samples are not the same. Hence, the three samples are independent of each other.

In Table 3, we performed a Chi square test to determine if the samples are likely to be from the target census population data based on the Age distribution. The results were all significant at the 5% level meaning we can reject the null hypothesis in favour of the alternative that the samples are representative random samples from the target population.

It is very important to understand the make up of the individuals surveyed to enable the right policies or interventions to be tailored to them. A study noted that such information describes the study sample and is suitable for determining whether respondents captured are adequately representative of the target population (Lee and Schuele, 2012). In this regard, some key characteristics of the respondents are explored starting with 'age distribution' and 'how long they have lived in the Green Port Hull area' in Fig. 3 and Table 4 respectively. This is aimed at showing how familiar they are with the local environment which in turn might impact the analysis.

Fig. 3 shows that over 60% of the respondents in all the surveys (first survey [70%]; second survey [76%]; third survey [69%]) were aged over 44 years with fewer participation from those below 35 years. Regarding how long respondents have lived in the Kingston upon Hull

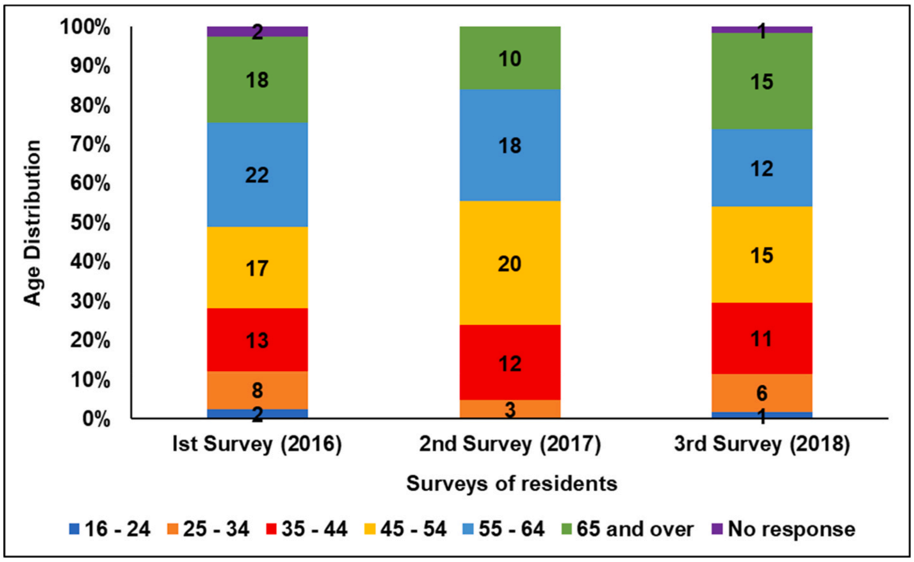

Fig. 3. Age Distribution of Survey respondents. The numbers in the chart represent the number of respondents for each category.
Data source: Surveys of Residents in Kingston upon Hull, 2016–2018

Table 4
Distribution of How Long Respondents have lived in the Green Port Hull area.

Length of time	Frequency					
	1st Survey (2016)		2nd Survey (2017)		3rd Survey (2018)	
	Number	%	Number	%	Number	%
0–3 months	1	1.2				
7–12 months	2	2.4				
13–18 months	2	2.4	2	3.2		
19–36 months	4	4.9				
3–5 years	3	3.7	5	7.9	7	11.5
5–10 years	13	15.9	11	17.5	3	4.9
More than 10 years	57	69.5	45	71.4	51	83.6
Total	82	100	63	100	61	100

Source: Surveys of Residents in Kingston upon Hull, 2016–2018

area, Table 4 shows at least 69% have always lived in the GPH area. The percentage increases to at least 85% if we include those who have lived in the area for more than 5 years.

We can deduce from these observations that most of the residents are likely to have a good awareness of their local environment and possible awareness of the Siemens Gamesa investment and GPH initiatives.

In terms of employment status, Fig. 4 captures the breakdown of the residents who responded with majority, at least 72% per survey, being economically active (in employment or unemployed). The findings also show a significant number of them belong to the economically inactive group (21%–28%) but these are mainly made up of retirees.

4. Data analysis and interpretation

This study adopts a mixed method approach, that is, statistical analysis (meta-analysis) and summary of residents' responses to describe the perceived impact of the blade facility on the local residents of Hull. The local community impacts cover noise pollution, scenery, air quality and offshore wind.

