UK Space Energy Initiative: Environmental Impact Assessment Scoping Review of an Offshore Rectenna in Scotland

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DOI https://doi.org/10.59332/jbis-076-01-0029

This paper will present the results of an environmental impact assessment scoping report which was conducted to gain a professional scoping opinion on the development of a hypothetical offshore rectenna site located in the Highlands and Islands local authority region to enable space-based solar power to the UK. The construction, operational and decommissioning phases of the development will be discussed throughout the paper with a specific focus on environmental impacts. Different levels of UK and Scottish policy and legislation will be used to highlight the requirements and contribution of the development towards sustainable development. Furthermore, it will allow for a deeper understanding of how the development can aid the 78% UK emission reduction target by 2035 and the UK net-zero target by 2050. Policy covered in this scoping report includes Space Policy, Renewable Energy Policy, Climate Change Policy, Research Policy, Conservation Policy and Planning Policy. Overall, this scoping report has been prepared to address likely significant impacts that the proposed rectenna site might have on the environment.

Keywords: Space Solar Power, Environmental Impact Assessment, Energy Systems, Sustainable Development, Environmental Governance

1 INTRODUCTION

This paper synthesises the pertinent details of a Scoping Report which was commissioned by the UK Space Energy [1]. The study was initiated to provide a professional scoping opinion on the development of a hypothetical offshore rectenna site located in Scotland to enable SBSP (space-based solar power) to the UK. The rectenna will be designed to receive energy sent wirelessly from a solar power satellite (SPS) in Geostationary Orbit (GEO). Therefore, the study will summarise likely significant impacts of the development ahead of a formal EIA (Environmental Impact Assessment). This includes a summary of the development, the potential effects of the development (including assessment of their significance) and the measures proposed to minimise adverse environmental effects.

This paper will discuss likely impacts from the construction, operational and decommissioning phases of the development, with a specific focus on environmental impacts. The categories to be considered are the offshore physical environment, offshore biological environment and offshore human environment. Different levels of UK and Scottish policy and legislation will also be discussed to highlight the contribution of the development towards national sustainability ambitions. This will allow for a deeper understanding on how the development can aid the UK emissions reduction target of net-zero by 2050 [2].

This paper was first presented at the 19th Reinventing Space Conference, 28-29 November 2022, Aerospace Bristol, Hayes Way, Patchway, Bristol, BS34 5BZ, UK.

2 DESCRIPTION OF THE PROPOSED DEVELOPMENT

2.1 Site Description

As there has been no preferred UK location provided for the development of an offshore SPS rectenna, various existing offshore developments were investigated for potential siting solutions. Due to various suitability factors such as existing infrastructure and undeveloped marine area within the proposed region, an opportunity for potential siting of an offshore SPS rectenna has been identified in the proximity of Beatrice Offshore Windfarm in Moray Firth, Scotland (Fig. 1).

The site of Beatrice Offshore Windfarm is 13.5 km seaward from the Caithness Coastline in Scotland and covers an area of 131 km^2 [3]. There are 84 operational offshore wind turbines which are expected to increase to 277 in the near future [4]. A total area of 148 km^2 to the North-West of the windfarm has been considered for siting the rectenna. This was because it was estimated that an area of 130-148 km^2 would need to be added to the Beatrice Offshore Windfarm development to host the rectenna, calculated through desk-based research.

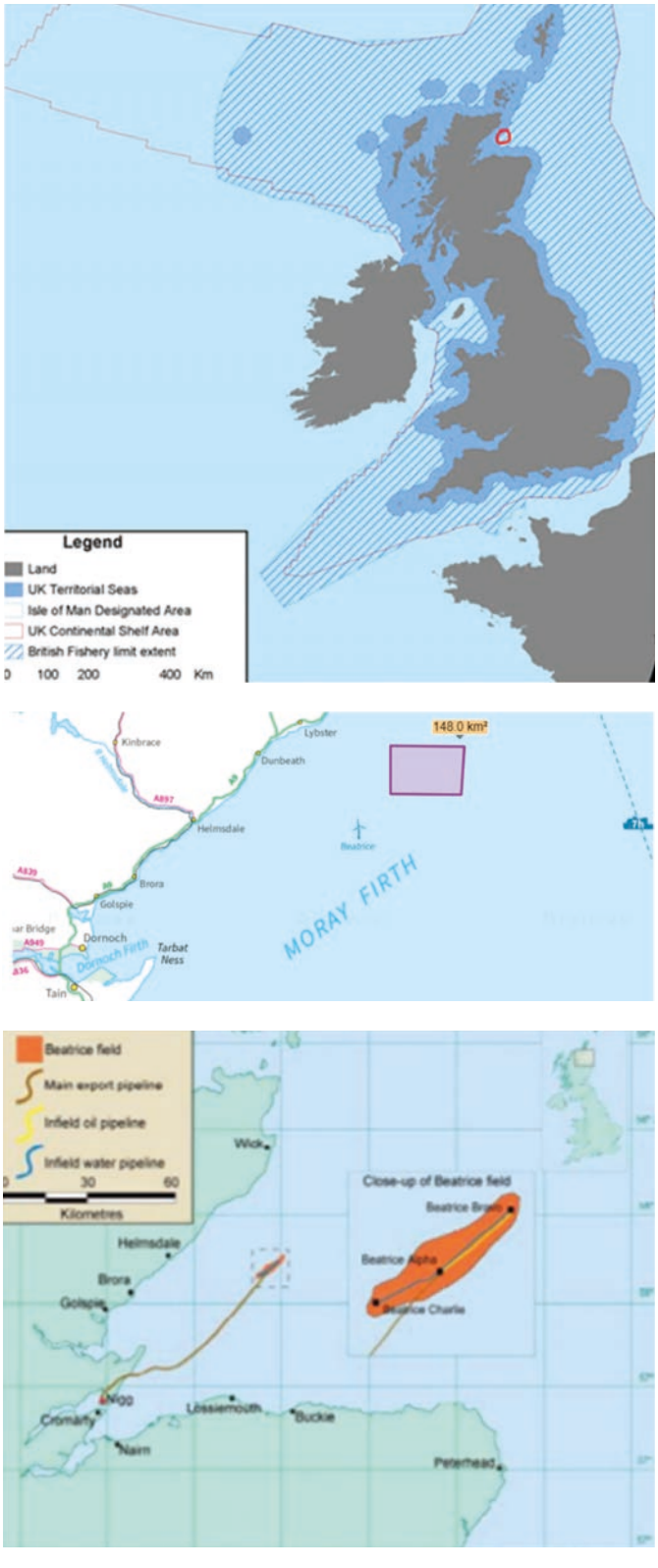

Fig.1 Site layout and extent (adapted from [6, 7, 8]).

