Contents

List of Tables

List of Figures

Abbreviations and Acronyms

EIA	Environmental Impact Assessment
ES	Environmental Statement
FTOWDG	Forth and Tay Offshore Wind Developers Group
ICOL	Inch Cape Offshore Limited
MW	Mega Watt
NNG	Neart Na Gaiothe
OSP	Offshore Substation Platform
SNH	Scottish Natural Heritage
SLVIA	Seascape, Landscape and Visual Impacts Assessment
WTGs	Wind Turbine Generators

6A Design Considerations

6A.1 Introduction

1 This Appendix provides an overview of the main considerations that have influenced the indicative design presented in this EIA Report, and which will influence the final design of the Inch Cape Wind Farm, particularly in reference to the Seascape, Landscape and Visual Impacts Assessment (SLVIA). It should be read in conjunction with *Chapter 6: Site Selection and Alternatives, Chapter 8: Benefits of the Development* and *Chapter 12: Seascape, Landscape and Visual Impact Assessment*.

2 Scottish Natural Heritage (SNH) requested in their response to Inch Cape Offshore Limited's (ICOLs) Scoping Report the following:

SNH note that there should be a clear statement of the design rationale, including any technical constraints which have influenced the WTG layout[1].

3 Therefore, this Appendix provides the rationale which has influenced the layout and aims to aid consultees in understanding the constraints and limitations to the information that can realistically be available to inform the design at the EIA stage and thus the determination of the worst case scenario(s) assessed.

4 In respect of the Inch Cape 2014 consented development, the Scottish Minister noted in the consent notice that it was '*recognised that the Forth and Tay developments will be a prominent new feature on the seascape, however are satisfied that this impact would not require consent for the Development to be withheld*'[2]. ICOL appreciates that the design changes from the consented development to the currently proposed development, with larger but fewer Wind Turbine Generators (WTGs), will introduce a large scale feature on the seascape. However, this application is being progressed to allow ICOL to potentially make use of the next generation WTGs. This will make the development more efficient, and as can be seen from this EIA Report, has limited additional significant effects on the environment than was assessed in the Inch Cape 2013 Environmental Statement (ES). The majority of adverse environmental impacts assessed in this EIA report have materially decreased from what was assessed in respect of the consented development (further information is provided in each of the technical *Chapters 9 to 17*, and a summary provided in *Chapter 18: Summary of Effects*).

6A.2 Consultation on Design Considerations

5 During the scoping process for this application ICOL and SNH met to discuss the design rationale of the wind farm: a summary of the discussions is provided in Table 6A.1 below. This document provides further information on the main design factors influencing the design of Inch Cape.

[1] Response to Scoping question 9.1.8 (page 39) of the Scoping Opinion, available here: http://www.gov.scot/Topics/marine/Licensing/marine/scoping/ICOLRevised-2017/Scoping-Opinion-July-17
[2] Inch Cape Section 36 Consent (page 35), available here: http://www.gov.scot/Resource/0046/00460543.pdf

