3 ALTERNATIVES CONSIDERED

3.1 INTRODUCTION

This Chapter of the Environmental Impact Assessment Report (EIAR) provides an assessment of the reasonable alternatives considered by the Developer in the design of the Proposed Development. Alternatives were assessed taking commercial, construction, operational and key environmental constraints into consideration.

3.2 STATEMENT OF AUTHORITY

This chapter has been prepared by Sarah Jones and David Kiely of Jennings O'Donovan & Partners Limited and Ben Stevenson of Black and Veatch Ltd.

Sarah Jones is an Environmental Scientist and Planner and holds a first-class MSc in Environmental Sustainability from University College Dublin and a Bachelor (Hons.) Degree in Geography from Manchester Metropolitan University. Sarah has recently developed a specialist knowledge of hydrogen production and her key capabilities include Environmental Impact Assessment (EIA) screenings, Appropriate Assessment (AA) screenings, Planning and Environmental reports and Applications, Environmental Impact Assessments, Feasibility Studies, Construction Environmental Management Plans, Stakeholder Engagement, Project Management.

David Kiely is a Director of JOD who holds a BE in Civil Engineering from University College Dublin and MSc in Environmental Protection from IT Sligo. He is a Fellow of Engineers Ireland, a Chartered Member of the Institution of Civil Engineers (UK) and has over 40 years' experience. He has extensive experience in the preparation of EIARs and EISs for environmental projects including Wind Farms, Solar Farms, Wastewater Projects, and various commercial developments. David has also been involved in the construction of over 60 wind farms since 1997.

Ben Stevenson is the hydrogen solution lead for the EMEA region at Black & Veatch. He has 4 years' experience in the renewable energy industry, with a particular focus on onshore wind and hydrogen. Ben began his career at Black & Veatch as an auditor of renewable energy installations. This involved the assessment of sites' compliance on both the Feed in Tariff and Renewable Obligation support schemes on behalf of the client, Ofgem. To date, Ben has completed c. 100 Ofgem audits and over 400MW of installed capacity, covering solar PV, wind, biomass, landfill gas and hydro technologies. After completing the graduate programme, Ben transferred to support the hydrogen energy team for the EMEA region and was involved with the UK businesses' first hydrogen energy projects for clients. This included feasibility, pre-FEED and cost estimation studies. Ben is now the hydrogen solutions lead for the region, and oversees a variety of green and blue hydrogen projects through to FEED level. Ben has completed additional internal and external training, including a hydrogen safety credential accredited by American Institute of Chemical Engineers, and also frequently represents Black & Veatch at hydrogen specific conferences. Education: MSc, Renewable Energy Engineering, University of Aberdeen, 2019, United Kingdom. BSc, Environmental Science, University of Edinburgh, 2015, United Kingdom. Construction Skills Certificate Scheme (CSCS), 2022. Fundamental Hydrogen Safety Credential, Center for Hydrogen Safety (American Institute of Chemical Engineers), 2023.

3.3 METHODOLOGY

3.3.1 Approach to the Consideration of Alternatives under the EIA Directives

Article 5(1) of the Revised EIA Directive requires:

"Where an environmental impact assessment is required, the developer shall prepare and submit an environmental impact assessment report. The information to be provided by the developer shall include at least: ...

(d) a description of the reasonable alternatives studied by the developer, which are relevant to the project and its specific characteristics, and an indication of the main reasons for the option chosen, taking into account the effects of the project on the environment"

Annex IV of the Revised EIA Directive (Information Referred to in Article 5(1) (Information for the Environmental Impact Assessment Report) states that:

"*A description of the reasonable alternatives (for example in terms of project design, technology, location, size and scale) studied by the developer, which are relevant for the proposed project and its specific characteristics, and an indication of the main reasons for selecting the chosen option, including a comparison of environmental effects*".

The Revised EIA Directive Consultation states that transposition of these provisions are mandatory, and that:

"*Guidance will be developed on the requirement to study reasonable alternatives, including reference to the fact that some alternatives may already have been studied in relevant SEAs. The guidance will also deal with relevant considerations, including 'do nothing' alternative(s), alternative site(s), alternative design(s)/layout(s), alternative processes(s), alternative mitigation measure(s). Reference will also be made to the requirement that "reasonable alternatives ... relevant to the project and its specific characteristics" are required to be studied*".

The subsequent EU Commission guidance, Environmental Impact Assessment of Projects - Guidance on the preparation of the Environmental Impact Assessment Report (2017) (the "**Commission Guidance**"), emphasises that for an alternative to be reasonable it must be both relevant to the specific project and feasible:

"'Reasonable Alternatives' must be relevant to the proposed Project and its specific characteristics, and resources should only be spent assessing these Alternatives. In addition, the selection of Alternatives is limited in terms of feasibility…. Ultimately, Alternatives have to be able to accomplish the objectives of the Project in a satisfactory manner, and should also be feasible in terms of technical, economic, political and other relevant criteria." (emphasis added)

The Environmental Protection Agency, in its guidance document on EIAR preparation (2022)[1], stipulates the following:

"*The presentation and consideration of the various alternatives investigated by the applicant is an important requirement of the EIA process…. and the alternatives can include:*

- *Alternative locations;*
- *Alternative layouts;*
- *Alternative designs;*
- *Alternative processes; and*
- *Alternative mitigation measures".*

The scope of the assessment of the environmental effects of any such reasonable alternatives is not required to be exhaustive but must be sufficient to provide an *"indication of the main reasons for the option chosen, taking into account the effects of the project on the environment"*. The Commission Guidance describes the obligation in the following terms:

"The method for assessing Alternatives will depend on the type of Alternatives; the only requirement in the EIA Directive is a comparison of the environmental effects (Annex IV to the EIA Directive)…. The level of detail concerning the description of the environmental effects of the Alternatives may be less than for the chosen option. Nevertheless, the aim of the exercise is to provide a transparent and well justified comparison."

[1] EPA. (2022). Guidelines on the information to be contained in Environmental Impact Statements.

The Guidelines on the information to be contained in Environmental Impact Assessment Reports, EPA, 2022, state that "*It is generally sufficient to provide a broad description of each main alternative and the key issues associated with each, showing how environmental considerations were taken into account is deciding on the selected option".*

The presentation and consideration of the various reasonable alternatives investigated by the developer is an important requirement of the EIA process. The objective is for the Developer to present a representative range of feasible alternatives considered which could achieve the project objectives. The alternatives should be described with *"an indication of the main reasons for selecting the chosen option, including a comparison of environmental effects"*. It is generally sufficient to provide a broad description of each main alternative and the key issues associated with each, showing how environmental considerations were taken into account in deciding on the selected option – an EIA for each alternative is not required.

In an effective EIA process, different types of alternatives may be considered at several key stages during the process. As environmental issues emerge during the preparation of the EIAR, alternative designs may need to be considered early in the process or alternative mitigation options may need to be considered towards the end of the process. Public consultations carried out as part of the wider project communication and consenting process can often be a useful source for identifying alternatives, leveraging local knowledge and highlighting wider local interests. The reasonable alternatives which emerged during this iterative design development process are set out in this section of this document.

Taking the legislative and guidance requirements into account, this chapter addresses alternatives under the following headings:

- 'Do Nothing' Option
- Strategic Site Selection
- Alternative Renewable Energy Technology
- Alternative Turbine Numbers and Model
- Alternative Layout and Design
- Alternative Transport Route and Site Access
- Alternative Hydrogen Production Processes and Technology
- Alternative Mitigation Measures

Given the intrinsic link between layout and design, the two will be considered together in this chapter.

3.4 'DO-NOTHING' ALTERNATIVE

Annex IV, Part 3 of the EIA Directive states that the description of reasonable alternatives studied by the Developer should include "*an outline of the likely evolution thereof without implementation of the project as far as natural changes from the baseline scenario can be assessed with reasonable effort on the basis of the availability of environmental information and scientific knowledge.*"

This is referred to as the "do nothing" alternative.