A potential limitation of the selected site could lie in the Scottish marine territory boundary as the development would be likely fully or partially located beyond this boundary. However, it would still fall under British Fishery limit extent area [5]. Due to the size required for siting of the SPS rectenna, alternative solutions would be locating the rectenna within/in the proximity of operational/non-operational oilrig areas as well as other renewable energy sites such as offshore solar.

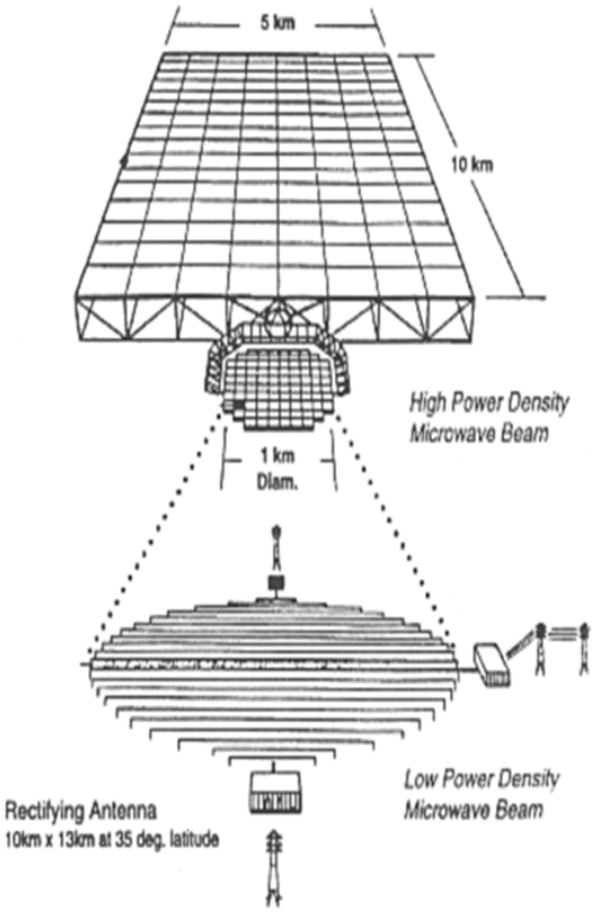

Fig.2 NASA/DOE SPS Reference System Rectenna Design [9].

2.2 Proposed Development Design

Although the final rectenna design is likely to use a more modern design approach, a lack of data on rectenna design forced use of the DOE/NASA SPS Reference System offshore rectenna design [9] (Fig. 2). It is hoped that advancements in the SEI technology roadmap will produce upgrades and modifications in advanced planning stages of UK rectenna design.

Regardless, the rectenna design is based on an adjusted version of the DOE/NASA SPS Reference System offshore rectenna study [10], suited for a 2GW CASSIOPeiA system [11]. In this regard, the rectenna size has been adjusted from 10 km × 13 km (onshore) to 10 km × 14.7 km (offshore) and then reduced by approximately 35 km² when used for CASSIOPeiA, since the rectenna model for the Reference System is sized to receive 5 GW. As such, the adapted version of the open reference system rectenna consists of the following:

- Half-wave dipoles feeding Schottky barrier diodes.
- A series of serrated rows of panels. Each panel has a steel mesh ground plane with 75-80% optical transparency. This mesh is mounted on a steel framing structure, supported by steel columns in concrete footings. Aluminium conductors are used for the electrical power collection system.
- A submersible float system. Four types of structures were suggested: submerged buoyant platform, piled structure, gravity base structure or piled guyed tower. For the purposes of this study, a submerged buoyant platform was considered as it more closely resembles modern rectenna designs.

2.3 Development Phases

2.3.1 Construction & Assembly

The construction of the rectenna would start when consent for the development is granted by the UK Government. The work would be carried out by chosen contractors and is likely to take several years. Following are some likely construction activities:

- Temporary compound area construction on the coastline, and/or within the offshore windfarm area.
- Adjustments of the access routes.
- Seabed adjustments for rectenna floating system foundations (subject to the float system choice).
- On land/seabed electrical installations (cables, transformers, etc.).
- Delivery and installation of the rectenna and construction of new control room spaces.

Environmental management measures should be put in place to minimise the area disturbance and waste generation.

2.3.2 Operations

The environment around the rectenna site should be continuously monitored and the rectenna regularly maintained as required. The full operation period is unknown at this stage, but is likely to last at least 30 years per rectenna.

2.3.3 Decommissioning

Site restoration activities may be carried out should the rectenna's operational phase come to an end. Operating equipment and components shall be removed from the site or repurposed, with the seabed being restored to its original state (prior to construction) if possible. Should the rectenna operator wish to extend the rectenna's life, a new assessment will be required at that time.

3 LEGISLATION, REPORT AIMS & METHODOLOGY

3.1 Policy & Legislation Context

3.1.1 Space Policy & Legislation

National Space Policy [12] within the UK exists to show the UK government's support of space industries and describes how they will compete with the changes happening within the space industry. In this policy, the government has put forward its ambitious target to grow the UK's share of the space market globally from 6.5% to 10%.

This piece of legislation links the National Security Strategy [13] and the UK Civil Space Strategy [14], aligning with the Government Science and Innovation Strategy [15]. It looks at different space technology in the long-term and the manner in which it should be used. The National Space Policy also regards the importance of space to different economic issues, public services, science and innovation as well as national security. Relevant policies within the framework are:

- Government supports the growth of a robust and competitive commercial space sector, underpinned by excellent academic research.
- Government commits to cooperating internationally to create the legal frameworks for the responsible use of space.

