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1.0 Introduction

Over the past 30 years, there has been growing worldwide interest in environmental impact assessments concerning anthropogenic impacts due to land use changes (Fischer and Onyango, 2012; Gonzalez and Enríquez-De-Salamanca, 2018). As a result there has been an increase in demand for empirical data and policies to regulate the process (Glasson and Bellanger, 2003; Fischer and Onyango, 2012). Policy change has been further encouraged by the public, governments, and international associations taking further interest in environmental health (UNECE, 2014; Gov, 2019). The first directive adopted by the EU was in 1985, being directive 85/337/EEC (DHPLG, 2018). Due to the growing demand and use of EIAs (environmental impact assessments) in terrestrial and marine environments, international associations such as the EU have been altering older legislations regularly to fit into modern approaches and developments. There has been a large quantity of literature released since the initial EU directive, but quantitative data has been scarce, relying on qualitative data which can be seen as more subjective (Wang, Yang and Xu, 2006; Fischer and Onyango, 2012).

In the case of renewable energy projects, quantitative data can be used to present accurate predictions on energy production (Willis *et al.*, 2010). Green infrastructure and renewable energy have been focus areas due to its potential positive impacts on wellbeing, pollution and area regeneration (Mackinnon *et al.*, 2018; Gov, 2019). These benefits are difficult to quantify. Environmental impact assessments are necessary in this case due to initial changes to the environment such as construction and land alteration having initial negative impacts on the environment in varying magnitudes, despite potential benefits later, the benefits being potentially difficult to quantify (Fischer and Onyango, 2012; Guo, 2022). This report aims to outline the current EIA process including processes, legislations and current UK and EU laws. A case study will be used to identify benefits to the current EIA process, as well as identifying flaws in the current system. The Swansea Tidal Lagoon will be the case study used, as it allows for a detailed look into legislations and processes of both on-shore coastal and off-shore marine developments. Literature from experts as well as current guidelines and recent reports will be used to assess the effectiveness of the EIA conducted and published in February 2014. The project itself has been denied, and some data and reports have been lost, however there is still enough information to make for a compelling case study in evaluating current legislations concerning marine EIAs in Wales.

2.0 EIA Overview

2.1 History and Legislation

The main purpose of an EIA is to identify possible environmental impacts a major development project will have on the surrounding area, while providing transparency for both public and private projects (European commission, 2022). The first introduction of EIAs was in the United States in 1969, where the NEPA 1969 was introduced (Dobрева, 2018; energy.gov, 2022). The act required EIAs to be conducted by federal agencies in regard to changes in policies or developments of large-scale projects which may affect the environment. This was a global driver of environmental policy change, which later resulted in the first European directive regarding EIAs to be introduced in 1985, Directive (85/337/EEC) (Glasson et al., 2019; DHPLG, 2018). Despite the directive being introduced in 1985, there has been literature which stressed the necessity for such policies since the late 70s (Fischer and Onyango, 2012). As a result of the directive, all member states of the EU had to comply with new processes regarding development projects. These directives have been altered since then, most recently in 2014, and codified into a single act; currently the revised Directive 2011/92/EU is in force in the EU (European commission, 2022). The purpose of this was to help alleviate administrative burdens, and to streamline the process without negatively affecting current safeguards in place (European commission, 2022).