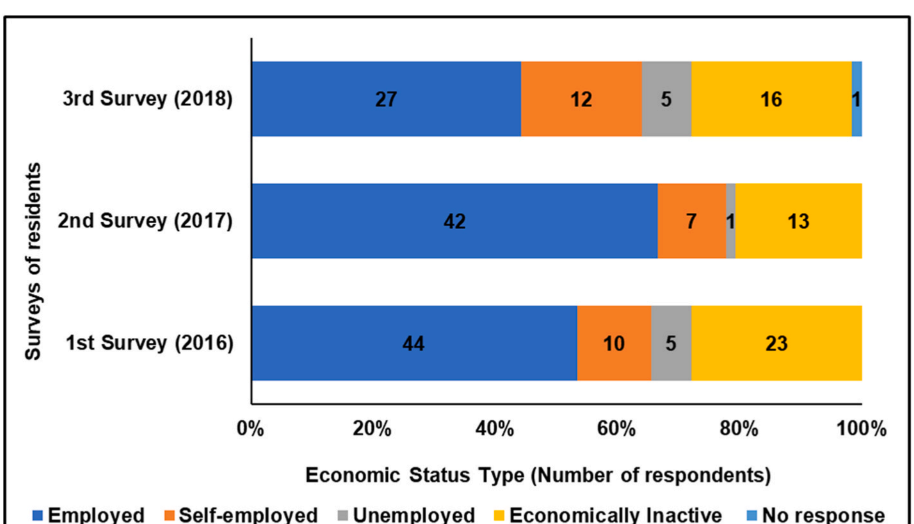

Fig. 4. Employment status of respondents.
Data source: Surveys of Residents in Kingston upon Hull, 2016–2018

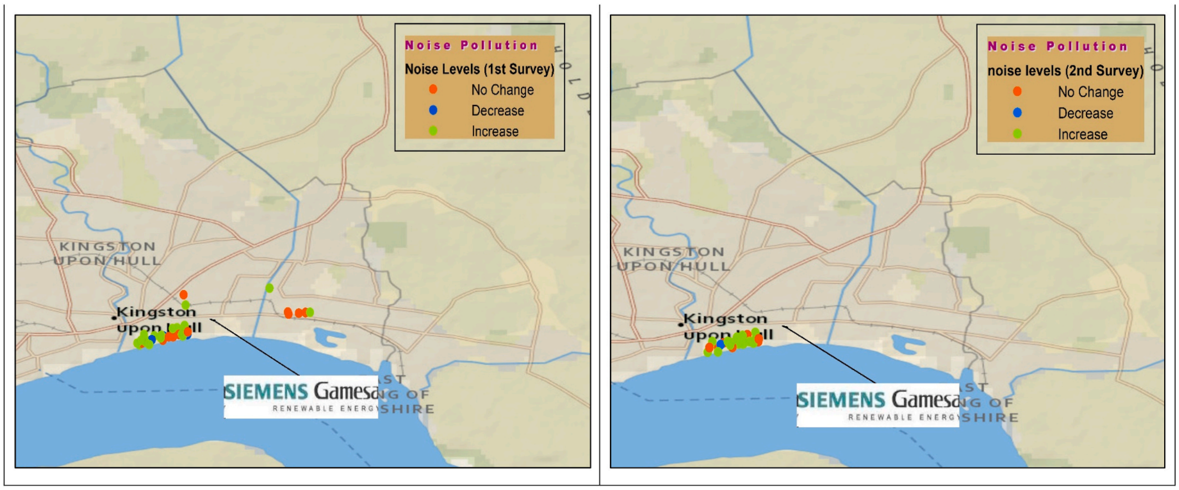

Fig. 5. Noise pollution impact of blade facility.
Data source: First and Second Survey of Residents in Kingston upon Hull.

Meta-analysis is a statistical method of analysing and combining results from similar studies (Aguinis et al., 2011; Hansen et al., 2022). Thus, to draw statistical inference about the local community impacts, we used this process to synthesize the responses across the three residents' surveys to reach an overall understanding of the effect of issues like noise pollution on Victoria Dock residents.