The Commission Guidance (EU, 2017) states that this should involve the assessment of "an outline of what is likely to happen to the environment should the Project not be implemented – the so-called 'do-nothing' scenario."

The Commission Guidance (at section 1.5.3) goes on to acknowledge the do-nothing scenario may not be a reasonable alternative where there is a pressing need for the project supported by policy.

"*In some cases, however, the do-nothing scenario cannot be considered a feasible option, as a Project is very clearly needed: for example if another policy dictates an action, such as a waste management plan requires improved waste management, then the new plant must be built."*

As outlined in **Section 1.6; Need for the Development**; Ireland has binding targets set by the EU. By 2030, Ireland is required to ensure that 32% of total energy consumed is generated from renewable resources. As of 2020 renewable energy account for only 13%[2] of Ireland's primary energy. The Climate Action Plan 2023 has a target of 80% of electricity coming from renewable sources by 2030. It also sets a target of increasing onshore wind to 8.2 GW by 2030, as of May 2022 this was 4.3 GW, leaving a shortfall of 3.9 GW to be achieved in the next 8 years. To meet the required level of emissions reduction by 2030, the Climate Action Plan aims has targets of at least 2.1 TWh consumption of zero emission gas (which includes green hydrogen) for industrial heating and up to 0.7 TWh of renewable gas to aid in the decarbonisation of residential heating by 2030. In light of these policies and targets the do-nothing scenario is not a feasible option in this instance. Notwithstanding the overarching policy imperative for the project, a comparison of the potential environmental effects of the 'Do-Nothing' Alternative compared to the chosen option of developing a renewable energy project are presented in **Table 3.1** below.

[2] SEAI. (2021). Energy in Ireland 2021. https://www.seai.ie/publications/Energy-in-Ireland-2021_Final.pdf

Under a 'Do Nothing' alternative, the development of the renewable energy project would not proceed. The land upon which the Proposed Development would occur would remain unchanged as cutover bog. Consequently, the environmental impacts, identified in the EIAR, positive and negative, would not occur. Under this scenario, the prospect of generating additional renewable energy would not occur.

Table 3.1: Environmental effects of 'Do-Nothing' compared with the Firlough Wind Farm and Hydrogen Plant Development

Criteria	Do Nothing	Firlough Wind Farm and Hydrogen Plant
Population & Human Health (incl. Shadow Flicker)	No increase in local employment and no financial gains for the local community. No introduction of hydrogen skills and apprenticeships. No potential for shadow flicker to affect sensitive receptors.	Increase in local employment, financial gains for local community, County Mayo and County Sligo via rates paid and community benefit fund. Introduction of hydrogen skills and apprenticeships. Increased risk of negative impacts of shadow flicker. Addition of improved Wind Farm access roads which can be used for walking as a local amenity.
Terrestrial Ecology	The ecology of the Proposed Development (including birds) would be expected to remain similar to the present, though continued grazing pressures could be detrimental to the peatland habitats. Peat extraction will continue to degrade habitats and any further afforestation in the area on would be detrimental to habitats. Terrestrial ecology is likely to undergo some level of change because of climate change.	The Proposed Development will result in some cutover bog and improved grassland habitat loss and habitat disturbance resulting in a slight negative impact on species and habitat. Biodiversity enhancements proposed would have a positive impact on the baseline cut over bog habitat at the Wind Farm Site, potentially making habitats more resilient to future climate change.
Aquatic Ecology	If the Proposed Development does not proceed, lands at and in the vicinity of the Proposed Development will continue to be used for forestry, turbary and agricultural purposes. This would result in no significant change to aquatic ecology and habitats. However, it should be noted that these land use activities are having some negative effects on water quality within the catchment as	Increased risk of impacts to water quality during construction, mitigation will be required to reduce and avoid.

Criteria	Do Nothing	Firlough Wind Farm and Hydrogen Plant
	evidenced by the results of the surveys undertaken. If the current turbary peat harvesting continues this will continue to impact water quality and aquatic ecology.	
Soils & Geology	The existing land-use practices, including peat harvesting, forestry and grazing will continue along with the associated modification of the existing soils.	Excavation of soils for turbine foundations, Hydrogen Plant Site and infrastructure has the potential to negatively impacts soils.
Hydrology & Hydrogeology	The existing land-use practice of commercial forestry, peat harvesting, and agricultural activities will continue with associated gradual alteration of the existing environment and associated pressures on water quality.	Site investigations and the conclusion of the Ground Water Supply Assessment found that the combination of ground water extraction from two boreholes and rainwater harvesting was sufficient to supply the expected water demand of the Hydrogen Plant Site without depleting the aquifer or impacting the wells nearby. A waste water treatment system and ongoing monitoring will minimise impacts of wastewater on the receiving environment. Increased run off is a potential impact with any development on a green field site, the drainage systems have been designed to mitigate impacts.
Air & Climate	No temporary localised dust emissions. There will be no increase in air quality or reduction of greenhouse gas emissions provided by the Proposed Development. The Proposed Development will not assist in achieving the renewable energy targets set out in the Climate Action Plan. County Mayo and County Sligo's potential renewable energy capacity will remain underutilised. Further fossil fuels in the transport and other industries will not be displaced by the hydrogen fuel produced at Firlough.	Slight temporary localised negative impacts from dust emissions of construction works. Long term positive impact from displacing fossil fuels and reducing emissions. Positive contribution to Irelands renewable energy targets and mitigation of climate effects. Carbon offset estimation at 1.6 million – 2.5 million tonnes for the lifetime of the Proposed Development.

Criteria	Do Nothing	Firlough Wind Farm and Hydrogen Plant
Noise	No impacts will occur to sensitive noise receptors if the Proposed Development were not to go ahead.	Some temporary negative impacts to noise associated with construction to local noise receptors. Some operational noise impacts to closest receptors of the Proposed Development.
Landscape & Visual	No impact to Landscape and Visual.	Impact to Landscape and Visual from turbines and Hydrogen Plant Site.
Material Assets	No addition of the Wind Farm Substation and Grid Connection as an asset to EirGrid. No removal of commercial Forestry.	Positive impact of provision of electrical infrastructure. Removal of commercial forestry at the Wind Farm Substation location (Replanting lands mitigate).
Cultural Heritage	No impact.	Potential indirect visual impacts to monuments. Potential impact to undiscovered artifacts.
Traffic and Transport	No impact of increased traffic. No displacement of fossil fuel heavy vehicles with green hydrogen vehicles.	Short term negative impact of increased traffic during construction and decommissioning of windfarm. Displacement of fossil fuel heavy vehicles in the transport industry with green hydrogen vehicles.

Having regard to the significant positive impacts associated with the Project, including its impact on climate change mitigation, renewable energy targets, improved air quality and economic development and the availability of reasonable measures to mitigate the negative impacts associated with the project, it is considered that the do-nothing scenario would not be justifiable in this instance.

3.5 STRATEGIC DEVELOPMENT SITE SELECTION

3.5.1 Alternative Wind Farm Site Locations

The extant planning permission granted on the 01.08.2013 for the construction of 21 wind turbines (under An Bord Pleanála Reference PL16.241592) included an EIS with consideration of alternative Wind Farm Site locations.

Those assessed in detail were:

- Kilcummin, on the eastern side of Lacken Bay, Co. Mayo.
- Sheskin, to the east of Slieve Fyagh and to the west of the Oweniny River, Co. Mayo.

These can be seen in **Figure 3.1**.

These sites had positive features as potential wind farm locations, however there were concerns about the visual impact, proximity of inhabited houses and road access at the Kilcummin site, and concerns about peat depths and ecological impacts at the Sheskin site.