Within the UK, the legislation regarding EIAs is currently governed by the Town and Country Planning (Environmental Impact Assessment) Regulations 2017, and stems down from the EU directive (gov, 2020). The understanding of the EIA process and its effectiveness has been improving over time, with more countries adopting such practices and new acts being adapted (Fischer and Onyango, 2012; Zhang, Kørnøv and Christensen, 2013). Projects fall within one of two categories, Annex 1, where EIAs are mandatory due to scale of the projects and their potential impacts, and Annex 2, where the national authority decides on a case by case basis whether an EIA is required (Dobрева, 2018). In Wales, the Well-being of Future Generations Act 2015 is an act that promotes sustainable development, research and public transparency regarding development projects (Welsh Government, 2015). As such, Wales adopts policies enforced by the EU and the UK, on top of independent domestic policies regarding environmentally friendly development. Any public bodies taking part in development in Wales must adhere to all policies in place before undertaking construction (TLSB, 2014d; Welsh Government, 2015; Orford and Henderson, 2017). In addition to this, the UK and Wales also have specific laws in place regarding development of marine environments, due to the UK's high potential of benefiting from such developments (Willis et al., 2010; Hamlyn, 2015). One of these is the Coastal Access Act 2009, first brought forward by the Department for Environment Food and Rural Affairs (Lyness, 2009; Willis et al., 2010). Resulting from this, any developments must first provide a description of the development, reasonable alternatives in technology and design, baseline of the area, significant impacts the development may have on the environment, as well as ways to prevent or mitigate potential impacts (Orford and Henderson, 2017). Public opinion is also included within EIAs, as developments will have impacts on the human population in the area, and so more weight has been given to public opinion in regards to decision making (UNECE, 2014). All these factors will impact decision making and will ultimately decide whether a project is able to proceed or not.

2.2 The EIA Process and Stages

The EIA process has been adjusted, outlined, and standardised, so that thorough assessments can be carried out regardless of location or project type (gov, 2019; European commission, 2022). The UK government requires developers to use third party contractors to carry out EIAs in advance of any developments taking place. The EIA process is broken down into five stages, which are outlined in the Town and Country Planning Regulations 2017 as follows:

Screening: This stage is a preliminary assessment of the project to determine whether or not it falls within the scope of the Regulations (gov, 2020). The project is also assessed on whether it will have significant impact on the environment, thereby deciding whether an EIA is necessary to proceed. Projects are likely to require an EIA if they are large in scale or situated along conservation areas, SSSIs (Sites of Special scientific Interest) or areas vulnerable to anthropogenic intervention such as wetlands.

Scoping: This stage is used to determine the extent of possible impacts that need to be assessed and reported within the EIA (gov, 2020). Within this stage, the applicant may ask the local planning authority for information that may need to be considered within the EIA. This is known as a 'scoping opinion' and may be beneficial to the applicant due to local authorities often possessing useful information and can provide a preliminary opinion of aspects that may need to be assessed during the EIA process (gov, 2020). This stage can be particularly useful to plan the EIA in a way that makes approval most likely during later stages.

Preparing an Environmental Statement: The project only progresses to this stage where it is decided by the planning authority that an EIA is necessary for the project to continue. The Environmental Statement must be submitted, including information listed under the Town and Country Planning Regulations, specifically regulation 18(3) in compliance with regulation 18(4) (gov, 2020). Additionally, the planning authority is required to provide any relevant environmental information they possess to aid the applicant in the process. The report must be completed by competent experts, whose relevant qualifications and expertise must be outlined by the developer along with the Environmental Statement (gov, 2020). Qualifications and third parties that can certify an expert in the field include CIEEM and BREEAM, both organisations that specialise in conducting EIAs (CIEEM, 2019; thomsonec, 2023). This is to ensure high quality and completeness of the report, making sure the third party that carries out the EIA is qualified to do so.

Making a planning application and consultation: During this stage the Environmental Statement and the development application are publicised through electronic means, along with a public notice within the local area of the project (gov, 2020). During this part consultation bodies must all receive a copy of the application, either through the applicant or local planning authority. This is to give the consultation bodies and the public concerned an opportunity to discuss and provide their views and opinions on the project and EIA before development commences (gov, 2020; UNECE, 2014).

Decision Making: This is the final stage where the Environmental Statement along with any extra documents which will affect the decision, including comments, representations and public opinions, are submitted to be taken into account by the local planning authority (gov, 2020). The planning authority or Secretary of State will decide whether the project is granted consent for development. The public and any relevant parties are informed of the decision, along with the reasoning behind it, publicly and electronically, to ensure transparency and avoid misinformation.