The effect size is a a quantitative measure of the strength of relationship between two entities. The larger the effect size, the stronger the relationship between two variables. Meta-analysis begins with a systematic review which is to determine whether it is appropriate to combine studies. In our study, since all the surveys are focussed on the social acceptability of the blade facility, it is appropriate to synthesis them. To enable us compute the effect sizes, the data of each survey was grouped into two: those residing within 4 min (treatment group) and those residing beyond 4 min (control group) drive of the blade facility.

Meta analysis chooses between two models. Fixed-effect model assumes that all differences between effect sizes observed in the different studies are purely sampling error. In random-effects model, all differences between effect sizes are assumed to be due to sampling error and variability between the studies. The literature strongly recommends using random-effects model as the assumptions underlying the fixed effect model are rarely met. However, when there is very little variance in effect sizes, the random-effects automatically converges to a fixed effect model.

We also employed maps, tables and charts to summarise the residents' responses to the perceived impact of the blade facility. Detailed responses are analysed in sections 4.1–4.4.

4.1. Noise pollution

Residents were asked whether they had noticed a change in average noise levels during construction (Survey 1) and when the blade facility became operational (Survey 2). with the responses mapped in. From Fig. 5, about 21% (31 respondents [Survey 1]) and 38% (13 respondents [Survey 2]) had not noticed a change in average noise levels. Quite a significant number, 49% (40 respondents) and 79% (49 respondents) from the first and second surveys respectively, reported they had noticed an increase in average noise levels. However, for the first survey it was mainly due to construction noise (banging noise from piling for the building) whereas for the second survey it was as a result of operational noise (continuous throbbing noise and noise from manufacturing).

We adopted meta-analysis to further investigate whether there was significant difference in noise levels between the treatment and the control groups (those residing within and beyond 4 min respectively).

Table 5
Summary of individual and combined log odds ratio of noise levels.

Meta-analysis summary		Number of studies = 3		
Random-effects model		Heterogeneity:		
Method: REML		$tau^2 = 0.0000$		
		I^2 (%) = 0.00		
		$H^2 = 1.00$		
Residents Survey	Log odds ratio	[95% conf. interval]		% weight
Survey 1	0.087	−0.888	1.062	60.12
Survey 2	0.098	−1.156	1.353	36.35
Survey 3	0.211	−3.812	4.234	3.53
theta	0.096	−0.661	0.852	
Test of theta = 0: z = 0.25		Prob > |z| = 0.8044		
Test of homogeneity: Q = chi2(2) = 0.00		Prob > Q = 0.9983		

Source: Surveys of Residents in Kingston upon Hull, 2016–2018

The main objective being to ascertain whether the noise insulation provided to the treatment group had any significant impact. A binary procedure was employed as the outcome of interest (noise) has a binary form, "increase" or "no increase". The associated effect size, the odds ratio measures the odds of success in the treatment group relative to the odds of success in the control group. Table 5 and Fig. 6 show the meta-analysis summary and forest plots of the noise responses respectively for the three surveys.

The summary output presented in Table 3 includes heterogeneity statistics, the individual and overall effects estimate (log odds ratio) with 95% confidence interval and study weights. Similarly, the forest plot (Fig. 6) graphically displays the same results with the log odds ratio represented by dark-blue squares centered at their estimates with areas proportional to the study weights and the length of the confidence intervals represented by horizontal lines. The overall effect size is also displayed as a green diamond with the width corresponding to the respective confidence Interval.

The overall log odds ratio means treatment group is 0.096 times more exposed to increased noise levels than the control group. However, the low value suggests weak relationship which may be due to the noise insulation provided by Siemens Gamesa to the treatment group.

The homogeneity test is undertaken to ascertain whether the assumption that all of the effect sizes are estimating the same population