Table 6A.1: Summary of the design meeting consultation with SNH

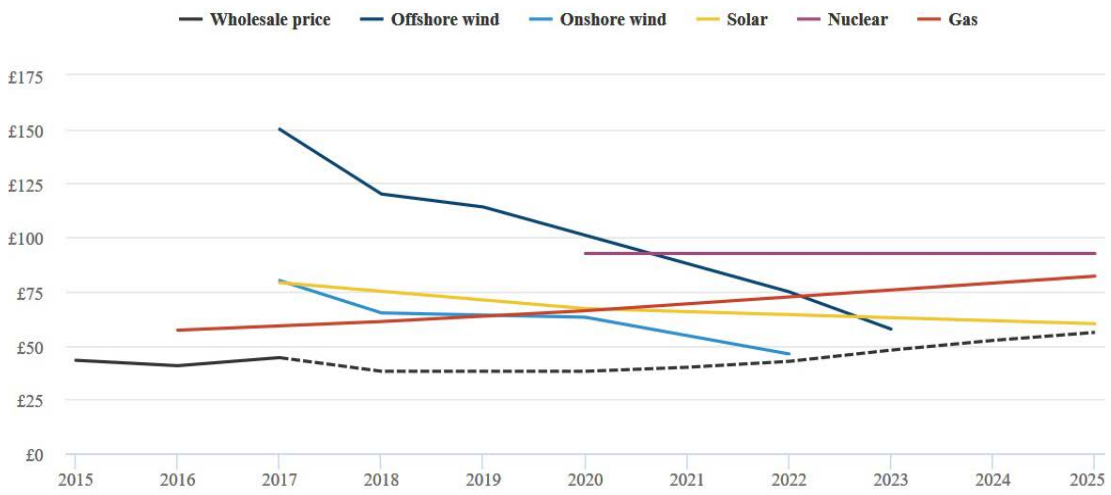
Consultation	Summary
Design Meeting with ICOL and SNH (29/09/2017)	ICOL confirmed that the 'worst case scenario' to be used for the purposes of the SLVIA will consist of the tallest proposed WTGs at 291m to blade tip (c.f. 301m at scoping stage). SNH agreed that the worst case scenario in respect of NNG and Seagreen should show the tallest proposed WTGs at Inch Cape with the consented NNG and Seagreen wind farms as this would demonstrate the greatest difference in appearance of the WTGs (tallest WTGs with greater spacing at Inch Cape with smaller, more closely spaced WTGs at the other offshore wind farms). ICOL explained some of the economic and engineering factors which influence the design of the wind farm including; • Logic behind a 48-location grid and a 90-location grid; • Current policy and economic context - Contracts for Difference - highly competitive auction process • Installation challenges – variable sea depths • Other known environmental considerations to avoid (such as archaeology) The impacts of these factors were discussed in relation to the composition and layout of the wind farm. ICOL confirmed that the design criteria set out in the EIA Report will be followed during design of the final layout, insofar as they can be applied whilst taking account of the other key constraints. ICOL provided a demonstration of the Virtual Reality Model showing both 40 and 72 WTGs layouts.

6A.3 Current policy and economic context

6 Offshore wind projects must be developed in order for the UK and Scottish Governments to meet their legally binding climate change commitments; aspirations to develop secure supply of electricity; lower electricity costs to consumers; and optimise industrial benefits. In recent years it has become evident that utilisation of next generation WTGs would significantly support Inch Cape to deliver a major contribution to these objectives.

7 Figure 6A.1 below shows the cost of UK electricity generation for different generation types. From this it can be seen that the cost of offshore wind generation has greatly reduced and is set to continue to decrease.

Figure 6A.1: Costs of UK electricity generation, £/MWh



8 WTGs with larger rotor diameters capture more energy, with the result that fewer WTGs are needed to generate the optimum economic capacity. This also means less supporting structures, foundations and associated cabling resulting in reduced capital costs (for manufacture and installation; as well as lower operating costs. All these factors should contribute to a reduction in the cost of energy. Should the Inch Cape application receive consent and win a Contracts for Difference, it is likely that installation of the WTGs would commence around 2023. The export capacity of the wind farm is not likely to change in the interim, but it is considered that WTG technology is likely to have advanced to allow a single WTG rated at c.15 MW- with rotor diameters approaching 250 m to be deployed. This would almost halve the number of structures required to deliver the same amount of energy compared to the existing technology. In addition to reduced construction and maintenance costs, there is also the knock-on effect of fewer WTGs having fewer direct physical/biological environmental impacts.

9 In view of the anticipated advance in WTG technology outlined above, it has been deemed prudent to 'future proof' the design envelope identified in this EIA Report for the Inch Cape Wind Farm. Accordingly, the application is based on WTGs with up to a 250 m rotor diameter that would give a blade tip height of up to 291 m. Although these are the largest WTGs proposed in Scotland so far, WTGs of this size are likely to become more widespread in the UK and Europe.

10 The link between WTG size and overall cost reduction can be further seen from review of the auction price at various different UK offshore wind farms shown in Table 6A.2 below.

Table 6A.2: Price paid in Auctions for some UK Offshore Wind Farms

Year Consented	Wind Farm	Tip Height	Price/ MW
2014	Beatrice Offshore Wind Limited	198.4 m	£140
2014	East Anglia 1	197 m	£119.89
2014	Neart Na Gaoithe	220 m	£114.39
2016	Triton Knoll	276 m	£74.75
2016	Hornsea 2	276 m	£57.50
2014	MORL East	204 m	£57.50

11 Due to the location, scale and nature of offshore wind development, ICOL are looking to all avenues to establish competitive advantages despite geographical hinderances when compared to projects in England and Wales such as offshore and onshore transmission charging.