3.1.2 Renewable Energy Policy & Legislation

The UK Energy Act [16] is a piece of legislation which allows a decarbonisation UK target to be set for 2030. Under this, there have been measures put in place to bring in more than £100bn of investment into the energy markets to manage the increase in demand that will occur over the coming years. In addition to this, there has been implementation of specific provisions to allow the sale of storage systems and government pipelines. Lastly, there have been an introduction of policy statements to tighten and improve regulations in relation to the UK energy systems. Since the rectenna is new technology in relation to space-based solar power, there are very few specific policies to include on the technology, meaning it is largely unregulated.

Moreover, the Scottish Renewable and Low Carbon policy [17] lays the foundations for the future energy systems which is also applicable to space-based solar power. In doing this, there is huge potential for industrial and economic growth. It lays down policies which are aiming to help reach the ambitious targets set out within the Climate Change Act (2008) [18] and Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 [19]. Going forth with an SPS system could contribute to meeting these targets set by the Scottish Government.

3.1.3 Climate Change Policy & Legislation

Despite the increasing demand in energy generation, the UK has ambitious targets in relation to reducing Greenhouse Gas (GHG) emissions. The Climate Change Act (2008) [18] is the origin of the GHG emission targets for the future and highly encourages new technology and activities that will promote the reduction or removal of GHG emissions from the atmosphere, in line with the commitments made under the Kyoto Protocol [20]. Additionally, it has brought together a committee on climate change as well as establishing a new system for carbon budgeting, which in turn will help to meet targets put forward by the act. Included within the Climate Change Act (2008) is the target for net-zero, aimed to be completed by 2050. However, from a Scottish perspective, the Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 [19] made changes to the Climate Change (Scotland) Act 2009 [21] by reducing Scotland's GHG reduction to net-zero by 2045, five years before the UK target. Therefore, ensuring that the overall development falls in line with achieving this goal is a vital consideration.

The Carbon Budget Order 2021 [22] is a piece of legislation which set carbon budgets during the budgetary periods and falls in accordance with the Climate Change Act (2008). It requires the UK to comply with European and International obligations which it must follow. The Climate Change Committee recommends these carbon budgets based on detailed scenarios for reducing emissions from each sector of the UK economy. Alignment with these pathways is vital since the development is marketed as a renewable baseload technology.

3.1.4 Research Policy & Legislation

The UK Research and Development Policy [23] aims to improve the UK for innovative business owners and ensure the nation excels in running businesses and services. It describes a large fund of £4.6bn that has been kept aside for scientific research and ensuring publicly funded research is accessi-

ble for everyone. This includes a UK Innovation Investment Fund [24], which invests in small businesses involved in clean technology and uses the government's purchasing power to drive innovation. This in turn encourages small businesses to develop and advance new, tech-based products and services. Since space-based solar power is a new clean technology, this would fall under this category within the policy. In addition to the UK Innovation Investment Fund, this policy also encourages the bringing together of a variety of skills, knowledge, technical resources and capital to promote world leading science.

3.1.5 Conservation Policy & Legislation

The Marine (Scotland) Act 2010 [25] is applicable for offshore developments. Under this Act, the development must "make provision in relation to functions and activities in the Scottish marine area, including provision about marine plans, licensing of marine activities, the protection of the area and its wildlife including seals and regulation of sea fisheries, and for connected purposes." This protects marine areas within the Scottish territory and ensures that any offshore developments such as the one detailed within this paper contributes to sustainable development. In addition, it also ensures that negative impacts on the marine environment are minimal.

3.1.6 Planning Policy & Legislation

The National Planning Framework 3 (NPF3) [26] aims for Scotland to be "a successful, sustainable place, a low carbon place, a natural, resilient place and a connected place." In particular, this relates to the proposed development in the following ways:

- **A Successful, Sustainable Place:** to ensure that all parts of Scotland make the best use of their assets to build a sustainable future. Planning helps to create high quality, diverse and sustainable places that promote well-being and attract investment. In addition, emerging technologies for renewable energy are specifically mentioned as being imperative towards "changing our understanding of what constitutes a sustainable community." Together with the NPF, this ensures that developments facilitate adaption to climate change, reduce resource consumption and lower GHG emissions.
- **A Low Carbon Place:** one of the main aims is to reduce GHG emissions in line with Scottish targets with a particular focus on investment for renewable energy infrastructure. This includes electricity grid enhancements to facilitate increased renewable electricity generation across Scotland. This can be considered essential for unlocking renewable resources for onshore as well as offshore.
- **A Natural, Resilient Place:** aims to respect, enhance and make use of natural and cultural assets, with a focus on protecting the environment and biodiversity during development. The Scottish Government's Land Use Strategy [27] also sets out key principles for the use of and management of Scotland's land.
- **A Connected Place:** the aim is to maintain and develop good internal and global connections. The Infrastructure Investment Plan [28] by the Scottish Government sets out a programme for investment in all modes of transport and other infrastructure. It emphasises the importance of how a place looks to ensure that all of Scotland derives benefit from infrastructure investment, maximising potential and reducing disparities.

Additionally, Scottish Planning Policy [29] is also an important consideration as it relates to nationally important matters that involve land use. Falling in line with the NPF3, the main objective of this policy is for planning to contribute to sustainable development. In this sense, it relates to the preparation of development plans, the design of the development and the determination of planning applications and appeals.

Additionally, Scottish ministers can issue guidance to planning authorities on requirements of a development to contribute to sustainable development. However, Scottish Planning Policy recognises that planning should ensure that the country is strengthening its natural assets and built environment when new developments are being carried out. One of the main concerns when it comes to design and layout is promoting energy efficiency and the use of low carbon technologies. In this case, it would be a rectenna site for renewable energy. Hence, the development plan should be in support of this assuming that significant impacts on the natural environment are not present and/or are mitigated.

Lastly, Local Development Planning must also be respected. The Inner Moray Firth Local Development Plan (LDP) [30] includes the area in which the offshore site is located. It is the first of three new development plans and stands alongside the Highland-wide LDP and supplementary guidance (forming the Highland Council's Development Plan which will guide future development in the Highlands) [31]. The Inner Moray Firth LDP describes where development can and cannot occur in the next 10-20 year timeframe. The area is the most populated part of the Highlands which means the demand for growth and development is high. Additionally, it contains some of the most important natural assets which must be protected when going ahead with new developments. The development should consider the full contents of the LDP.