The five stages are a guide to the process; however, it does not always proceed in that specific order (Fig. 1). This is due to possible revisions which may be necessary for the project to proceed (Environment Agency, 2002).

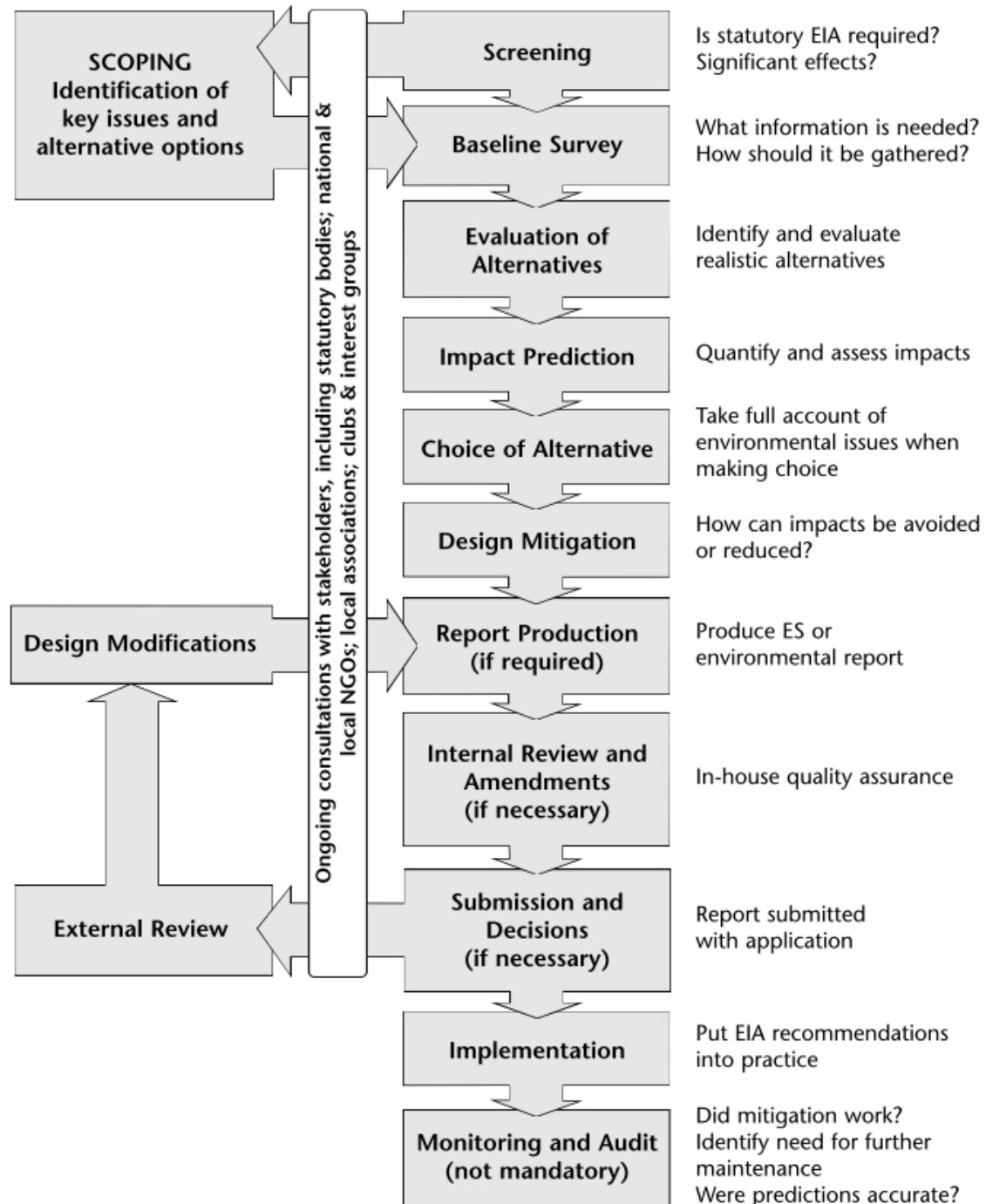


Figure 1. Key steps in the EIA process: The flow diagram shows how some of the stages in the process may be altered or repeated as a result of reviews and alternative options. The project is then altered to fit new requirements, after which the steps are repeated to see if the new version of the project is suitable for development (sourced from Environment Agency, 2002).