The inspectors report[3] from the original EIS notes that:
"The EIS subsequently states that both of these sites had positive attributes as potential wind farm locations, although they were eliminated from further consideration having regard to certain critical site selection criteria. For example, the Kilcummin site apparently raised concerns with regard to visual impact, the proximity of nearby dwellings and the adequacy of the road access arrangements, whilst there were also concerns about peat depth and potential ecological impacts at the Sheskin site. Accordingly, the case has been put forward that the subject site is the preferred location for the proposed development due to its larger site area, its location adjacent to another wind energy development, and its siting within an area of cutover bogland habitat which is served by an existing road structure. It has also been suggested that the application site was chosen in support of planning policy, presumably in reference to its location within an area identified as 'Tier 1 - Preferred (Large Wind Farms)' in the Renewable Energy Strategy for Co. Mayo, 2011".

The Wind Farm Site is designated in the Mayo County Development Plan 2022-2028, which has been subject to Strategic Environmental Assessment, in a 'Preferred' area for wind farms. The Wind Farm Site lies within a sub-category 'Tier 1 (Preferred Large Wind Farms)' indicating it is an area with the potential for large scale wind energy developments. The Wind Farm Site is located predominantly in an area of extensive peat extraction with access tracks already in place. It does not overlap with any environmental designations and is located in an area with a relatively low population density. It is adjacent to a neighbouring wind farm Carrowleagh, which allows the Wind Farm to take advantage of existing access tracks and turbine delivery route. It is within a viable proximity to the existing Glenree – Moy 110kV overhead line. The Wind Farm Site also has excellent wind resources. Taking these aspects in to consideration, the Wind Farm Site was identified as a suitable location for the provision of a wind farm of the scale proposed.

Due to the Existing Permission and suitability of the Wind Farm Site, alternative locations for the Wind Farm Site were not considered further.

[3]I An Bord Pleanála. (2013). Inspectors Report. https://archive.pleanala.ie/en-ie/case/241592

3.5.2 Alternative Hydrogen Plant Site Locations

During the site selection process, the Hydrogen Plant Site's impact on the environment, local communities and the landscape was given careful consideration. Key factors identified included:

- Proximity to the Firlough Wind Farm
- Availability of water for production
- Proximity to the national road network to limit the impact on the local public road network and its users
- The relative landscape and topography of the Hydrogen Plant Site in relation to sensitive receptors (including inhabited houses) to reduce the visual impact of the Hydrogen Plant
- Location of landscape sensitivity designations, scenic routes and viewpoints as defined by the County Development Plans of Sligo and Mayo
- Ground conditions and soils to avoid areas of deep peat
- Biodiversity considerations; Ecology of the Hydrogen Plant Site, proximity to conservation or protected areas
- Hydrological considerations including a 50 m buffer to water courses, consideration of private water supplies and ground water dependent terrestrial systems

It was considered optimal from an operations point of view that suitable sites for the Hydrogen Plant in immediate proximity to the Wind Farm would be preferred. Initially several locations within the Wind Farm Site were considered for the location of the Hydrogen Plant Site. Two were considered, between T6 and T7 and near the location of the Wind Farm Substation. The location near the Wind Farm Substation was selected due to the alternative being impractical in terms of access and the public being in the vicinity for peat cutting.

In February 2022, a letter drop along the local roads that hydrogen tube trailers would take to reach the national road network (N59) resulted in considerable feedback from local residents with concerns about the number of hydrogen tube trailers using these local roads during the operational phase of the Proposed Development.

As an alternative, a hydrogen depot on the N59 with a pipeline was considered but due to the high pressures required over a short distance this solution was commercially unviable. There was also concern from local communities regarding the disruption from construction of a hydrogen gas pipeline and the perceived negative health and safety implications.

It was concluded that transporting the green hydrogen between the Wind Farm Site and the National Road network was not a viable option. Therefore, it was considered that the Hydrogen Plant Site needed to move to a location in closer vicinity to the national road network but within a viable distance to connect to the Wind Farm Site with an under-ground Interconnector to transport electricity for the green hydrogen production process.

In total 13 potential sites were identified for the Hydrogen Plant Site (including at the Wind Farm), these are shown on **Figure 3.2.**

Of these, six were disregarded as unsuitable at an early stage due to various technical and commercial issues, for example overhead wires in close proximity, distance from the wind farm site making cabling financially prohibitive, right of way for access and size of available land, that made the locations unviable.

Six were considered further as reasonable alternatives against the assessment criteria outlined above.

These alternatives along with the original Wind Farm Site location are described below:

1. **The Hydrogen Plant Site**

A site of 6.5 ha currently an agricultural field used for grazing horses. It is located in County Sligo in the townland of Carraun, adjacent to the Co. Mayo border, 6 km west of the Wind Farm Site and 0.6 km from the N59 national road. Site elevations range from 53 m OD at the north-west corner to 45 m OD along the southern boundary. It is 5.3 km north-west of the village of Bunnyconnellan (Co. Mayo) and 2.9 km south of the village of Corballa (Co. Sligo). The nearest large settlement is the town of Ballina (Co. Mayo.) 5.5 km to the south-west. It is located in a rural setting, set back from the clusters of ribbon development along the N59. Population density is 19 persons per km^2, much lower than the national average in Ireland of 72 persons per km^2. The principal land uses in the surrounding area is agricultural lands, individual dwellings, the N59 national primary road and commercial conifer plantations.

There are no natural watercourses on the site, the closest is 70 m south. This has a "'Good' Status and flows into the Moy Estuary. According to the Catchment Report issued by the EPA, no significant pressures were identified during the 3rd Cycle Draft Assessment. Furthermore, the River Waterbodies Risk is currently under review during this cycle assessment. Land underlying the site is comprised of peat bogs and surrounded by pastoral land, underlying subsoils have been classified as '(Carboniferous) Limestone tills (diamictons)' along with 'Cutover peat. It is underlain by an area classified as 'Moderately Productive Bedrock (LI)' with a vulnerability rating of 'High' Vulnerability. RSK Group Ltd was commissioned by the Developer to carry out a groundwater supply assessment for the water supply for the Hydrogen Plant. The report assessed the capacity of the ground water and rainwater harvesting to supply the Proposed Development with the required volume and quality of water without impacting nearby water supplies or the aquifer. The conclusion of the Ground Water Supply Assessment, that can be found in **Appendix 9.8**, was that the two boreholes can supply the expected water demand of the Hydrogen Plant Site without materially impacting the aquifer or impacting the wells nearby.

In terms of landscape, this site is located in a "Normal Rural Landscape" in the Sligo County Development Plan 2017-2023 and adjacent to an area of "Sensitive Rural Landscape".
There are no known archaeological monuments on the site, the closest is 0.6 km east on the N59 and is an unclarified Barrow.

2. **Hydrogen site at the Wind Farm**

This is a relatively flat site, ranging from 117 m O.D. to 121 m O.D., of 8.5 ha within the Wind Farm Site located where the proposed Wind Farm Temporary Construction Compound materials storage area is located. It is adjacent to cutover peatland and commercial forestry in the townland of Carrowleagh (Kilbride), Co. Mayo, in the lower north-western foothills of the Ox Mountains. Bunnyconnellan (Co. Mayo) is 4 km to the south-west, Corballa 6.5 km (Co. Sligo) to the north-west, Culleens 7.5 km (Co. Sligo) to the north, Enniscrone (Co. Sligo) 11 km to the north. The nearest large settlement is the town of Ballina (Co. Mayo.) 12 km to the west. Population density in the surrounding area is generally very low, with 4.97 persons per km^2, the closest dwelling is 440 m to the southwest. The principal land use in the general area is comprised of a mix of peat bogs, agricultural lands, commercial forestry and the Carrowleagh Wind Farm and extension adjacent to the east and north-east. There is one order one watercourse running through the site, this has a "good" status and is not at risk of meeting Water Framework Directive (WFD) objectives. The groundwater is classed as a "Locally Important Aquifer - Bedrock which is Moderately Productive only in Local Zones", the aquifer has a "good" status and is not at risk of meeting WFD objectives.