3.2 EIA Scoping Process Aims & Methodology

An EIA assessment seeks to prevent, minimise and if required mitigate environmental impacts. The scoping is a systematic approach which initially assesses identified significant impacts. The key steps of the potential significant impacts' assessment are named below:

- Baseline information: Existing environmental conditions, likely receptors, data.
- Potential significant environmental impacts & initial assessment: Potential impacts in different development phases and related factors such as sensitivity, likelihood of reoccurrence or certainty.
- Mitigation & opportunities: Limitations, suggestions for further study and data acquisition, mitigation.

Each of the above steps will be investigated for the construction, operation and decommissioning of the proposed development across a range of issues relevant to the physical, biological and human environment. The relevant issues under each heading, as well as the information for assessing the environmental baseline of each were collected using desk-based research. In particular, these data were mainly derived from the Environmental Statements, Scoping Reports and EIAs of the Beatrice Offshore Windfarm development due to the proximity of and similarities to the development to the proposed rectenna site. Specificities of the rectenna development were considered against the baseline information collected,

in order to inform the other elements stated in the above list, using expert judgement. The main reason that this study approach was chosen was due to the fact that no preferred UK location has yet been outlined for the development of an offshore SPS rectenna. As such, it was not in the interests of the UK SEI to spend time, resources and energy on a site visit to a hypothetical rectenna location, which ultimately may not be chosen as the preferred site for the development.

4 SCOPING – LIKELY SIGNIFICANT IMPACTS

4.1 Physical Environment

4.1.1 Coastal Processes

Relevant coastal processes considered under this category include a range of marine physical processes as well as water and sediment quality as detailed below:

- **Tidal range:** The way tidal range changes through the Moray Firth, with the most available information being derived from the Renewables Atlas [32]. This source indicates that within the rectenna site tidal range varies between 2.8 and 3.1 m during mean spring tides and between 1.4 and 1.5 m during mean neap tides, with tidal range generally increasing westwards.
- **Tidal Currents:** The relevant data for tidal currents indicates that peak currents vary between 0.52 and 0.45 metres per second during a mean spring tide, and 0.26 and 0.22 metres per second during a mean neap tide [32]. Spatially, current speeds generally decrease towards the west.
- **Non-Tidal Influences:** Non-tidal surges are formed by rapid changes in atmospheric pressure [32]. These effects can cause water levels to fluctuate considerably above or below the predicted tidal level and have the potential to modify predicted current vectors for the rectenna site. The development of the rectenna will also have to consider predicted rising sea levels in Scotland.
- **Wave Regime:** The wave climate within the Wind Farm site is relatively active with an annual mean significant wave height ranging between 1.33 and 1.54 m. Instantaneous significant wave heights of 2-2.5 m are experienced in the Outer Moray Firth for approximately 10% of the year. The largest waves encountered within the Moray Firth will originate in the North Sea and approach the site from northerly through easterly or south-easterly sectors where the available fetch is relatively large. Wave heights will however be smaller and more spatially variable when the wind is from other directional sectors, due to the more limited fetch [32].
- **Marine Sedimentary Regime (Seabed Deposits):** A desk-based geotechnical site evaluation has been undertaken on behalf of BOWL by Senergy Survey & Geoengineering Ltd [33]. They report that the seabed of the Outer Moray Firth is predominantly fine sands down to a depth of about 50 m. Off Lossiemouth on the south coast of the Firth, at the mouth of the River Spey, there is over 100 km^2 of gravel deposits. Smaller patches of gravel are found along the northwest coast of the Firth. In the Inner Moray Firth, within the Special Area of Convervation (SAC), there are sandbanks that qualify as habitats. Seabed Mobility Marine sediment is thought to enter the Moray Firth from the north and migrates out to the southeast. There is, however, presently insufficient evidence to estimate the rate and direction of sediment transport, which will vary spatially and temporally depending upon the interaction between wind, waves and tidal currents and the local effect of deep channels, bank features, firths and headlands. Net sediment transport into and within the Moray Firth, including over the Smith Bank, is thought to be intermittent (limited in frequency) and related to low-frequency, high energy (i.e. storm) events. It is considered likely that sediment mobility will vary spatially across the Smith Bank and within the rectenna site, due to variations in water depth and relative exposure to waves.
- **Marine Sedimentary Regime (Suspended Sediment Concentrations)**: There is no evidence at this stage for significant quantities of fine sediment to exist in the surficial seabed sediments of the Outer Moray Firth. Therefore, it might be expected that intermittent peaks of suspended concentration will be observed, primarily as a result of storms, with a magnitude controlled locally by the wave intensity and water depth. An ecosystem model was used in Baxter et al. (2008) [34] to provide a map of suspended sediment concentrations in the North Sea including the Moray Firth. The reported range of depth mean values in the Firth was approximately <5-10 mg/L, however, the degree of validation or comparison against any in-situ samples was not reported.

Potential impacts of the rectenna development, both alone and in combination with other proposed developments, during each lifetime phase are identified below according to the Cefas (2004) [35] and COWRIE (2009) [36] guidance. During the construction phase, this includes an increase in suspended sediment concentration during installation of foundations or cables, or the initial phases of seabed scouring around foundations as well as seabed compaction or smothering in the footprint of foundations during construction, leading to mortality of sensitive marine life in these areas. Potential impacts during the operational phase which have been identified include changes to patterns of tidal currents and wave activity leading to changes in sediment transport pathways (suspended or bedload) and the form and function of the Smith Bank, impacting on sensitive receptors. There may also be impacts on swell waves and changes to erosional/depositional processes along the adjacent coastline impacting on morphology and consequently on sensitive receptors. During the decommissioning phase, the potential impact relates to an increase in suspended sediment concentration during removal of foundations or cables.

As a result of this, the potential cumulative and in-combination effects on coastal processes can be identified at this stage as those listed below:

- The interaction between plumes of sediment created by the coincident installation of foundations or burial of cables as part of the rectenna site developments during the construction phase, leading to enhanced levels of suspended sediment concentration or rates or thicknesses of sediment deposition, impacting on sensitive receptors.
- The cumulative changes to patterns of tidal currents and wave activity as a result of the presence of the rectenna site foundations in the operational phase, leading to changes in sediment transport pathways (suspended or bedload) and the form and function of the Smith Bank, impacting on sensitive receptors.
- The cumulative attenuation of waves as a result of the presence of rectenna site developments in the

operational phase, leading to greater changes or likelihood of changes in erosional / depositional processes along the adjacent coastline impacting on morphology and consequently on sensitive receptors.