2.3 Concerns

The regulations and policies have been evolving and changing since their introduction by the EU in 1985 (Fischer and Onyango, 2012). This is due to ever changing technologies and advancements in environmental sciences, exposing new gaps in knowledge and legislation (Gonzalez and Enríquez-De-Salamanca, 2018). This means that even in current legislation, there may be gaps and omissions due to missing research or knowledge. This can especially be an issue since development projects can differ greatly in scope and purpose, resulting in legislations being vague to fit potential future projects. One such example can be found in the Town and Country Planning Regulations 2017, where the requirement of environmental statements being prepared by a 'competent expert' can be found (gov, 2020; legislation.gov, 2017). The term 'competent expert' is not clearly defined, and can be up to interpretation. Many organisations such as CIEEM (Chartered Institute of Ecology and Environmental Management) and BREEAM (Building Research Establishment Environmental Assessment Method) are reputable organisations which train experts and provide qualifications to prove their expertise. This however, is not guaranteed to be the case for all organisations. There is no universal government standard to hold 'competent experts' to, and as such the lack of definition can potentially lead to poor quality EIAs. This however can be mitigated by revisions, public opinions, and representations of EIAs during later stages of the process, which is why such steps are necessary to accurately assess potential projects. Yet, this does not guarantee all EIAs to be carried out to the same standard.

Most development projects will be marine, or on solid ground, however some projects can be both. This can create challenges for developers in the case of renewable energy projects due to all developments connecting to the national grid (Willis *et al.*, 2010; Hamlyn, 2015). Due to this, construction rights need to be obtained for marine parts of the project, as well as inland parts that may need to cut through public or private property (Hamlyn, 2015). This can complicate planning due to each component being under different jurisdictions and having differing levels of sovereignty on a national or international level, especially in the case of marine projects (Glasson and Bellanger, 2003; Hamlyn, 2015). This usually results in delays in developments due to legal challenges that arise in obtaining proprietary rights for construction on land and water (Hamlyn, 2015). For coastal projects this is usually not an issue, due to coastal waters being governed by local authorities. Additionally, some of the current legislation present in the UK originally stem from EU directives, and as such contain similar standards and requirements to international laws within Europe (Hamlyn, 2015; Orford and Henderson, 2017; Dobрева, 2018). In the case of development projects in international waters, legal issues may arise due to international and national law potentially having differing requirements for construction (Hamlyn, 2015; Dobрева, 2018). Differences in law can lead to differing requirements between states that lead to higher costs of preliminary assessments, as well as delays in obtaining permits and rights for construction. In the case of large-scale projects, this can lead to significant costs and delays, affecting the feasibility of development in the long term.