6A.4 Design Sensitivity Analysis

12 A Design Sensitivity Analysis was carried out for the Inch Cape 2013 EIA by the Forth and Tay Offshore Wind Developers Group (FTOWDG) in respect of three different generic design concepts for the four Forth and Tay offshore wind farm developments comprising the Inch Cape, Neart na Gaoithe (NNG) and Firth of Forth Alpha and Bravo offshore wind farms. Although the parameters of WTG heights and number of WTGs have now changed for the Inch Cape Wind Farm as well as the other three wind farms, the principles established during this process have been revisited and are still considered relevant. With the aim of identifying which of the three generic layouts demonstrated the most balance, coherence and greatest degree of legibility, the analysis concluded that there was a preference firstly for the least "busy" layouts (i.e. taller WTGs with wider separation distances), as well as a slight visual preference for the offset grid layout over a grid layout, and either offset grid or grid being preferable to an arc pattern. The design sensitivity analysis indicated that a layout based on a deliberate pattern was preferable to a randomised or organic layout.

13 It is acknowledged that the layout and consequent appearance of the WTGs becomes even more important in respect of potential impacts on seascape and landscape character as well as visual amenity with increasing WTG height as the individual WTGs will become more legible at distance, and any anomalies in the layout will be apparent. In the light of this, and on recommendation from SNH, ICOL undertook a review of the Design Sensitivity Analysis at the start of the design process for the current Inch Cape Wind Farm application. It was considered that the key findings of the original Analysis (2013) remained valid and relevant

as a starting point for developing a new layout using larger turbines for the current application.

6A.5 SLVIA considerations for layout design

14 Alongside economic and other environmental considerations, seascape, landscape and visual impacts have been taken into account during the design process. Mitigation of significant adverse effects on seascape, landscape and visual may be achieved by layout design. Achievement of a balanced and coherent layout is the key aim of the SLVIA design process, whilst being mindful of other technical, health and safety, environmental and physical considerations and constraints. The design of the WTG layout, whilst indicative, has taken account the previous design sensitivity analysis undertaken for the Inch Cape 2013 EIA, as well as related 'Design Principles'. These are discussed below.

6A.6 Design Principles

15 Drawing on the findings of the Design Sensitivity Analysis, and key design principles identified in SNH's Siting and Designing Windfarms in the Landscape (2017), as well as their experience in designing wind farms, the SLVIA consultants to ICOL set out some key design principles for the WTG layout to be considered by ICOL, for this application. These comprise:

- Aim to achieve a coherent and reasonably balanced and consistent pattern of WTGs across the array;
- Grid or Offset Grid pattern to be the preferred starting point (based on FTOWDG design sensitivity analysis) for layout evolution;
- Avoid continuous gaps larger than the grid spacing on the perimeter WTGs which create channels and appear to separate the wind farm into groups;
- Avoid single outlier WTGs (there will always be corner WTGs); and
- Offshore Substation Platforms (OSP) positions to be within the main area of WTGs and not on the western periphery of the Development.

16 As the appearance of the wind farm from the coast will change depending on the location, achievement of these design principles in the different layout options being considered will be assessed from key design viewpoints.

6A.7 Layout Design Process

17 Alongside consideration of the layout of the proposed Inch Cape Wind Farm in terms of the above design principles, the layout needs to maximize efficiency as well as avoiding or minimising potentially adverse impacts on other environmental factors.

18 Taking into account the design sensitivity analysis for the Inch Cape 2013 EIA, a grid or offset grid layout within the Development Area has been adopted as the starting point for the proposed layout. This may potentially indicate more than the required number of WTG positions to achieve the target capacity for the Development, but allows flexibility if seabed

conditions or other constraints are later found which would preclude the use of some locations within the grid.

19 In order to develop a layout design for the Inch Cape EIA a series of development criteria has been followed alongside the design principles set out above. These criteria will also be applied in respect of the final layout of WTGs. These development criteria are listed below:

- A layout that minimises the cost of electricity:
    - Maximum site capacity;
    - Maximum WTG size (subject to capital and maintenance costs);
    - Achieve spacing to mitigate wake effects;
    - WTGs located to minimise construction costs (eg considerations of length of cable connections, movement of construction materials, and maintenance distances); and
    - WTGs located to maximise yield.
- A layout that meets the technical and health and safety requirements:
    - Wind WTG manufactures requirements (minimum WTG spacing - see wake effects above);
    - Layout that adheres to shipping and search and rescue requirements (e.g. spacing required for Search and Rescue (500 m between blade tips minimum); Avoidance of spacing and patterns that suggest false passages for shipping and navigation purposes, to be discussed with the Maritime and Coastguard Agency;
    - Layout that avoids extremes of water depth.
- A layout that takes account of all environmental considerations:
    - Environmental effects need to be acceptable.
    - Layout that avoids hard environmental constraints (e.g. ship wrecks) and physical constraints (bedrock, sand waves, extremes of sea depths). Much baseline data in respect of hard environmental constraints (geology, wrecks, seabed depths etc.) is identified as early as possible within the EIA process but there is always the potential for unknowns to be revealed from the more detailed site surveys and construction preparation which would happen post consent. Therefore the layout has to be flexible enough to accommodate some changes in WTG position to avoid these unknowns.
    - Ornithology- rotor diameter at increasing heights from the surface of the sea reduces impacts from collisions as well as greater spacing between WTGs potentially minimises displacement impacts.
    - Grid and offset grid pattern to ensure WTG coherence for fishing, navigation and search and rescue requirements.