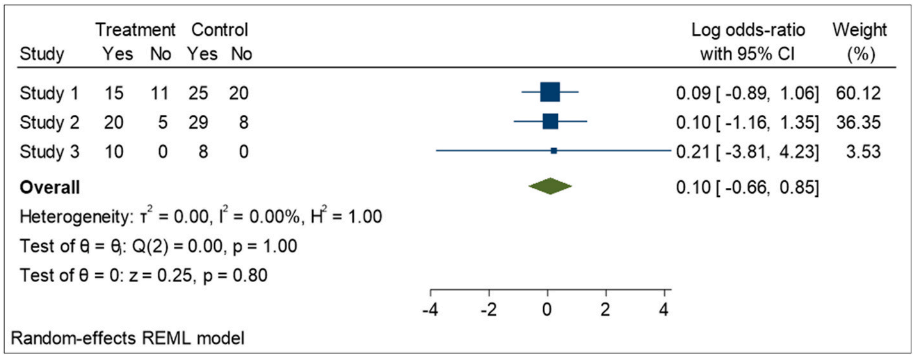

Fig. 6. Forest plot of individual and overall log odds-ratio of noise levels.
Data source: Survey of Residents in Kingston upon Hull, 2016–2018

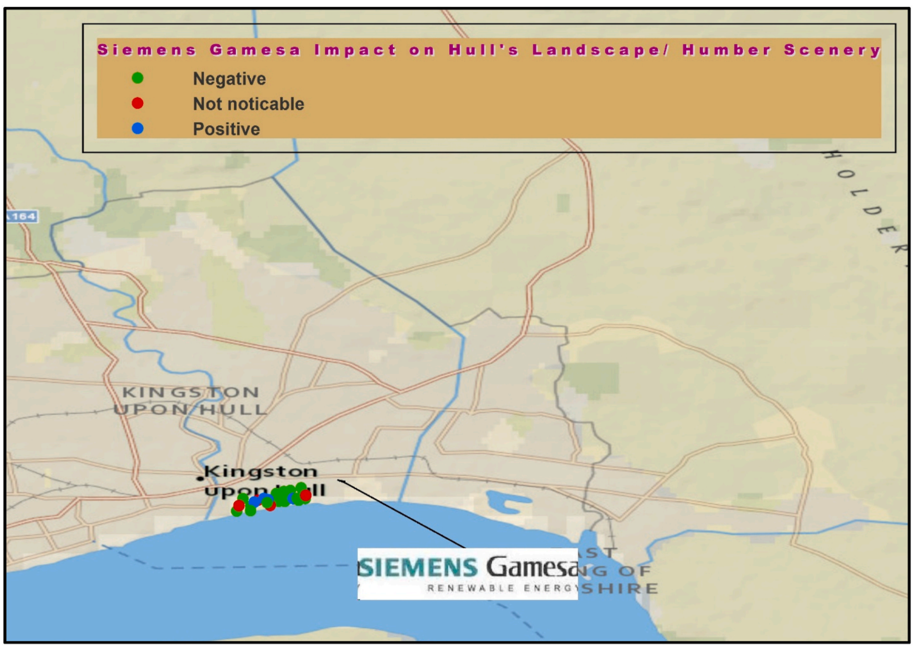

Fig. 7. Blade facility's Impact on Hull's Landscape and Humber Scenery.
Data source: Second Survey of Residents in Kingston upon Hull

mean is reasonable. If homogeneity is rejected, then the distribution of effect sizes is assumed to be heterogenous. Our results indicate that the chi-squared test statistic (Q = 0) with the *p*-value = 1.00 > 0.05, thus we fail to reject the test of homogeneity of study-specific effect sizes. Borenstein et al. (2021) noted the extent of heterogeneity (I^2) is measured as the proportion of observed variance that reflects real differences in effect size. Our value $I^2 = 0\%$ suggests low heterogeneity between the three surveys. Borenstein et al. (2021) advised to use I^2 as a criterion for deciding whether a subgroup or moderator analysis is required. The very low value of I^2 suggests no heterogeneity is present and as such an analysis is not needed.

4.2. Scenery

As to the impact the blade manufacturing facility had on the landscape of the City of Kingston upon Hull and the wider Humber scenery, 15 respondents (18%) from the first survey were of the view that the erection of the wall separating Victoria Dock and the blade facility, that extended partly in the river had spoiled their view of the estuary. Note that this wall is supposed to act as a sound barrier. The percentage grew to 73% in the second survey, where 46 of respondents suggested that the

Table 6
Individual and overall log odds ratio of blade facility's impact on Hull Scenery.