3.0 Case study: Tidal Lagoon Swansea Bay (Generating Station)

3.1 Background and key information

Climate change and greenhouse emissions have been a widely discussed topic globally in the past decade, with high amount of pressure being put onto governments to encourage and develop renewable energy (Roche *et al.*, 2016; Moreira *et al.*, 2022). The Swansea Tidal Lagoon would have been the first energy producing lagoon in the world, situated by the Swansea docks in the Swansea Bay area (Fig. 2) (TLSB, 2014e; Langley and Evans, 2017). This meant the technology is still in its early stages of adaptation and has not been tested in this context yet. The proposed development would have potentially generated average electricity to power ~120,000-155,000 homes, alternatively equating to around 70-89 percent of Swansea Bay's annual domestic electricity use (TLSB, 2014e; Petley and Aggidis, 2016; Roberts *et al.*, 2018; Moreira *et al.*, 2022). The project was almost entirely privately funded, however the UK government should have provided funding based on the HMT Guarantee scheme, to help alleviate debt where market conditions constraint organisations from making use of typical lenders such as commercial banks (Hendry, 2016). The Swansea Lagoon was rejected in the end by the UK government, due to a high initial cost for a low energy return with relatively high strike price on electricity, when compared to other potential projects utilising wind and solar energy (Guo, 2022). One aspect that was not entirely considered was the longevity of the project, with a 80 year energy plan and possible 120 year operating life, compared to shorter operating life spans of solar and wind farms (TLSB, 2014e; Guo, 2022).