In terms of landscape, according to the Mayo Landscape Appraisal of County Mayo from the Mayo CDO 2022-2028, this site falls in to a Sensitive Area classed as "Peat bogs". The CDP states:

"*These areas have a distinctive, homogenous character, dominated by natural processes. Development in these areas has the potential to create impacts on the appearance and character of an extensive part of the landscape. Applications for development in these areas must demonstrate an awareness of these inherent limitations by having a very high standard of site selection, siting layout, selection of materials and finishes. Applications in these areas may also be required to consider ecological, archaeological, water quality and noise factors insofar as it affects the preservation of the amenities of the area*."

And:
"*These areas are indicative and prone to localised change over time where vegetative cover or agriculture management practices are the principal determinants*."

It is in policy area 3, where industrial/commercial development, in the Landscape Sensitivity Matrix is considered to have medium potential to create adverse impacts on the existing landscape character area. There are no known archaeological monuments on the site, the closest is 0.8 km north and is a Megalithic court tomb.

3. Culleens

This is a flat, brownfield site of 1.78 ha located adjacent to the existing Hilltop Service Station on the N59 in the townland of Culleens, Co. Sligo at 84 m O.D. The area is currently used for storage and is generally underutilised. The site has direct access on to the N59 and has an artificial, hard standing surface. There are no watercourses on, or in the vicinity of the site, the closest is 500 m west. The groundwater is a regionally important aquifer, with a good status, not at risk of failing to meet WFD objectives. The wider area is classed as Agricultural Areas; Pastures, in the Corine 2018 index. There are blanket bogs 0.8 km to the east. The closest designated sites are the Ox Mountains Bogs Special Areas of Conservation and the Ox Mountains Bogs Proposed Natural Heritage Area 4.6 km to the east. It is located approximately 15 km northwest of Ballina, 7 km north of the Wind Farm Site and 5 km east of Enniscrone. The population density in the surrounding area is 24.56 persons per km^2 and the closest dwellings are 40 m south and 60 m west.

In terms of landscape, according to the Sligo County Development Plan 2017-2023, this is in in a "Normal Rural Area". These are considered generally to have the capacity to absorb a wide range of new development forms. There are no known archaeological monuments on the site, the closest is 0.4 km north and is a Megalithic wedge tomb.

4. Carra

This is a flat site of 5.56 ha, in the townland of Carha, County Mayo, 0.39 km east of the County Sligo border and 7.26 km northeast of Ballina. It is currently used for agricultural grazing and has an area of cutover peat in the western corner of the site. Initial visits suggest there is deep peat present in areas. The subsoils are classed as "cutover peat". There are three watercourses across the site, these have "good" status and are not at risk of meeting objectives in the WFD. The groundwater, classed as a "Locally important gravel aquifer" has a mixture of both high and medium aquifer vulnerability with a "good" status and is "not at risk" of meeting WFD objectives. The River Moy Special Area of Conservation is 1.25 km to the southwest, the site drains towards the west where watercourses connect to the SAC 3.28 km downstream.

The site is located 4 km west of the Wind Farm Site and 3.34 km along local roads to the N59. There is ribbon residential development and an equestrian centre along these local roads.

The wider area is largely classed as Agricultural Areas: Pastures, in the Corine 2018 index, with an area of peatland 0.33 km to the southwest. The population density in the surrounding area is 24.56 persons per km^2 and the closest dwellings are located 120 m to the west, there are several one-off dwellings surrounding the site on the west and north. In terms of landscape, according to the Mayo Landscape Appraisal of County Mayo from the Mayo CDO 2022-2028, this site falls into a Sensitive Area classed as "agricultural lands with significant natural vegetation". The CDP states:
"*These areas have a distinctive, homogenous character, dominated by natural processes. Development in these areas has the potential to create impacts on the appearance and character of an extensive part of the landscape. Applications for development in these areas must demonstrate an awareness of these inherent limitations by having a very high standard of site selection, siting layout, selection of materials and finishes. Applications in these areas may also be required to consider ecological, archaeological, water quality and noise factors insofar as it affects the preservation of the amenities of the area*."

And:
"*These areas are indicative and prone to localised change over time where vegetative cover or agriculture management practices are the principal determinants*."

It is in policy area 4, where industrial/commercial development, in the Landscape Sensitivity Matrix is considered to have low potential to create adverse impacts on the existing landscape character. There are no known archaeological monuments or sites on the site, the closest is an enclosure 0.5 km to the southeast. There is an area of forestry 0.27 km to the southeast and some sparse hedgerows on the northwest and southeast boundaries.

5. Shanaghy

This site is in a flat, low lying (18 m O.D.) agricultural field of 5.62 ha in the townland of Ardnaree, 200 m south of Ballina Golf Course. It is adjacent to a dwelling and farm buildings and is currently used for grazing. The next closest dwellings are 170 m to the north. It is 2.07 km southeast of Ballina, Co. Mayo, the main centre for this region, population 10,171 (CSO 2022). The population density at the site 55.35 persons per km^2. It is 700 m southwest from regional road R294 which leads to the national road N59 in Ballina town. It is 10 km southwest of the Wind Farm Site.

The wider area is largely classed as Agricultural Areas: Pastures, in the Corine 2018 index. The wider land uses include the Ballina golf course, the urban area of Ballina, commercial forestry, agriculture and an area of peatbog 1.5 km southeast. There are no watercourses on the site. The closest is adjacent to the southeast corner of the site, this flows in a northeast direction, towards the River Moy Special Area of Conservation, the closest protected area, 550 m northeast of the site. The watercourse has a "good" status and is not at risk of meeting the WFD objectives. The bedrock aquifer is categorised as a regionally important, karstified aquifer and groundwater status is classed as "good" not at risk of meeting WFD objectives.

In terms of landscape this site is close to a "Vulnerable Area" in the Mayo Landscape Appraisal of County Mayo from the Mayo CDO 2022-2028, which broadly follows the route of the River Moy SAC. It is in policy area 4, where industrial/commercial development, in the Landscape Sensitivity Matrix is considered to have low potential to create adverse impacts on the existing landscape character. There are no archaeological sites or monuments on the site, the closest, an enclosure, is 700 m southeast.

6. Bunnyconnellan East

This is a large site with 465 ha of potential space, 1.4 km south of the Wind Farm Site, in the townlands of Bunnyconnellan East and Drumsheen, County Mayo, adjacent to the Sligo County border. It has undulating topography generally and includes a ridge in the southwest which peaks at 389 m O.D. and is part of the Ox Mountains. This ridge has a high susceptibility to landslides, and there are three previous landslide events in this area, the majority of the rest of the site has a low, or moderately low susceptibility. There is bedrock at the surface along the ridge and this is classed as moors and heathland in the Corrine

2018 index. It is 2.18 km west of the village of Bunnyconnellan, 10 km east of Ballina and 18 km west of Tobercurry. The site is located in Kilgarvin bogs, a cutover bog and location of the operational Bunnyconnellan Wind Farm. The habitats on site appear to include, wet and dry heath and blanket bogs, though significant areas are degraded due to peat cutting. There is a marked walking trail through the bog, part of the Kilgarvin loop and the Western Way walking route. The site is 500 m east of the Windy Gap, a scenic area. Lough Hoe Bog Special Area of Conservation and Lough Hoe Bog Proposed Natural Heritage Area are adjacent to the east and south. The site drains towards the northwest, away from the SAC and pNHA. There are six order one watercourses, two order two water courses, two order three watercourses and a small lake on the site. There are also a number of non-mapped manmade drains in the cut over bog areas. All watercourses have a "good" status, and are not at risk of meeting the WFD objectives apart from one in the northeast corner of the site which has a high status, and is considered at risk of meeting the WFD objectives for this watercourse which include retaining this high status. The bedrock aquifer is classed as "Poor Aquifer - Bedrock which is Generally Unproductive except for Local Zones", with a "good" status and not at risk of meeting the WFD objectives. The majority of the site has low and medium aquifer vulnerability with some areas of high vulnerability.