To address the above effects on coastal processes and to these sensitive receptors, it is proposed that potential mitigation measures are investigated as part of a full EIA, the details of which are pending the outcomes of the assessments recommended above.

4.1.2 Geology

Senergy Survey & GeoEngineering Ltd [32] carried out a desk-based site evaluation of the development area. The evaluation found that the seabed of the Moray Firth generally comprises coarse sands and fine gravels. ERM (2010) report that offshore sediment is predominantly fine sands down to a depth of about 50 m, with the area off Lossiemouth, on the south coast of the Firth, consisting of over 100 km^2 of gravel deposits. Smaller patches of gravel are also found along the northwest coast of the Firth. During all phases of the development, impacts on geology are unlikely.

4.1.3 Air Quality

It is proposed that air quality be scoped out of the assessment as no negative impacts of significance are anticipated. However, air quality has also been covered by an independent LCA.

4.1.4 Noise & Vibration

Existing noise sources are likely from fishing and shipping activities and residential developments that are near the shoreline of the development - as well as natural sources such as waves and animal calling. The receptors to underwater noise were identified as grey seals, common seals, salmon, minke whales, harbour porpoises and bottlenose dolphins [37].

During construction and decommissioning, marine mammals and fish could be affected by underwater noise created through the movement of vessels, trenching and piling. In regard to impact on human receptors, this could be during constructing and removing rectenna components, and manoeuvring large vessels. However, potential airborne noise and vibration impacts during operational phases are likely to be minimal. Given the distances between the development (13.5 km to nearest coastline based on the siting of Beatrice Offshore Windfarm) and any noise sensitive receptor it is considered that airborne construction noise will not be significant [37]. However, during construction, marine mammal watches will ensure no marine mammals are in close proximity to the development before activities commence.

4.1.5 Traffic & Transport

It is unlikely that land-based traffic and transportation will have significant effects on the environment. Rectenna components will be delivered to a suitable port facility before being transferred to the site to be erected.

4.2. Biological Environment

4.2.1 Plankton

According to DTI (2004), phytoplankton off the northeast coast of Scotland are dominated by diatoms, dinoflagellates and pico/nanoplankton (the smallest plankton groups). The most frequently recorded taxa are dinoflagellates (*Ceratium*) which are increasingly dominating phytoplankton populations [38]. Comparatively, zooplankton populations are dominated by copepods, particularly *Calanus helgolandicus* and *Calanus finmarchicus*. Meroplankton are the larval stages of bottom living (benthic) species. They include echinoderms (starfish and sea urchins), decapods (crabs and lobsters) and coelenterates (jellyfish). The higher concentrations of meroplankton in the North Sea are not observed off the northeast coast of Scotland. Megaplankton are much larger zooplankton and include euphausiids (krill), thaliacea (salps and doliolids), siphonophores and medusae (coelenterates). This group are more abundant off the northeast coast of Scotland than in the rest of the North Sea but their numbers have been declining [37]. It is unlikely that plankton will be significantly affected by the development and can therefore be scoped out.

4.2.2 Seabed Marine Life

The Smith Bank supports a relatively rich seabed community of animals which are broadly representative of the moderately deep, moderately tide swept, sandy environments found in the North Sea. The animal communities living within the seabed are dominated by bivalve molluscs, polychaete worms and the amphipod crustaceans [37]. As such, the construction phase has the potential to have an impact on seabed disturbance and habitat loss due to installing seabed cables and substation foundations. During the operational phase, permanent physical habitat loss could occur as a result of each substation foundation and the rectenna. Furthermore, there is the potential for localised impacts on tidal flows and sediment transport as well as small changes in the makeup of benthic communities [37]. It is possible that boulder groups may be discovered within the boundary of the proposed development area.

Wherever possible, impact on these 'islands' of marine biodiversity should be avoided through a process similar to micro-siting of wind turbines and other seabed structures. The design of the foundations should be developed to minimise the required benthic footprint of the rectenna supports as far as possible. Additionally, modern cable laying approaches will minimise the area of disturbance caused by installation.

4.2.3 Fish Ecology

The Smith Bank area is identified, in full or in part, as a spawning and nursery area for a variety of fish species [37]. The species identified within the Wind Farm boundary are:

- Nursery: plaice, haddock, nephrops, lemon sole, sandeel, herring, saithe and whiting,
- Spawning: cod, lemon sole, nephrops, sprat, plaice, sandeel.

Herring and whiting also spawn within the Firth but no spawning areas are known inside the Beatrice Offshore Wind Farm site area. In addition, basking sharks are considered as an elusive species and have been observed during most summers within the Moray Firth [37].

The construction and decommissioning phases may result in seabed disturbance during the removal of seabed structures. This could result in a change of fish feeding and spawn-

ing patterns. Sensitive species (such as sandeel, herring and cod) may experience avoidance behaviour during construction and decommissioning as a result of underwater noise. However, during the operation of the development, it is unlikely that there will be significant effects on fish ecology. Impacts from the development are likely to be small and localised. However, in order to help minimise impacts on periods of spawning and nursing of species, the construction phase should be well-timed.

4.2.4 Marine Mammals

The main species in the area are common seals, grey seals, minke whales, harbour porpoise, common porpoise and bottlenose, white-beaked and common dolphin - the most common being harbour porpoises, and second common being minke whales. The Inner Moray Firth has the largest population of bottlenose dolphins in the UK and is home to breeding populations of common seals [37].

The construction and decommissioning phases could result in underwater noise due to movement of large structures. This could disturb the marine mammals. The operational phase could have impacts from the 'barrier effect' created by the presence of new structures within the marine environment [37]. However, research on UK offshore windfarms suggests that operational noise from the rectenna site is unlikely to have a significant impact on marine mammals [37]. The approach to foundation design and seabed attachment techniques should aim to minimise the impacts to marine mammals wherever possible. During the EIA, it is also likely that underwater noise limits (threshold levels) will be agreed and developed in consultation with the relevant statutory bodies. These limits will be based on the research and assessment undertaken and conclusions of the EIA.