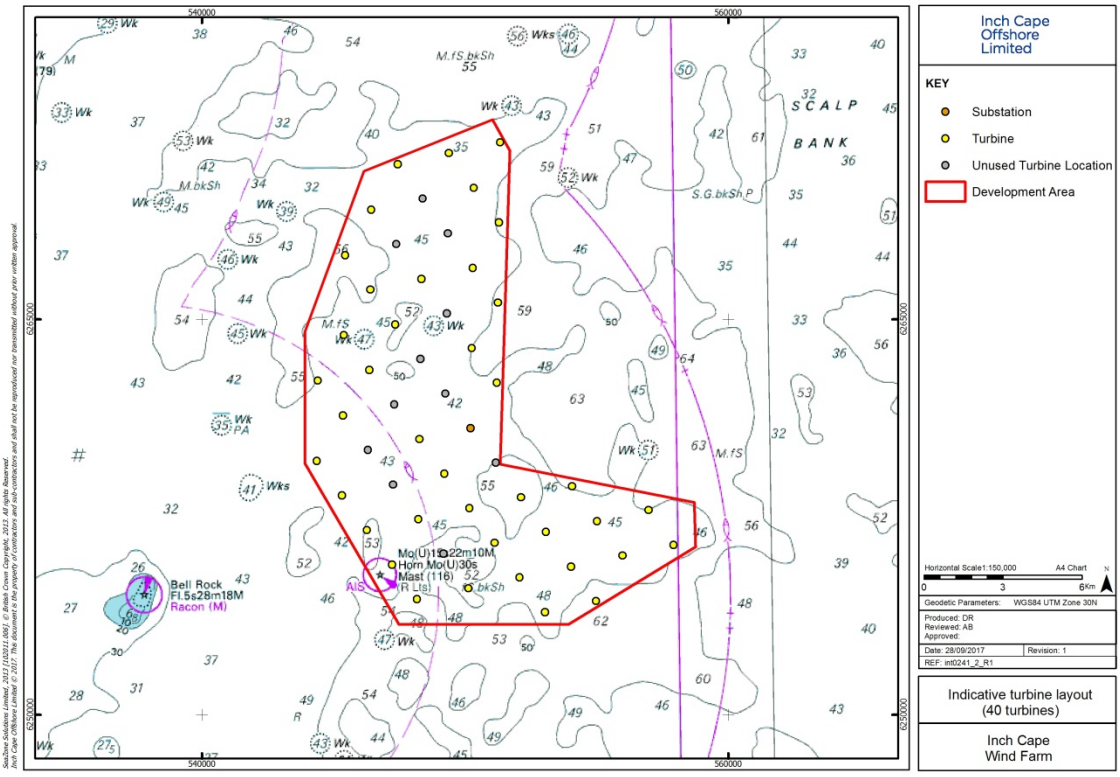
- Seascape, landscape and visual impacts of layout to adhere to design principles insofar as possible whilst taking account of other hard environmental constraints and other development criteria, and be prioritised from key sensitive viewpoints.

20 There are also further considerations to those listed above that will influence the design as it evolves, namely:

- The number of points within a grid or offset grid pattern to be utilised (as indicated above) (e.g. if 72 WTGs consented, up to 90 points in a grid or offset grid may be considered);
- These 'additional' locations are required until further information on seabed and any additional constraints are known (see explanation above) (see Figure 6A.2 below for a visual representation);
- WTGs and OSP to be located on the grid points (with micrositing allowances);
- OSPs not to be located on the coastal periphery of the wind farm.

21 For the purposes of the EIA and the EIA Report an indicative layout which takes into account the considerations detailed in this Appendix has been developed. This layout will remain indicative until more specific information about the site is gathered and ICOL appoint a specific WTG manufacturer. This layout is shown in Figure 6A.2 below.