Land uses in the wider area include forested areas, agricultural pastures, peat bogs, areas of scrubland, a quarry adjacent to the west and the village of Bunnyconnellan, with a population of 188 in the 2016 census and location of the Bunnyconnellan agricultural show which attracts upwards of 30,000 visitors annually. The wider area is sparsely populated with a population density of 4.97 persons per km^2. The closest dwelling is 400 m to the northwest. Ribbon development occurs along the regional road R294, and local roads to the west of the site. There are no dwellings to the south and east and sparse ribbon development to the north.

The national road N17 is 18 km east along regional road R294 which is adjacent to the site. In terms of landscape, according to the Mayo Landscape Appraisal of County Mayo from the Mayo CDO 2022-2028, this site is close to a "Vulnerable Feature - Skylines" along the ridge and a designated scenic route traverses the site. It falls into a sensitive area classed as Peat Bogs. It is in policy area 3, where industrial/commercial development, in the Landscape Sensitivity Matrix is considered to have medium potential to create adverse impacts on the existing landscape character area. There is one "unclassified" registered archaeological site on the sites and monuments record on this site.

A comparison of the environmental impacts of these 5 options along with the original Wind Farm adjacent option is shown in **Table 3.2.**

Table 3.2: The Environmental impacts of the alternative locations of the Hydrogen Plant

Criteria	Hydrogen Plant Site adjacent to Wind Farm Site	Hydrogen Plant Site adjacent to national road network	Culleens	Carra	Shanaghy	Bunnyconnellan East
Population & Human Health (incl. Shadow Flicker)	Higher impact from disturbance, nuisance and dust emissions from additional road transport on local roads in proximity to inhabited houses and other sensitive receptors. Transportation of hydrogen by underground pipeline was also considered. However, it was found that the pressure required for the pipeline was not feasible over a short distance. There was concern from local communities regarding the disruption and perceived health and safety implications of a pipeline. Distance to inhabited dwelling circa 440 m.	Reduced negative impacts from vehicles on local roads in relation to hydrogen transport. Increased temporary disturbance due to construction of Interconnector. Distance to inhabited dwellings circa 300 m. Potential, though distant hydrological link to the River Moy SAC, potentially higher impacts to water quality could effect salmon populations and the fishing and tourism industry during the construction phase. Use of construction best practice, mitigation and monitoring reduces this impact to imperceptible.	Hydrogen produced close to the national road network so lower disturbance, nuisance and dust emission impacts to sensitive receptors along local roads. Increased temporary disturbance due to construction of Interconnector. Higher potential impacts to two dwellings located within 60 m of the site.	Higher impact from disturbance, nuisance and dust emissions from additional road transport on local roads in proximity to inhabited houses and other sensitive receptors. Increased temporary disturbance due to construction of Interconnector. Distance to inhabited dwellings circa 120 m. Potential hydrological link to the River Moy SAC downstream, potentially higher impacts to water quality could effect salmon populations and the fishing and tourism industry during the construction phase. Use of construction best practice, mitigation and monitoring reduces this impact to imperceptible. Potential higher impacts to the equestrian centre which is along the hydrogen transport route to the national road network.	Significantly higher number of sensitive receptors in proximity to the development, increases potential impacts from disturbance, nuisance and dust emissions during construction. Location close to Ballina means hydrogen transport during operation is likely to need to travel through Ballina town centre to reach the national road network which would cause unacceptably high impacts to traffic, disruption, nuisance, noise etc. Adjacent to closest dwelling. Increased temporary disturbance due to construction of Interconnector which would be the longest route of the options. The River Moy SAC is relatively close at approximately 550 m away, this could cause potentially higher impacts to water quality which could effect salmon populations and the fishing and tourism industry. Potentially higher disturbance to the golf club and impacts to tourism.	Very low population density results in a small number of sensitive receptors in close proximity. Close proximity to regional road reduces impacts on local roads, however, distance to national road network is great, potentially increasing impacts along the regional roads. If hydrogen is required to travel west, vehicles would need to go through both Bunnyconnellan village and Ballina town, creating a high number of sensitive receptors on the transport route. Potential higher impacts to tourism due to proximity to Bunnyconnellan show, a scenic route and potential short term impacts to walking routes during construction phase. Closest dwelling is 400 m.
Terrestrial Ecology	Footprint confined to one location, reduction in negative disturbance impacts to habitats. Production plant located on cutover bog which has little ecological value.	Additional site location of Hydrogen Plant Site and additional underground cabling causes more habitat loss and disturbance during construction. Hydrogen Plant Site now located on agricultural lands which has little ecological value.	Brown field site so reduction in impacts of habitat destruction and disturbance. Slight increase due to length of underground cabling required.	Additional site location of Hydrogen Plant Site and additional underground cabling causes more habitat loss and disturbance during construction. Impacts caused by loss of some peatland habitat, though this has been subject to historic peat cutting.	Additional site location of Hydrogen Plant Site and additional underground cabling causes more habitat loss and disturbance during construction. Lower impacts from habitat loss due to low ecological value of agricultural grassland habitat.	Additional site location of Hydrogen Plant Site and additional underground cabling causes more habitat loss and disturbance during construction. Impacts caused by loss of peatland habitat, though areas have been subject to historic peat cutting so habitat is degraded. Potential loss of other important habitats including wet and dry heath. Close proximity to intact peatland habitat which

Criteria	Hydrogen Plant Site adjacent to Wind Farm Site	Hydrogen Plant Site adjacent to national road network	Culleens	Carra	Shanaghy	Bunnyconnellan East
						could have high disturbance impacts during construction.
Aquatic Ecology	Single location for whole Proposed Development reduces number of watercourses in proximity potentially reducing risk to water quality. Higher potential negative impacts to peatland aquatic ecology due to Hydrogen Plant Site being located in closer proximity to peatland habitats.	Proposed Development spread over two sites potentially increases number of sensitive receptors. Potential for disruption to hydrology network due to ground works needed for cable route. Hydrogen Plant Site moved to undeveloped agricultural land rather than cutover bog reducing the hydrological risks to peatland aquatic ecology.	Proposed Development spread over two sites potentially increases number of sensitive receptors. There are no watercourses on the site which already has an artificial surface and there is a lower risk to water quality. Potential for disruption to hydrology network due to ground works needed for cable route. Site moved brownfield site rather than cutover bog reducing the hydrological risks to peatland aquatic ecology.	Proposed Development spread over two sites potentially increases number of sensitive receptors. Higher potential negative impacts to peatland aquatic ecology due to Hydrogen Plant Site being located in closer proximity to peatland habitats. Higher potential impacts due to possible connectivity with the River Moy SAC, designated for species that depend on high water quality including White-clawed Crayfish, Sea Lamprey, Salmon and Otter.	Proposed Development spread over two sites potentially increases number of sensitive receptors. Lower impact to peatland hydrology due to distance to large areas of intact peatland. Some smaller areas of peat soil on the site could be avoided to reduce impacts. Higher potential impacts due to proximity to the River Moy SAC, designated for species that depend on high water quality including White-clawed Crayfish, Sea Lamprey, Salmon and Otter.	Proposed Development spread over two sites potentially increases number of sensitive receptors. Higher potential negative impacts to peatland aquatic ecology due to Hydrogen Plant Site being located in closer proximity to intact peatland habitats. Highest number of watercourses on the site increases potential sensitive receptors. The nearby SAC is designated for White-clawed Crayfish which depend on high water quality. Potentially high impacts could effect this species especially during the construction phase.
Ornithology	Single location for whole Proposed Development reduces impacts in terms of disturbance.	Splitting the Proposed Development over two locations increases potential habitat disturbance.	Splitting the Proposed Development over two locations increases potential habitat disturbance. However, the brownfield, nature of the site and due to it being regularly frequented by people there is unlikely to be a significant increase in impacts to birds.	Splitting the Proposed Development over two locations increases potential habitat disturbance.	Splitting the Proposed Development over two locations increases potential habitat disturbance.	Splitting the Proposed Development over two locations increases potential habitat disturbance.
Soils & Geology	Single location with shared access road slightly reduced impact to soils. Hydrogen Plant on Wind Farm Site increases footprint and peatland soil disturbance.	Additional access road to second site causes a small increase in land take and soil impact. Reduction in impact on peatland soils as Hydrogen plant located on agricultural land. Cable connection increases soil disturbance and excavation.	Reduction on impact to peatland soils as site is brownfield and further away from peatland. Cable connection increases soil disturbance and excavation.	Additional access road to second site causes a small increase in land take and soil impact. Hydrogen plant on peatland soils, potentially increasing negative impacts to surrounding peatland soils. Cable connection increases soil disturbance and excavation.	Lower impact to peatland hydrology due to distance to large areas of intact peatland. Some smaller areas of peat soil on the site could be avoided to reduce impacts. Longest cable connection route, increases soil disturbance and excavation.	Hydrogen plant on peatland soils, potentially increasing negative impacts to surrounding peatland soils. Cable connection increases soil disturbance and excavation, though impact lower than other remote site due to proximity to Wind Farm.
Hydrology & Hydrogeology	Hydrogen Plant Site is close to large area of cutover and degraded peatland. The	Located further from the large area of peatland with lower related risks of water	Located further from peatlands with lower related risks of water input requirements of the	Site is close to an area of cutover and intact peatland. The electrolyser requires water	Located further from the large area of peatland with lower related risks of water input	Hydrogen Plant Site is close to large area of intact peatland. There is an increased risk of