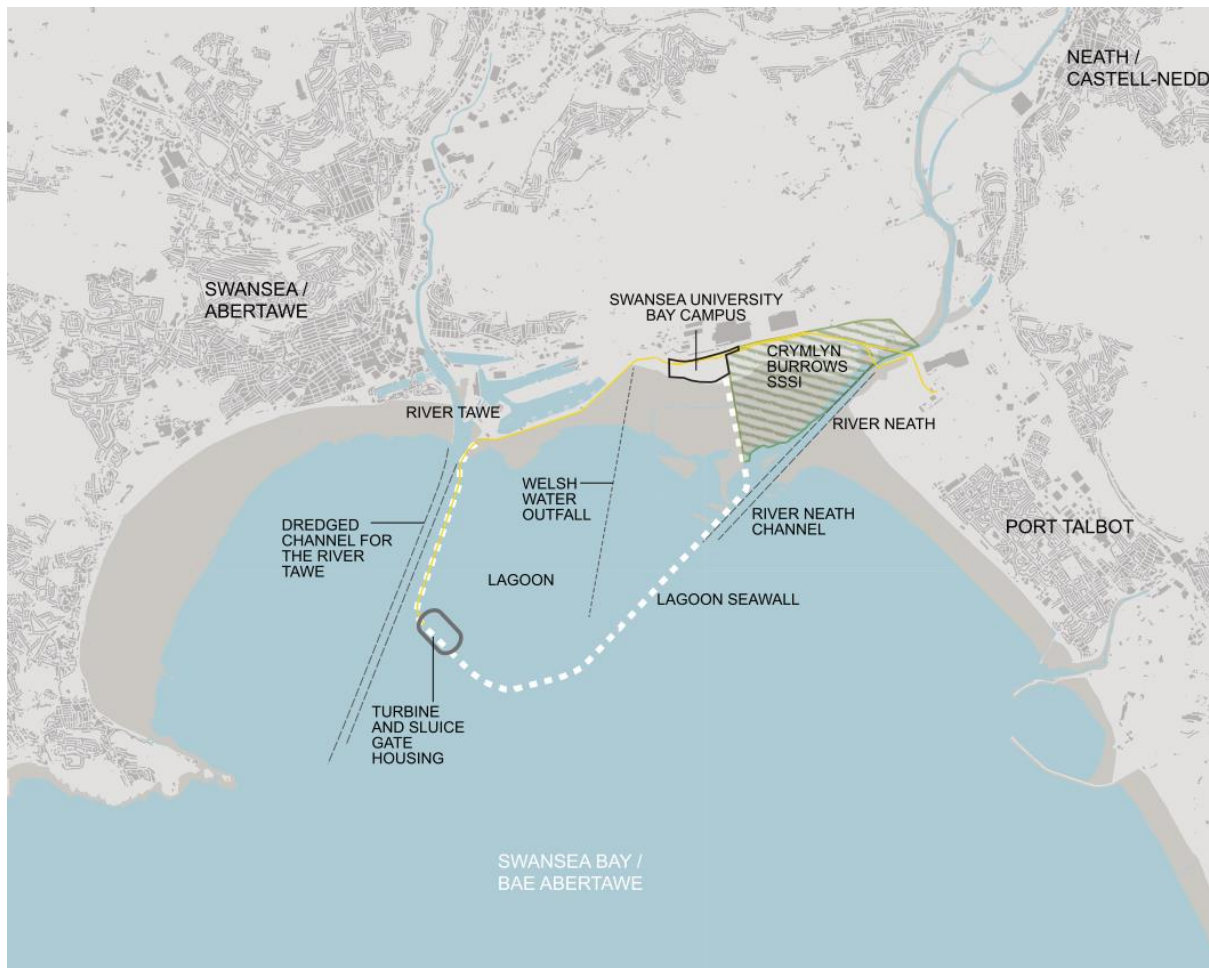


Figure 2: The proposed development area. Situated in the Swansea Bay, the Western part of the lagoon connects to the Swansea docks, right of the mouth of the river Tawe. The Eastern section connects to land by Swansea University Bay Campus, bordering the Crymlyn Burrows SSSI by the mouth of the river Neath (Sourced from TLSB, 2014e).

The lagoon itself produces energy using the tidal movement in the bay. 16 bi-directional turbines with a diameter of 7m within the array would produce the energy, using sluice gates which would control water movement in and out of the lagoon (TLSB, 2014e, 2014c; Petley and Aggidis, 2016). Water would be kept in the lagoon during low tide, and water would be kept out during high tide. This creates a constant water level gradient, allowing electricity to be generated during both high and low tides (TLSB, 2014e; Petley and Aggidis, 2016; Roberts *et al.*, 2018). With the Swansea Bay having an average spring tidal range of 7.5m, it has very high potential for effective electricity generation (Thomas, Phillips and Lock, 2015; Roberts *et al.*, 2018). The lagoon also featured off coast buildings for public use, as well as public swimming areas, safe places for water competitions, ecological parks, routes for pedestrians and cyclists, and public transport routes (TLSB, 2014e). This aimed to encourage the local public's use of the lagoon and bring in tourism to the city of Swansea. As the first energy producing lagoon in the UK, apart from helping reach UK's renewable energy goals, this was a potentially positive impact on local culture and appeal to a wider audience across the UK.

There are a number of legislations that this project fell under. A marine license under the Marine and Coastal Planning Access Act 2009 was required for the project to proceed (Lyness, 2009; TLSB, 2014; naturalresources.wales, 2022). The application for the license was submitted concurrently with the planning application. Along with this application, the Development Order Form, the Environmental Statement, Consultation report were submitted to the Planning Inspectorate, including Natural Resource Wales (TLSB, 2014e). Additionally, an EIA was carried out due to the Marine Works Regulations 2007 (TLSB, 2014e). Electronic copies of all documents were sent out to concerned public parties, and hard copies were made available to the general public in multiple locations in the Swansea Bay area (TLSB, 2014e). This project followed all major directives and laws concerning development, and effort was made to provide the public with as much information as was available. This resulted in the planned development process being transparent, and majority of information on the project is still readily available on the Tidal Lagoon Power website ([tidallagoonpower](http://tidallagoonpower.com), 2023).