Figure 6A.2: Indicative 40 WTG grid layout, showing 'unused' WTG locations



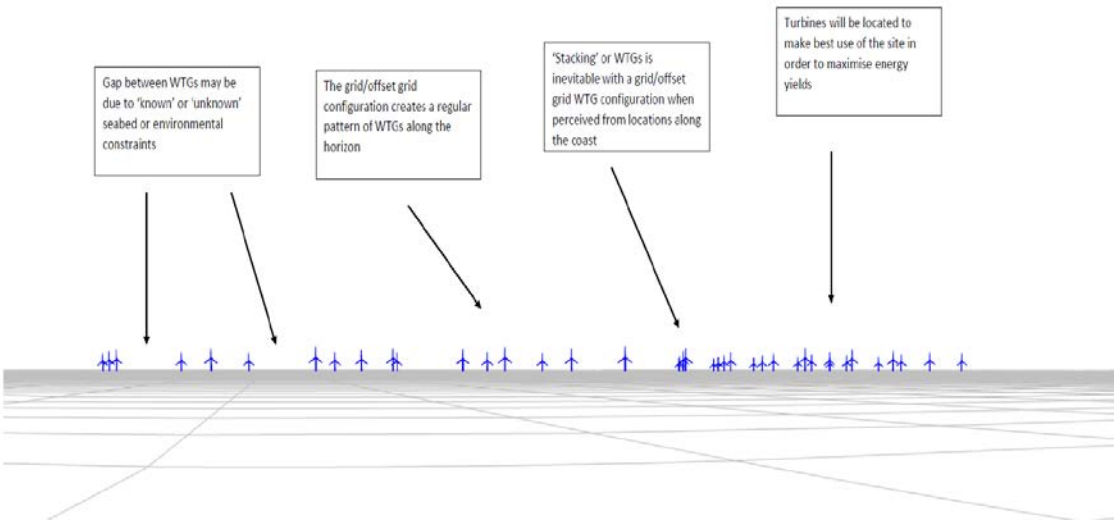
6A.8 Layout considerations and implications on the composition of the wind farm

22 The layout considerations as noted above will influence the composition of the wind farm as perceived from the coast. As the appearance of the wind farm from the coast will change depending on the location the following summarises the potential implications on the composition:

- WTG height will make the blades and hubs of some WTGs visible from coastal locations;
- Nominal WTG spacing, as required by the WTG manufacturer and to maximise energy efficiency, means the WTGs may be seen as individual WTGs along the horizon;
- WTGs will be positioned on a grid/ offset grid pattern which will ensure that the WTGs are observed in a regular pattern, of course from some locations stacking of WTGs will be inevitable
- Seabed, technical and environmental constraints, whereby WTGs cannot be located, may mean that the WTGs appear unevenly spaced from some locations along the coast;
- In order to deal with 'unknown' surprises, such as unfavourable seabed conditions and unknown environmental factors (such as undiscovered marine archaeology) the grid/ offset configuration allows for a greater number of potential WTG locations to be built out. This could create the illusion of 'gaps' between the WTGs from certain locations along the coast.

23 In order to visually present some of these considerations a 'marked up' example wireline is presented below in Figure 6A.3, which identifies how some of these factors may influence the composition of the wind farm as perceived from the coast.

Figure 6A.3: Example wireline identifying how some of the technical and environmental considerations may influence the composition of the wind farm



6A.9 Final Layout Design

24 ICOL's understanding of the site conditions, WTG technology and evolution of environmental considerations will continue to improve as development of the project progresses. Therefore, the final layout is likely to differ from the indicative layout used for the EIA process. In preparing the indicative layout used for the purposes of the EIA Report, ICOL have followed the design considerations laid out in *Section 6A.7* above to present a realistic worst-case scenario for inclusion in the Design Envelope.

25 For the purposes of the SLVIA it has been agreed with SNH that the worst-case scenario would assess WTGs at the largest height and diameter being proposed. As per the design envelope this will be a WTG comprising a 250 m diameter rotor and thus resulting in an indicative 40 WTGs across the Development Area at a maximum height to tip of 291 m. A WTG of these dimensions would also require the greatest spacing between each other of approximately 1445 m.

26 Should the application receive consent, a condition dealing with the final layout will be part of the consent. This condition will ensure that key stakeholders are consulted and approve the final layout.

27 ICOL commit to the design considerations laid out in this document for the final Development layout.