Meta-analysis summary		Number of studies = 3		
Random-effects model		Heterogeneity:		
Method: REML		$tau^2 = 0.0000$		
		I^2 (%) = 0.00		
		$H^2 = 1.00$		
Residents Survey	Log odds ratio	[95% conf. interval]		% weight
Survey 1	−0.111	−4.139	3.916	8.53
Survey 2	0.074	−1.213	1.361	83.49
Survey 3	−0.251	−4.413	3.91	7.99
theta	0.032	−1.144	1.208	
Test of theta = 0: z = 0.05		Prob > |z| = 0.9571		
Test of homogeneity: Q = chi2(2) = 0.03		Prob > Q = 0.9867		

Source: Surveys of Residents in Kingston upon Hull, 2016–2018

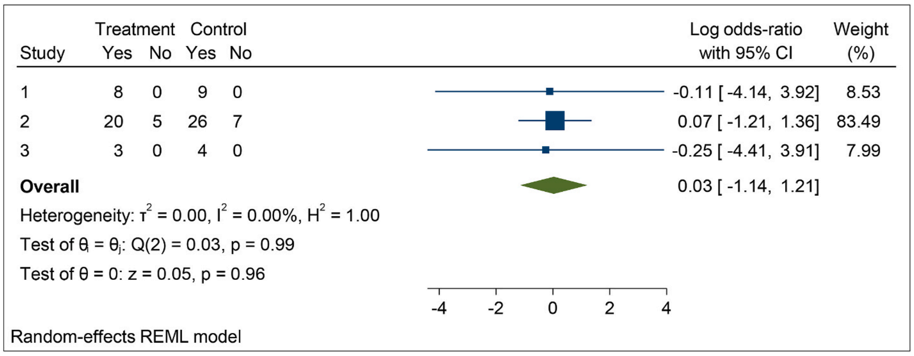

Fig. 8. Forest plot of Blade Facility's impact on Hull's scenery.
Data source: Survey of Residents in Kingston upon Hull, 2016–2018

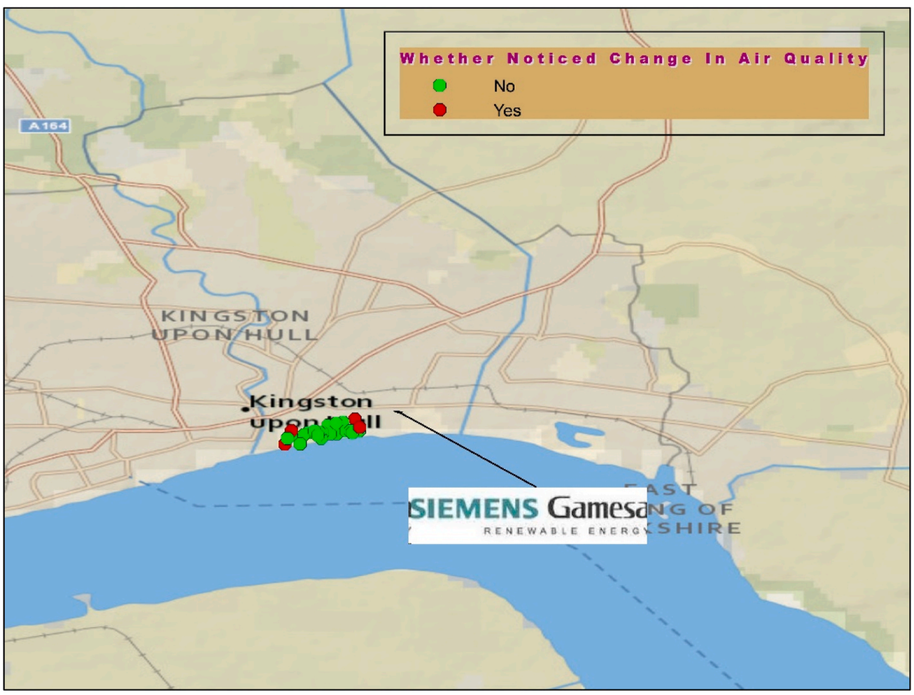

Fig. 9. Air Quality Impact of blade facility.
Data source: Second Survey of Residents in Kingston upon Hull

impact of the sound barrier was negative and had reduced their view of the Humber (see Fig. 7). 19% (12 respondents) however, felt the site had added a positive dimension to the landscape and view of the Humber.