3.2 Environmental Statement

3.2.1 Preliminary scoping, consultation, and positioning

Preliminary research on the project was conducted as part of the application and EIA process (TLSB, 2014b). This is reported in chapter 2 of the ES conducted by Tidal Lagoon Swansea Bay, however a copy of the preliminary report is not readily available. A link to the website containing the document no longer exists, and as such obtaining a copy of the report was unsuccessful. This could be due to the project being denied, and so information on the project has been made unavailable on certain government websites. The project itself falls within Schedule 1 Regulation 15 of EIA regulations, which is a dam or other project which is designed to store or hold over 10 million cubic metres of water (TLSB, 2014b). This means the project automatically required an EIA to be conducted (Dobreva, 2018; gov,2020). In 2012, the applicant requested a scoping opinion form the Planning Inspectorate, and this document was granted in accordance with legislation. The preliminary scoping found 19 factors for consideration, including local fauna, water quality, sediment transport, visual impact, and cultural heritage to name a few (TLSB, 2014a, 2014b, 2014e). The seabed feasibility was also assessed based on possible locations, to give the EIA a clearer definition of near-field and far-field areas to be studied during the following EIA stages (TLSB, 2014e). Preceding and following the initial scoping, continuous consultations and presentations were carried out with consultees and the general public between 2011 and 2013 as a way to start and continue engagement with concerned parties, as required by law in the case of this project (TLSB, 2014b; UNECE, 2014; Hendry, 2016; Dobreva, 2018). The practices displayed here followed legislation appropriately. However, due to the unavailability of the scoping report, it is difficult to comment on whether it followed government standards and legislations. From the rest of the available reports, it can be concluded that legislations were followed accurately, and consultees along with the general public were satisfied with the standard of the report submitted with the application. In this case continuous consultations with concerned parties would allow for mistakes and issues in the report to be identified and rectified before the project proceeded to the next stages.

For this project, multiple locations were considered during the planning stage. The location was selected on a number of factors, some of these including the tidal range, beach profile, position of the landfall, and potential turbine depth (TLSB, 2014c). With Swansea Bay being a shallow bay with a low sediment depth gradient and a high tidal range, it was a favourable spot when compared to other options (TLSB, 2014c; Hendry, 2016; Petley and Aggidis, 2016; Guo, 2022). Swansea Bay is a mostly inhabited area, and so factors such as potential impacts to water quality of public swimming areas was taken into special consideration (TLSB, 2014c). Many iterations of the lagoon design are provided, with the one with minimal impact to formerly mentioned environmental factors was selected (TLSB, 2014c). For example, the turbines were positioned facing south to westerly waters, to maximise potential electricity production, while having minimal impact of water quality within Swansea Bay (TLSB, 2014c; Roberts *et al.*, 2018). This development came as a result of consultations with local public authorities and general public, while providing numerous options and alternatives to proposed development. Due to this, an informed decision with possible options took place, resulting in minimal impact to the environment, while still providing benefits of the project.

3.2.2 Possible impacts and additional mitigation

During the process of the EIA, 19 possible impacts were identified (TLSB, 2014a, 2014e). Out of these 19 possible impacts, not all of them required additional mitigation measures. Majority of impacts were nullified or kept to a minimum due to the design of the lagoon; for example, the benthic ecology, and sediment transport saw small to negligible impacts across the bay, and water quality saw a possible improvement inside the lagoon (TLSB, 2014e; Langley and Evans, 2017; Horrillo-Caraballo *et al.*, 2018). This is a potential positive impact in the bay, and as such is in line with European and local legislation, despite potential initial negative impacts (Welsh Government, 2015; Dobрева, 2018).

In other cases, few to several mitigation measures were proposed, depending on the significance and extent of possible impacts. In the case of marine mammals, potential impacts were significant, and as such more mitigation measures were proposed. With most impacts occurring during construction due to noise, vertical piling techniques have been proposed, and in the cases of percussive drilling, the project would follow the Joint Nature Conservation Committee piling protocols to mitigate impact (TLSB, 2014e). Additionally, in the cases of benthic species, the lagoon wall was designed to promote ecological growth, partially to promote growth of vulnerable species such as the honeycomb worm (TLSB, 2014e). This promotes local fauna coexisting with new infrastructure, and is in-line with local legislations, such as the Well-being of Future Generations Act 2015, which promotes green infrastructure in Wales (Warren, 2010; TLSB, 2014e; Welsh Government, 2015). This legislation can potentially help local species, and in the case of the lagoon, can promote growth of rare species local to the area. The lagoon wall is promoting growth by being constructed from local and imported sediment. This idea is good in theory; however, the acquisition and transport of such materials can be negatively impactful in regard to greenhouse emissions. The rock armour that covers the barrier was predicted to produce over 50,000 tonnes of carbon dioxide during manufacture (Simon, 2015). This is not mentioned in the report and can be a factor omitted by legislation. This proposes a potential gap in assessment, as further research was only done by independent researchers, and was not a standard part of the EIA. The process of examining such impacts can be difficult and costly, however it could provide a more accurate insight into actual carbon emissions compared to emissions negated by the use of renewable energy. This can be especially significant in large scale projects with long life-spans, however could also be applied to smaller projects or where the life span is not as long.