During construction it is anticipated that, if required, marine mammal watches will be adopted prior to the start of any activities considered to be in exceedance of agreed noise limits. Watches will ensure activities do not commence with marine mammals in the immediate area. Techniques, such as 'soft starts', will allow time for sensitive marine mammals to leave the area before noisy operations commence [37].

4.2.5 Ornithology

The coastal and offshore waters of the Moray Firth are internationally important for populations of seabirds, seaduck, wader and wildfowl. Within the Moray Firth there are several protected areas that have been designated to protect these populations and it has been classified as a Special Protection Area (SPA) under the EU Birds Directive [37]. In addition, the eastern coastal section of the Scottish north coast between Peterhead and Duncansby Head contains seven SPAs. Of these, five are also designated as Ramsar sites. It is likely that there will be some degree of interchange between bird populations using these sites and other sites around the UK coast [37]. Breeding season for seabirds in the Moray Firth is from April to June. Species include razorbills, guillemots, auks and puffins. They disperse to feeding grounds further offshore to feed on sandeel and other prey fish species. In the Moray Firth, overwintering species include great crested grebes, red throated divers and seaducks (eider, goldeneye, long tailed duck, common scoter and velvet scoter) [37].

As a result of construction and decommissioning activities, disturbance can occur which could impact birds resting on the sea surface in particular but may also displace birds from the area which may reduce access to feeding, moulting or other important locations for specific activities. During the operation of the development, there is a possibility that birds may roost on the rectenna. The health effects of this on birds will require further study. However, the rectenna will be developed in light of the environmental sensitivities of the area. As far as possible the design of any required rectenna lighting will take account of bird sensitivities. During construction best practice guidance will, as far as possible, be followed and will including the following.

- Construction noise management.
- The use of standard vessel routes.
- Avoidance of rafting birds by vessels.

A Species Protection Plan should be implemented to avoid residual effects on bird populations and designated sites.

4.2.6 Designated Sites

Whilst the proposed rectenna site is not directly within a designated site there are a number of designated sites within the vicinity which will be considered as part of the EIA. The principal nature conservation designations which may be relevant to the rectenna site should include the following Special Protection Areas (SPAs) and Special Areas of Conservation (SACs). The eastern coastal section of the Scottish north coast between Peterhead and Duncansby Head contains seven SPAs. Of these, five are also designated as Ramsar sites. It is noted that the bird populations using these sites are unlikely to be completely independent and that there will be interchange between sites around the UK coast [37]. Below are a list of the SPAs and SACs:

- **Loch of Strathbeg (SPA and Ramsar):** Provides wintering habitat for wetland bird species.
- **Troup, Pennan and Lion's Heads (SPA):** Provide nesting sites for seabirds.
- **The Moray and Nairn Coast (SPA and Ramsar):** Important for coastal and riverine habitats, supports a variety of wetland birds throughout the year.
- **The Inner Moray Firth (SPA and Ramsar):** Intertidal flats contain rich invertebrate fauna, providing food sources to migrating and wintering waterbirds.
- ***Cromarty Firth (SPA and Ramsar):*** Intertidal flats contain rich invertebrate fauna, providing food sources to migrating and wintering waterbirds.
- **The Dornach Firth (SPA and Ramsar):** The tidal flats support internationally important numbers of waterbirds on migration and in winter and are the most northerly and substantial extent of intertidal habitat for wintering waterbirds in the UK, as well as Europe.
- **The East Caithness Cliffs (SPA):** Ideal nesting sites due to cliff ledges, stacks and geos.
- **The Inner Moray Firth SAC:** Largest marine SAC in the UK. Primary reason for designation is bottlenose dolphins.
- **Dornoch Firth SAC:** Supports rich biogenic reefs associated with commercial mussel beds and a range of subtidal sandbank habitats.
- **Berriedale and Langwell, Oykel, Morriston and Spey SACs:** Designated to protect salmon.
- **Culbin Bar SAC:** Designated for its coastal habitats.

During all phases of the development, marine mammals from SACs and water birds from SPAs have the potential to be

impacted. The impacts should be considered in detail through a Habitats Regulation Assessment which is required in order to comply with the EC Habitats Directive [39]. The Habitats Regulation Assessment will consider the impacts on adjacent sites covered by European nature conservation designations, as a result of the development. To protect designated areas, monitoring assessments should take place and the design and construction of the development should be considered very carefully to avoid any disturbance that could have long-term effects on the environment. As such, a Habitat Management Plan should be implemented.

4.3 Human Environment

4.3.1 Landscape, Seascape & Visual

The coastline in which the proposed development would sit supports four designated National Scenic Areas which must be considered. In relation to offshore renewable energy this site is within a seascape of low to medium sensitivity and has a moderate to high capacity for further development on the current wind farm site. In terms of population, the area on the coastline is light. The A9 is the main route through the area and is situated close to the coastline. These routes must be considered when going forward with the development application [37].

During construction, visual impacts from the rectenna on the site and increased vessel movements carrying materials to the site may occur and must be considered. During operation, this relates to the visual impact of the rectenna in operation and maintenance activities, and a change in landscape/seascape because of the new rectenna structure. The potential cumulative effects may include adverse landscape impact and impacts of both the combination of the already existing wind farm development and the rectenna. It is important that all the effects are considered and assessed when carrying out the Environmental Impact Assessment (EIA).

Potential mitigation opportunities lie in the distance in which the rectenna is sited from sensitive receptors. However, due to climatic conditions such as fog and wind, the visibility throughout the year will be limited by these conditions. Furthermore, the colour of the rectenna may also mitigate any visual impacts that the development has on the landscape/seascape.

4.3.2 Archaeology & Heritage

The construction and decommissioning phases have the potential to directly and indirectly impact marine archaeology by affecting wreck sites. There is also a possibility that new wreck and debris sites will be discovered – which can be seen as a positive impact. During operation, the wind farm and rectenna could impact the features of cultural heritage that sit on the coastline due to their large visual presence. It should be ensured that no physical impact occurs to land-based heritage features as a result of the proposals. In this regard, the main impact will be visual.

A Landscape and Visual Assessment should be conducted. Should new features be discovered on the seabed within the site area it may be possible to micro-site construction activity around these features. If micro-siting is not possible and the feature cannot remain in-situ it will be recorded in accordance with regulation and guidelines and removed or relocated in accordance with advice from the relevant cultural heritage stakeholders [37].