We employed meta-analysis to determine if there was any significant difference in the views of the treatment and control groups. From Table 6 and Fig. 8, the overall effect size (log odds) indicates the treatment group is 0.032 times more disposed to having a negative view of the sound barrier. Again, the low value means weak relationship for the treatment group which may suggest similar negative views on the sound barrier as the control group. For the homogeneity test results of $Q = 0.03$ with p-value $= 0.99 > 0.05$, we fail to reject the test of homogeneity of study-specific effect sizes (heterogeneity). Similarly, $I^2 = 0\%$ suggests low heterogeneity between the three surveys and as such subgroup or moderator analysis is not required (Borenstein et al., 2021).

4.3. Air quality

The residents were asked whether they had noticed any changes to air quality since the blade facility became operational (Survey 2). 79% of the respondents stated that they had not noticed a difference in air quality with the rest (21%) stating they had noticed a change such as: smell/bad odour; dust on garden furniture, windows and cars; worsened traffic fumes. Fig. 9 shows that most of the respondents that had a negative response reside in the Victoria Dock estate close to the blade facility.

4.4. Offshore wind

The first survey sought to ascertain whether Siemens Gamesa's presence had a positive or negative impact on the area. Majority of the respondents were of the view it had brought or would bring employment/job opportunities to the area. However, an equal amount were also of the view that it had a negative impact on the area in terms of construction noise, erection of sound barrier and loss of footpath/bicycle path. Some did acknowledge however that the construction noise was only temporary and given the positives, this was a necessary inconvenience (Table 7).

The second survey sought to ascertain residents' perception of the use of offshore wind. Residents were asked whether they thought the overall impact of wind turbines was good or bad for the environment or

Table 7
Whether Siemens Gamesa had had a positive or negative impact on the area.

Impact of Siemens Gamesa's Presence on area	1st Survey (construction phase)	
	Number	Details
Whether Had Positive Impact	54	Employment/jobs (20); Employment and Investment (1); Employment and Skills (2); Employment and Positive vibe (1); Future benefits (1); Demand for Housing (1); Improvement in area by Associated British Port (ABP) and Siemens (1); Productivity (1); Better Landscape (1); Future prospects (7); Not Yet (6); No (11)
Whether Had Negative Impact	56	Banging (1); loss of footpath (5); Loss of footpath and Sound barrier (1); construction noise (16); construction noise and loss of footpath (4); construction traffic (6); access to fishing cut off (1); obstruction of Humber scenery due to erection of sound barrier (9); noise and dust (1); Noise and Traffic (2); noise, traffic and sound barrier (2); None/ too early (8)

Source: First Survey of Residents in Kingston upon Hull

whether they needed further information to form an opinion. 52% of surveyed residents (33 respondents) were of the opinion that the production and use of wind turbines had, overall, a positive impact on the environment (Fig. 10). However, 17% (11 respondents) perceived the overall impact of wind turbines to be negative and the remaining 30% (19 respondents) could not form an opinion.

5. Discussions and conclusion

This paper has highlighted how residents in Kingston upon Hull, the direct beneficiaries of the Siemens Gamesa blade facility perceive a renewable energy sector based investment. In all three surveys, residents perceived the blade facility investment to be positive for the area in terms of job creation and employment opportunities. The first survey findings also indicated the investment would help overcome the negative image of Kingston upon Hull as a deprived area by: giving the area a positive vibe and helping attract future investment. To buttress the feedback from the local residents, the blade facility has created over 1000 direct jobs for the area with 90% of the beneficiaries residing within 30 miles radius of the facility (The Guardian Online, 2016). In addition, Siemens Gamesa worked closely with GPH to design the Advanced Level 3 Engineering Manufacturing Apprenticeships Framework leading to the training of over 818 apprentices in engineering and technician qualifications for the offshore wind energy and wider manufacturing sector. These contributed to a growth of 4.2% in Kingston upon Hull's economic output, beyond the national average of 1.3%, over the two years to 2018 according to Office for National Statistics (2018) data. Similarly, Demos-PwC (2018) Growth for Cities Index ranked Kingston upon Hull, the third-most improved UK city to live and work based on economic performance and quality of life.