Criteria	Hydrogen Plant Site adjacent to Wind Farm Site	Hydrogen Plant Site adjacent to national road network	Culleens	Carra	Shanaghy	Bunnyconnellan East
	electrolyser requires water input to produce green hydrogen. There is an increased risk of impacting the peatland hydrology by having the water input required coming from groundwater close to the peatland which could potentially cause further degradation and further reduction in the likelihood of peatland restoration to a carbon sink.	input requirements of the Hydrogen Plant Site impacting peat hydrology. Aquifer has been shown to be able to sustainably supply water for the hydrogen production process without materially depleting the aquifer or having a detrimental impact on surrounding groundwater and soils. Over pumping of the well can potentially reduce groundwater levels in excess of seasonal fluctuation, however with continuous monitoring and management, the risk of adversely impacting on groundwater levels in the locality will be easily mitigated. There is a small degraded peatland area to the south of the Hydrogen Plant Site, this has been avoided and results from hydrology and hydrogeology impact assessment find that water abstraction will not impact the hydrology of this area.	Hydrogen Plant Site impacting peat hydrology.	input to produce green hydrogen. There is an increased risk of impacting the peatland hydrology by having the water input required coming from groundwater close to the peatland which could potentially cause further degradation and further reduction in the likelihood of peatland restoration to a carbon sink.	requirements of the Hydrogen Plant Site impacting peat hydrology. Proximity to River Moy SAC potentially increases impacts due to water abstraction.	impacting the peatland hydrology by having the water input required coming from groundwater close to the peatland which could potentially cause degradation and impact the peatland functionality as a carbon sink. This site has the highest number of watercourses on the site, higher risk of impacts to hydrology and hydrogeology. Increased risk of impacting water quality due to presence of water course that must retain "good" status.
Air & Climate	Higher negative impact of dust emissions locally due to road transportation increase. Increase in carbon payback time due to being located on peat soils.	Reduction in transportation vehicles; lower dust impact locally. Slight increase in carbon payback time due to increased soil excavation for underground cable.	Reduction in transportation vehicles, site is located directly on to national road network; lower dust impact locally. Slight reduction in carbon payback due to reduction in soils excavation due to brown field nature of site.	Higher negative impact of dust emissions locally due to road transportation increase. Increase in carbon payback time due to being located on peat soils and soil excavation for underground cable.	Increase in carbon payback time due to soil excavation for underground cable. Higher negative impact of dust emissions locally, due to road transportation increase and proximity to higher number of sensitive receptors in Ballina town.	Higher negative impact of dust emissions locally due to road transportation increase. Increase in carbon payback time due to being located on peat soils. Slight increase in carbon payback time due to soil excavation for underground cable.
Noise	Equal distance to sensitive noise receptors from Hydrogen Plant Site and mitigation by design makes impact neutral.	Equal distance to sensitive noise receptors from Hydrogen Plant Site and mitigation by design makes impact neutral.	Site is within 60 m, of dwellings, this has potentially unacceptably high noise impact on these receptors during the construction and operational phases of the development.	Site is within 120 m, of dwellings, this could potentially cause a high noise impact on these receptors during the construction and operational phases of the development.	Site is adjacent to dwellings and in close proximity to a golf club this has potentially unacceptably high noise impact on these receptors during the construction and	Significant distance to any sensitive receptors reduces noise impacts. Traffic on local roads and through Ballina Town Centre and Bunnyconnellan increases noise

Criteria	Hydrogen Plant Site adjacent to Wind Farm Site	Hydrogen Plant Site adjacent to national road network	Culleens	Carra	Shanaghy	Bunnyconnellan East
	Traffic on local roads increases noise impact on sensitive receptors.	Reduction in noise impact from local road traffic and no impact from pipeline.			operational phases of the development. Traffic on local roads and through Ballina Town Centre increases noise impact on a high number of sensitive receptors.	impact on a high number of sensitive receptors.
Landscape & Visual	Single location of project reduces visual impacts and screening of nearby forestry on the Wind Farm Site further reduces visual impact.	Hydrogen Plant Site as a separate location increases the number of sensitive receptors to the project, however the location, topography, building design and natural screening reduces visual impacts.	The site already includes development, however there are houses in close proximity, as well as the national road and the site has very little natural screening so the development would be clearly visible. This site is not close to scenic routes and is not considered in a sensitive landscape area.	Site is in a sensitive landscape area. Potentially high impact to landscape and visual due to close proximity to dwellings on multiple sides with little natural screening from vegetation or topography.	Potential higher impact landscape due to sensitive landscape area.	Lower number of sensitive receptors in the vicinity. However there are higher potential impacts on landscape and visual due to the proximity of a "vulnerable feature", a designated scenic route and walking trails within the site.
Material Assets	Loss of cutover peatland.	Loss of agricultural land at Hydrogen Plant Site.	The Hydrogen Plant could potentially economically benefit the service station adjacent to the site. There would be minimal change of land use as the area identified is underutilised at present.	Small loss of agricultural land at Hydrogen Plant Site.	Small loss of agricultural land at Hydrogen Plant Site. Potential impact to sensitive and productive fisheries due to proximity to River Moy SAC.	Adjacent to existing wind farm, substation and over-head line cabling route needs to be carefully managed to ensure capacity in road and existing cabling is not impacted.
Cultural Heritage	Neutral	Neutral	Neutral	Neutral	Neutral	Potential higher impacts to archaeological site on the site.
Traffic and Transport	Higher negative impact on local roads during operational period. The Developer commissioned the route analysis report outlined in **Appendix 15.1**. The finding of this report was that transporting the green hydrogen by road from the Wind Farm Site Hydrogen Plant to the N59 road was not viable.	Significantly lower impact during operational phase of Proposed Development on local communities.	Significantly lower impact during operational phase of Proposed Development on local communities due to direct access to the national road network.	Higher negative impact on local roads during operational period.	Higher negative impact on local roads and high number of sensitive receptors in Ballina town during operational period.	Higher negative impact on regional roads and high number of sensitive receptors in Ballina town and Bunnyconnellan village during operational period.
Major Accidents and Natural Disasters	Hydrogen Plant Site remains at safe distance from inhabited houses, areas of high public use and outside of environmentally sensitive areas or areas of	Hydrogen Plant Site remains at safe distance from inhabited houses, areas of high public use and outside of environmentally sensitive areas or areas of geological	Potential increase in risks to people frequenting the service station and in adjacent dwellings due to proximity to the plant.	Potential increase in risks to dwellings due to proximity to the plant.	Potential increase in risks to dwellings due to proximity to the plant.	Hydrogen Plant Site remains at safe distance from inhabited houses, areas of high public use and outside of environmentally sensitive areas and flood risk,

Criteria	Hydrogen Plant Site adjacent to Wind Farm Site	Hydrogen Plant Site adjacent to national road network	Culleens	Carra	Shanaghy	Bunnyconnellan East
	geological instability and flood risk, neutral impact to Natural Disasters and Major Accidents.	instability and flood risk, neutral impact to Natural Disasters and Major Accidents.			Potential cumulative impacts with Upper Tier Seveso Site 1.6 km northwest.	neutral impact to Natural Disasters and Major Accidents. This site however has areas of high landslide susceptibility. Though these areas would be avoided, there still remains a potential risk to the development.