4.3.3 Aviation & Ministry of Defence

The location in which the development is in the vicinity of the civil commercial and passenger airports of Wick Airport and Inverness Airport. Despite not being directly impacted, further consultation with relevant authorities will be required before going ahead with the rectenna. This is to ensure any potential issues are solved at the earliest possible stage of the development plans.

In Moray Firth and Moray Outer Firth, there are areas which are in use by the RAF for low flying practice 65 km and 80 km southwest of the site. However, after previous discussions when the wind farm development was constructed, it was realised there would be no potential significant impacts. Despite this, during construction, large structures in the vicinity of aircraft and military operations must be considered. In addition, potential adverse effects of rectenna operations on radar systems and the obstruction of aircraft or military operations must be considered. If it is found that the offshore rectenna will cause any negative impacts on aviation whether it be obstruction or effects on radar systems, an effort must be made to resolve these issues.

4.3.4 Shipping & Navigation

There are a range of shipping vessels that use the Moray Firth (the most common being fishing boats) with busy fishing ports at Buckie and Fraserburgh. Commercial as well as recreational ships are attracted to the area as a result of many ports (the main ones being Cromarty Firth and Inverness) and the entrance to the Caledonian Canal. Oil and gas vessels navigate in this area in support of the Beatrice complex and its satellites and drilling operations. Drilling rigs also use Nigg and Invergordon yard facilities for refitting and repair and can often shelter in the Cromarty Firth when out of contract. Commercial shipping densities within the Moray Firth, and within the vicinity of the Beatrice Offshore Wind Farm site, are generally low. However, there is a main shipping route ten kilometres north-east of the site boundary [37].

The safe navigation of every vessel variation has the possibility of being affected during construction, operation and decommissioning. Potential impacts include collision with equipment, re-routing, increased activity during construction and decommissioning phases could result in collision with other vessels and could interfere with radar which can result in higher navigational risks. Routes may have to change permanently as a result of the rectenna being added to the site.

A shipping survey and navigational risk impact assessment should be carried out. The assessment should include and consider safety zones, lights & markings, routeing measures, information to mariners and guard vessels during construction.

4.3.5 Commercial Fisheries

To quantify precise levels and values of commercial and recreational fishing previous experience on such projects identified methodologies that are acceptable to regulators in gathering this data. This technique involves utilising catch data alongside Vessel Monitoring Systems/Overflight data and attributing effort to the specific study area or site boundary.

In order to ground truth these estimates a baseline data gathering exercise will be required from a range of sources [37].

Fishermen will not be able to access in or around the rectenna area during construction and decommissioning. This has the potential to prevent fishermen accessing regular fishing grounds. The operation phase has the following impacts:

- As a result of construction, fish may become displaced from the site. This would require fishermen to travel further and to different areas in order to catch fish.
- Fish and shellfish populations could be affected due to nursery or spawning impacts which could prevent the growth of fry into their adult fish - reducing population sizes. This could result in fewer adult fish to catch, meaning fishermen will find it more difficult to obtain the same level of catch.

A specialist fisheries consultant should undertake an impact assessment on how the development will impact commercial fishing operations on the Moray Firth.

4.3.6 Salmon & Sea Trout Fisheries

Salmon (*Salmo salar*) and sea trout (*Salmo Trutta*) are anadromous migratory species, spending their adult life at sea and returning to their home rivers to spawn. The salmon and sea trout fishery in Scotland is divided into commercial and recreational fishing. The rod and line industry are currently considered to form a 'pivotal part' of the Scottish rural economy, with salmon fishing amongst the more popular activities for visitors to Scotland.

The main impact on salmon and sea trout fisheries that in theory could be associated with the rectenna site would be the effects upon migratory behaviour. Given that the impacts on the fisheries will be directly related to the impacts on the ecology of these species. During the EIA process discussion and consultation with relevant stakeholders and consultees will be undertaken and used to shape any mitigation measures that may be required to reduce any identified significant impacts.

4.3.7 Oil & Gas

Much of the area off the northeast coast of Scotland has never been licensed for oil and gas exploration or was previously licensed but has since been relinquished. The main oil and gas activity in this Moray Firth area at present is the Beatrice oil field (Block 11/30a). This field was discovered in 1976 and began production in 1981. The oil field has produced over 160 million barrels of oil to date. In the 23rd Licensing Round, Ithaca was also awarded, as one licence, several further blocks and part blocks which surround the Beatrice Field. Polly, 2.5 km east of Beatrice oil field is an emerging opportunity and straddles blocks 11/30a and 12/26c [37]. The Polly oil field region has been illustrated with reference to Ithaca Energy website [40]. The existing oil and gas structures include the following elements:

- The Jacky platform.
- Beatrice Alpha, Bravo and Charlie platforms.
- Seabed cables and pipelines linking the platforms.
- Beatrice oil is exported via a 66 km long 16-inch pipeline from the Alpha complex to a shore terminal at Nigg in the Cromarty Firth, where it is stored until tanker shipment.
- The Beatrice complex is linked to the mainland via a 132/33 kV seabed power cable from Dunbeath.

The demonstrator wind turbines provide approximately 30% of the Alpha platform's daily requirements. Beatrice oil platforms A, B and C are owned by Talisman Energy and operated by Ithaca Energy. The Jacky platform is owned and operated by Ithaca Energy. Existing oil and gas infrastructure will be afforded certain wayleaves and buffer zones, restricting certain types of activities and development within their proximity.

Potential construction and decommissioning impacts may include the following:

- An increased risk of accidental damage to existing oil and gas infrastructure. This could occur, for example, as a result of construction vessels breaking free from its moorings. During operation there are no likely significant impacts predicted.
- It is possible that cumulative impacts of a similar type to those discussed above may arise from the rectenna base being constructed/ decommissioned in parallel or in sequence with the nearby Moray Firth Round 3 Wind Farm.

In order to identify and minimise potential risk of damage to existing oil and gas infrastructure, discussion should take place with the owners and operators of the infrastructure. The layout of the rectenna site would also be designed to ensure that no included structure has the potential to damage existing infrastructure during its operation. Any existing safety zones or wayleaves afforded to existing oil and gas infrastructure will be mapped and incorporated into the offshore rectenna site layout.