The local community impact focussed on issues like air quality, noise pollution, wider Humber scenery and offshore wind. These were analysed through summary of responses (maps, tables and charts) and through a synthesis of all the surveys responses (meta-analysis). Some respondents were of the view it had brought employment and investment to the area (construction of new foot/bicycle path [5%]), property rental opportunities (1.6%) and increase in property value (1.6%). 52% (33 respondents) were of the opinion that the production and use of wind turbines had, overall, a positive impact on the environment. However, the surveys highlighted perceived issues. Some were concerned about construction noise from banging and piling whereas others also highlighted operational noise resulting from continuous throbbing noise and manufacturing noise. In addition, there were few complaints about reduction in air quality due to dust, traffic fumes, and smells and obstruction of the view of the Humber estuary from the erection of a sound barrier. The meta-analysis showed that there was not substantial differences in exposure to noise between the treatment and control groups. It is worth noting, Hull City Council, Local Environmental Agency, Siemens Gamesa and the representatives of the local area worked together to mitigate the issues raised. For instance, drilling was restricted to daytime hours during construction and air ventilation units/noise reduction insulation was provided by Siemens Gamesa to those closest to the facility. These align with literature on location and landscape (Fast, 2013) and socioeconomic acceptance and environmental concerns (Rand and Hoen, 2017).

The results are also aligned with empirical studies (Teisl et al., 2015; BushHoagland, 2016; McKenna et al., 2016) which highlighted the role of communication and transparency in the social acceptance of offshore

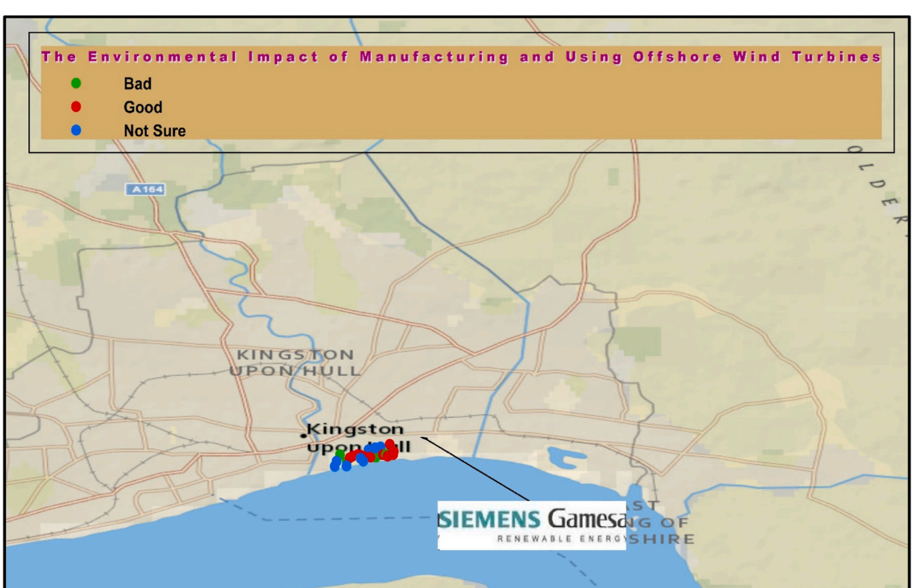

Fig. 10. Offshore wind impact of blade facility.
Data Source: Second Survey of Residents in Kingston upon Hull

wind farms.

The key conclusion from this study is the need for local authorities to work closely with would-be investors and the local community to ensure that the maximum benefit is derived from such investments like the blade facility whiles minimising the negative impact on local residents. The findings indicate the need for a holistic approach to a major investment that matches the socio-economic benefits to the environmental considerations that are likely to arise. This work would also contribute to the ongoing literature and debate on how to undertake impact assessments on major investments and influenced the key considerations of the newly created University of Hull's Logistic Institute Social, Economic and Environmental Impact Assessment (SEEIA) methodology on undertaking project impact assessments. Similarly, it would aid researchers identify the variables to take into consideration in designing a research survey of the type undertaken as part of the Green Port Impact Assessment. It also highlighted some of the challenges of conducting a survey such as capturing enough responses.

CRediT authorship contribution statement

Roland Yawo Getor: Methodology, Investigation, Writing – original draft. **Amar Ramudhin:** Project administration, Supervision, Funding acquisition. **Samira Keivanpour:** Conceptualization, Writing – review & editing.

Declaration of competing interest

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

Data availability

The authors do not have permission to share data.

Acknowledgement

This study was funded by Green Port Hull through the Regional Growth Fund. We thank the whole GIA team for their contribution to this study. Further details can be found at http://gia.hull.ac.uk/.

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