The Hydrogen Plant Site was selected based on its proximity to the national road network and the positive results of a road assessment report, feedback from the HSA and the site being a safe distance from inhabited houses, with appropriate setback distances to sensitive receptors and avoidance of densely populated areas and areas of high public use including amenities such as walking trails. The location avoids ecologically protected areas and high value habitats including peatland. It is outside of areas of geological instability and flood risk. It has a sustainable water source, and the location has lower impacts to water quality, hydrology and hydrogeology than the alternatives considered. It is a viable cabling distance to the Wind Farm Site and lower than some of the alternatives considered, which reduces the number of sensitive receptors along the route and soil disturbance during construction. The location provides natural screening and avoids impacts to cultural heritage sites.

3.5.2.1 Suitability of the Hydrogen Plant Site

The Hydrogen Plant Site is located in County Sligo. The Sligo County Development Plan (CDP) 2017-2023 is the current, adopted plan. Stimulating the economy and generating employment are important aspects of the plan. Climate change is addressed, and the plan highlights the County Council's responsibility to implement measures to aid the transition to a low carbon economy and society, including increasing the use of renewable energy in line with regional and national policy. The Hydrogen Plant Site is designated as a "Normal Rural Landscape" in the Sligo CDP, which are defined as:

"Areas with natural features (e.g. topography, vegetation) which generally have the capacity to absorb a wide range of new development forms – these are largely farming areas and cover most of the County. At the same time, certain areas located within normal rural landscapes may have superior visual qualities, due to their specific topography, vegetation pattern, the presence of traditional farming or residential structures. These areas may have limited capacity for development or may be able to absorb new development only if it is designed to integrate seamlessly with the existing environment."

The Hydrogen Plant Site is adjacent to an area of "Sensitive Rural Landscape" designated in the Sligo CDP, this area has been avoided including a buffer zone to minimize negative impacts.

The Sligo CDP does not mention hydrogen specifically, however it does contain a section pertaining to the "Major Accidents Directive (Seveso III)" it states:

"This development plan does not designate sites or zones for uses that might be classified as Seveso establishments and no such establishments exist at present. However, such

uses will not be permitted in the vicinity of houses, places of concentrated public use or in environmentally sensitive areas and designated conservation areas."

The Hydrogen Plant Site, under advice from the HSA (details located in **Chapter 1: Introduction, Section 1.10.2**), comes under the lower tier of SEVESO. It is not located in the vicinity of houses (closest inhabited house is 299 m to the north), areas of concentrated public use (Castleconnor community centre 2.2 km, to the north) or in any environmentally sensitive or designated areas (River Moy SAC, 2.5 km to the south).

The Hydrogen Plant Site is within connection distance to the Wind Farm Site using an underground cable (the Interconnector). There are no sensitive aquatic or terrestrial receptors in the vicinity of the Hydrogen Plant Site.

The Hydrogen Plant Site is located on agricultural lands currently used for horse grazing and has low ecological value. There is some natural screening from the topography and vegetation already in place and the set back of approximately 600 m from the main road.

Hydrological testing at the Hydrogen Plant Site found that water extraction using two boreholes is sufficient to supply the expected water demand of the Hydrogen Plant Site without materially depleting the aquifer or impacting the wells nearby.

The Hydrogen Plant Site is located in a rural setting, set back from the clusters of ribbon development along the N59. Population density is 19 persons per km^2, much lower than the national average in Ireland of 72 persons per km^2. There are 22 inhabited houses within one km of the Hydrogen Plant Site and the closest inhabited house is 299 m to the north-east.

3.6 ALTERNATIVE RENEWABLE ENERGY TECHNOLOGIES

An alternative source of renewable energy considered for the Wind Farm Site was solar energy. Commercial solar energy production is the harnessing and conversion of sunlight into electricity using photovoltaic arrays (panels). The capacity factor of solar energy is significantly lower than that of wind energy, requiring approximately three times the installed capacity of the Wind Farm (i.e., 3 x 78 MW = 234 MW) to produce the same amount of energy. Solar farms require one hectare per MW, the land area required would be in the region of 234 hectares. This compares to a footprint of circa 30 ha for the 13 no. proposed turbines and infrastructure.

Table 3.3 outlines the potential impact from the development of a solar photovoltaic array when compare against the Firlough Wind Farm.

Table 3.3: Environmental Effects from a Solar Photovoltaic Array compared to a Wind Farm Development

Criteria	Solar Alternative	Firlough Wind Farm
Population & Human Health (incl. Shadow Flicker)	No potential for shadow flicker to affect sensitive receptors. Potential for glint and glare impacts on local road users.	Potential for shadow flicker, though no glint and glare impacts.
Terrestrial Ecology	Larger footprint would result in greater habitat loss.	Lower footprint reduces habitat loss.
Aquatic Ecology	Larger footprint would result in greater impact to water quality and aquatic ecology with increased runoff.	Lower footprint reduces impact.
Ornithology	Potential for mimicry of sensory cues i.e., glint and glare similar to water. Decrease in the risk of bird collisions without moving turbine blades.	Reduced risk of glint and glare, increased collision risk to birds.
Soils & Geology	Larger footprint would result in wider spread impact to soils. Shallower excavations involved in solar PV array development would decrease the potential for peat instability.	Smaller footprint results in smaller areas of peat soils impacted. Deeper requirements for turbine foundations increases peat instability risk.
Hydrology & Hydrogeology	A solar PV array development would require a larger footprint therefore increasing the potential for silt laden runoff to enter receiving watercourses.	Lower footprint reduces impact.
Air & Climate	Solar energy requires less steel and less concrete than wind energy; Concrete c. 60 tonnes per MW (234 MW installed capacity=14,203 t).	Wind energy requires more steel and more concrete than solar energy; Concrete between 240 and 413 tonnes per MW (78 MW installed capacity= between 18,993 and 32,214 t).

Criteria	Solar Alternative	Firlough Wind Farm
	Steel c. 67.9 tonnes per MW[4] (234 MW installed capacity=15,888). These have a high embodied carbon value. Despite requiring a larger installed capacity to achieve the same output, the volume of steel and concrete required and related embodied carbon for solar panels would be lower. It therefore has a shorter carbon payback time.	Steel between 107 and 132 tonnes per MW[5] (78 MW installed capacity= between 8,346 and 10,296 t) These have a high embodied carbon content. Despite requiring a lower installed capacity to achieve the same output, the volume of steel and concrete required and the related embodied carbon for wind turbines would be higher. It therefore has a longer carbon payback time.
Noise	No potential for noise impacts on nearby sensitive receptors during operational phase.	Higher impact of noise impacts from turbines during operational phase.
Material Assets	The larger footprint will have a greater impact on the land use (peat harvesting, forestry and agriculture).	Lower footprint reduces impact.
Landscape & Visual	Potentially less visible from surrounding area due to screening from forestry and topography.	Higher visibility impact.
Cultural Heritage	Larger footprint would result in a bigger impact on undiscovered cultural artifacts.	Lower footprint reduces impact.
Traffic & Transport	Potential for greater traffic volumes during construction phase due to the number of solar panels required to achieve the same output.	Fewer deliveries will be made, however due to the size of turbine components potential for higher impacts to road widening requirements.
Major Accidents and Natural Disasters	Lower risks associated with poor weather and ground stability. Higher risk from fire and electrical faults.	Higher risks associated with the impacts of poor weather on turbines and ground stability due to foundation depths. However, these risks are well understood and turbine design, sensors and good practice reduce these risks.