4.3.8 Pipelines & Cables

The Kingfisher Cable Awareness Charts [41] identify the main cable routes around the coast of the UK. In referring to these charts the closest cable to the rectenna site relate to a submarine power cable running north/south between Banff and Orkney.

Given the distance from the rectenna site to existing submarine cable and pipeline infrastructure it is not considered that there will be significant impact on these features as a result of constructing, operating or decommissioning the rectenna site. Given this it is proposed that this topic area is scoped out of the EIA.

4.3.9 Marine Waste & Spoil Disposal

Between Burghead and Macduff there are four main marine disposal sites [37]. Due to the distance between the proposed development and the coastal locations, there are unlikely to be any significant impacts to these sites during any phase of the development. As a result, it is proposed that this area be scoped out of the EIA.

4.3.10. Socioeconomics

The socio-economic impacts of the construction and operation of an offshore rectenna site of the size of the proposed development are likely to be significant and will impact at a national and local level. Impacts will vary considerably at each level depending on the technology deployed, type of structures, contracting strategy and other factors such as the availability and capacity of the supply chain. A range of scenarios will be considered in the assessment. It is proposed

that socio-economic impacts at national level will not be quantified as part of the EIA exercise. Impacts on the Inner Study Area and Broader Study Area will however be assessed and quantified at a level consistent with available industry sector multipliers.

During the construction phases, there will be a significant need for local support services. A development of this will require an intense period of activity during construction and the long-term operation and maintenance. As a result, this is likely to create further demand for local suppliers. Additionally, suppliers and contractors will be required to fabricate and/or deliver the following elements:

- Main rectenna structure
- Sub-structures.
- Cables.
- Electrical systems.
- Sub-stations.
- Control systems.

Specialist contractors may also be required to stay in the area over the construction period and may require the support of local hotel, accommodation and other service industries. Marine operations are less likely to require local service providers.

Moreover, potential operational impacts may include the following:

- During the likely operational life of the rectenna there will be an ongoing programme of operation and maintenance that will require the provision of permanent locally based work force and facilities.
- The operation and maintenance of the rectenna will require the provision and support of dedicated vessels and the creation of a dedicated work force which will be augmented by specialist contractors on a regular basis.
- The regular servicing and upgrades are likely to require external specialist contractors input, some will be required to stay in the area over the construction period and may require the support of local hotel, accommodation and other service industries.
- The operation and maintenance phase of the rectenna site represents a significant opportunity for new, highly skilled jobs in the Moray Firth area and beyond.

Potential cumulative impacts may include the likely further substantial investment in the Moray Firth renewables sector, including Beatrice Offshore Windfarm. This would represent a very significant positive economic opportunity for the Moray Firth area. Wider, there are further positive cumulative economic opportunities when the Pentland Firth marine energy developments are taken into account. There are particular cumulative benefits in the power and marine sectors and associated service industries.

Social impacts will also be considered although the methodologies for assessing social impact tend to be less precise and more qualitative. However, such an assessment will complement the economic assessment. In the context of an offshore rectenna site the definition of "community" needs to be examined at a local, regional and Scottish level. A qualitative model will be developed to look at how the project is likely to impact on people, considering – community structure, infrastructure and functioning (behaviour and perceptions), as well as social equity and individuals.

It is anticipated that the overriding socio-economic impacts of the proposed offshore rectenna site will be positive in nature. The key to maximising the positive socio-economic impacts will be to ensure the development of the Rectenna proposals, and its construction and operational support facility requirements, are discussed with the local stakeholders.

5 SUMMARY

A scoping report has been prepared to initially address likely significant impacts that the proposed rectenna siting for the SEI technology programme. This has shown that the development has the potential to increase renewable energy usage and aid carbon reduction targets which will help with UK commitments, such as achieving net-zero by 2050, whilst being in line with Scottish planning policies, regulations and guidance. The initial classification of found impacts' significance in relation to specific project phases can be found in the Appendix.

Ongoing consultations with various interested parties are expected thorough the full length of the development. Working closely with the relevant authorities means that any issues can be resolved as early as possible in the development plans. It is advised that further baseline studies and data collections take place to examine the issues laid out during the scoping in a more detailed view.

Going forward, four high-level recommendations should be considered. Such recommendations will allow any potential significant impacts to be kept to a minimum and ensure any alternatives are explored as early as possible in the development. These are:

- Additional baseline studies and data collections should take place to examine the issues laid out during the scoping in a more detailed view.
- Further consultation with local authorities as well as relevant professional stakeholders.
- A full EIA and/or Strategic Environmental Assessment (SEA) should be carried out.
- Ensure that the development is known to the public and communities on the coastline near the development, with regular consultation and involvement.

Acknowledgements

The authors would like to thank Kaela Campbell (Metasat UK), Megan Campbell (Metasat UK), Katy Murphy (Metasat UK) and Erika Tonhauser (Metasat UK) for their contribution to the underlying report on which this paper is based.

Disclaimer

The report on which this paper is based was commissioned by the UK SEI and prepared by Metasat UK with support from the University of Strathclyde in collaboration with the SEI Environment Working Group. All of the information contained within this paper has been derived from the report, which is considered accurate (to the furthest extent possible) as of 23 August 2021 for an offshore rectenna site located next to Beatrice Offshore Windfarm in Scotland, UK. Subsequent updates and revisions to the underlying report are expected periodically since the results are highly susceptible to change due to design advancements of the SEI programme, particularly relating to the desired placement of the rectenna.

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APPENDIX A: IMPACTS MATRIX

Potential Receptors of Impact		Phases of the Project		
		Construction	Operation	Decommissioning
Physical Environment	Coastal Processes			
	Geology			
	Air Quality			
	Noise & Vibration			
	Traffic & Transport			
Biological Environment	Plankton			
	Seabed Marine Life			
	Fish Ecology			
	Marine Mammals			
	Ornithology			
	Designated Sites			
Human Environment	Landscape, Seascape & Visual			
	Archaeology & Heritage			
	Aviation & Ministry of Defence			
	Shipping & Navigation			
	Commercial Fisheries			
	Salmon & Sea Trout Fisheries			
	Oil & Gas			
	Pipelines & Cables			
	Marine Waste & Spoil Disposal			
	Socioeconomics			

Key

	Positive impact
	Minimal impact
	Medium impact
	High impact

Received 16 January 2023 **Approved** 7 March 2023