A Seascape and Landscape Visual Impact Assessment (SLVIA) was conducted as part of the EIA. Potential landscape and seascape impacts were identified within a 15km area around the designated project area (TLSB, 2014e). The SLVIA was conducted under the definitions stated by The Landscape Institute & Institute of Environmental Management and Assessment (IEMA) in 2013 (TLSB, 2016). Since the construction area was mostly within an industrial and maritime environment, the landscape area would be negligibly affected (TLSB, 2014e). After revaluation, a possible impact was brought forward in the form of the cable that would connect the lagoon to the national grid. The 275kV cable was therefore housed underground, so visual impact would be limited to the construction phase (TLSB, 2016). In this case, due to possible impacts being discovered after the EIA was conducted, the project details were amended in 2016 as to accommodate these changes based on guidelines outlined by IEMA. This presents a scenario where an impact was not initially considered during the EIA stage, however, was mitigated with further consultation.

4.0 Conclusion

EIAs in the UK have been under constant amendments and revisions since their initial adoption into law from the EU directive (Fischer and Onyango, 2012; Dobрева, 2018; gov, 2020; gov, 2021; European commission, 2022). This is as a result of the field constantly growing and evolving, with changes to legislation being necessary due to new techniques and concerns being discovered to ensure highest possible standard of EIAs being carried out across the UK. With the primary purpose of EIAs being prevention of environmental impacts and mitigating impacts where possible, since their introduction many changes have been made to further promote environmentally friendly development. Many potential impacts are regulated and taken into consideration depending on the project type and location, to allow the best potential examination of impacts projects may have on the environment. Within this process, there exist gaps concerning certain vague definitions, as well as issues when development is both inland and marine simultaneously (Hamlyn, 2015; Dobрева, 2018). Vague definitions allow legislation to be applied to a wider range of projects without overly complex explanations, however, can lead to misunderstandings or potential errors in the EIA process due to interpretation. In some cases of marine and inland projects, differences in legislation between land based and marine projects may lead to delays of projects and increased costs, potentially decreasing the feasibility of a project based on legal expenses. It is suggested that more specific definitions could be provided, not with less room for interpretation, but rather more standardised levels of responsibility to which experts and developers are held.

Some aspects of development are yet not required by the government as part of the EIA process. One example identified in the case study was greenhouse gas emissions as part of material production and transport. These gas emissions are not necessarily part of the construction itself and is handled by external parties, however these emissions still contribute to climate change, and as such should be taken into consideration (Simon, 2015). Such studies are undertaken by independent researchers, and as such should not be impossible to conduct by large companies working with multiple consultant third parties. Research such as this being part of EIAs could further display the impact development may have on climate change, especially in the context of projects promoting renewable energy. All renewable energy products produce greenhouse emissions during material production and transport, however knowing these amounts can give a more accurate representation of real impacts projects have on climate change.

Overall, the current processes and legislation in the UK and Wales concerning EIAs are satisfactory and provide a comprehensive break down of impacts development may have on the environment. It is not however perfect, and there is still room for improvement in legislation, as well as the process itself. When the legislation is followed appropriately, even large-scale projects such as the Tidal Lagoon in Swansea can be approved based on low environmental impact, however even then in some cases funding can be the ultimate issue which leads to a project not being approved.

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