[4] EU. (2020). Raw materials demand for wind and solar PV technologies in the transition towards a decarbonised energy system. https://op.europa.eu/en/publication-detail/-/publication/19aae047-7f88-11ea-aea8-01aa75ed71a1/language-en
[5] EU. (2020). Raw materials demand for wind and solar PV technologies in the transition towards a decarbonised energy system. https://op.europa.eu/en/publication-detail/-/publication/19aae047-7f88-11ea-aea8-01aa75ed71a1/language-en

In considering alternative renewable energy technologies, the plan area land requirement of 234 ha for the solar energy alternative for an equivalent output from a 78 MW wind farm was considered not sustainable when compared to the circa 30 ha plan area requirement for the Wind Farm.

3.7 HYDROGEN PLANT

The Existing Permission and originally designed project did not include a green hydrogen element. To harness the Proposed Development's full potential to generate renewable energy, a hydrogen element was included during the design process. The production of green hydrogen creates zero carbon emissions and enhances the output potential of the Wind Farm and its contribution to renewable energy and climate targets for Ireland. This hydrogen can be utilised as a fuel which can benefit Ireland's economy and energy security and can be used to displace fossil fuels in hard to abate sectors giving further climate benefits. The environmental impacts of an alternative development design without the hydrogen element compared to the development design with the hydrogen element is shown in **Table 3.4**.

Table 3.4: The environmental impacts of an alternative development design without the hydrogen element compared to the development design with the hydrogen element

Criteria	Alternative Process; No Hydrogen Plant	Firlough Wind Farm Co-location with Hydrogen Plant
Population & Human Health	No addition of hydrogen skills or employment to the region. No impetus for hydrogen-based enterprise to locate in the region. No growth of green hydrogen transport and industry sectors and no related improvements to air quality. No further increases to energy security. No water element to Proposed Development so no potential impact on aquifer or wells nearby.	Increased positive impacts; Addition of hydrogen skills and employment opportunities, transportation jobs and potential of attracting hydrogen-based enterprise to the region. Growth of zero emissions green hydrogen use in transport and industry sectors, reduction in emissions and related improvement of air quality. Green hydrogen improves energy security and reduces constraint and curtailment of the Wind Farm, maximising the renewable energy that can be produced. Hydrogen production requires a water supply with potential impacts to the local aquifer. However, analysis of data collected shows that water required can be sourced sustainably with no negative impacts to the

Criteria	Alternative Process; No Hydrogen Plant	Firlough Wind Farm Co-location with Hydrogen Plant
		aquifer and nearby wells. Rainwater harvesting will be utilised to reduce reliance on groundwater. Waste water from the water treatment processes is also produced by the Hydrogen Plant. The water treatment process, controlled discharge and assimilative capacity of the receiving waters will mitigate any risks of contamination which could impact human health. Chapter 9 Hydrology and Hydrogeology assesses the impacts of this. It is not anticipated that there will be any air pollution or hazardous emissions generated by the Hydrogen Plant Site which could impact human health. The only atmospheric emission to be emitted from the electrolysis process will be oxygen produced as a biproduct of the green hydrogen production. Oxygen is not considered a pollutant or dangerous to human health by either the Air Quality Standard Regulations 2011, WHO, EPA or the CAFE Directive (Directive 2008/50/EC). The noise assessment for the Hydrogen Plant found that the maximum predicted noise levels are well within the noise limits for areas of low background as recommended by the EPA's NG4 for day, evening and nigh-time, these are well below levels that could impact human health. In terms of Major Accidents and Natural Disasters, hydrogen has a proven safety track record as a fuel for more than 100 years worldwide. Producing hydrogen from water is a well-established and safe technology. As with all fuels, the production and handling of hydrogen has an inherent degree of risk. Whilst some properties of hydrogen make it safer than other fuels, there is still a requirement to adopt controls and best practice to ensure safety. Health

Criteria	Alternative Process; No Hydrogen Plant	Firlough Wind Farm Co-location with Hydrogen Plant
		and Safety has been a key consideration in the design of the Hydrogen Plant, and the approach has incorporated good practice principles such as inherently safer design, the hierarchy of controls and safety standards. Chapter 16 Major Accidents and Natural Disasters provides a full assessment.
Terrestrial Ecology	Smaller footprint has a lower impact to habitat loss and disturbance.	Larger footprint will result in greater habitat loss and disturbance.
Aquatic Ecology	Smaller footprint has a lower potential impact to water quality through run off. Zero requirement for water input or output so lower potential impact to aquatic ecology.	Larger footprint will result in greater potential impact to water quality through run off. Wastewater from hydrogen production potentially poses a risk to aquatic ecology. The water treatment process, controlled discharge and assimilative capacity of the receiving waters will mitigate risks to water quality which could aquatic biology. **Chapter 9: Hydrology and Hydrogeology** and **Chapter 6: Aquatic Ecology** assesses the impacts of this.
Ornithology	Smaller footprint, lower potential impact to bird habitat.	Larger footprint will result in greater habitat loss which could impact bird habitat.
Soils & Geology	Smaller footprint results in a lower potential impact to soils.	Larger footprint would result in greater volumes of peat and spoil to be excavated and stored, having a higher potential impact to soils.
Hydrology & Hydrogeology	Smaller footprint results in a lower potential impact to hydrology and hydrogeology. No requirement for water abstraction or discharge.	Larger footprint increases the potential for silt laden runoff to enter receiving watercourses. Site investigations and the conclusion of the Ground Water Supply Assessment found that the ground water extraction from two boreholes was sufficient to supply the expected water demand of the Hydrogen Plant Site without depleting the aquifer or impacting the wells nearby. Rainwater harvesting will be utilised to reduce the reliance

Criteria	Alternative Process; No Hydrogen Plant	Firlough Wind Farm Co-location with Hydrogen Plant
		on groundwater for the production of green hydrogen. A waste water treatment system and ongoing monitoring will minimise impacts of wastewater on the receiving environment. This process is in line with EPA guidelines. Displacement of fossil fuel transport and industry emissions improves water quality on a wider scale.
Air & Climate	Due to the continued use of fossil fuels in electricity production, the Wind Farm alone results in a faster carbon payback period and higher carbon displacement. The Wind Farm alone would displace between 2 and 2.5 million tonnes of CO_2 over the proposed 40 year lifetime of the Project. However, as fossil fuels are phased out of electricity production, the displacement of carbon of the Wind Farm Reduces. Wind energy produced when the grid is at capacity is wasted instead of being captured. No energy storage available at the Proposed Development. No production of zero emissions fuel for transportation sector, heating or industry. Loss off carbon offsetting in these hard to abate sectors.	Maximum production of 31 tonnes of zero emissions green hydrogen per day to displace fossil fuels to be used in transport, heating or industry. Over 40 years, the Hydrogen Plant and Wind Farm would displace between 1.7 and 2.4 million tonnes of CO_2. In addition, by displacing diesel vehicles the green hydrogen also displaces 835 to 30,759 kg of NOx and 84 to 669 kg of PM per year, further improving air quality. Contribution to hydrogen specific targets laid out in Ireland's Climate Action Plan 2023 and European Hydrogen Strategy. Improved energy security by addition of new type of locally produced renewable energy. Improved energy efficiency of wind farm, less of Co. Mayo's wind resources wasted and impacts of curtailment of wind energy reduced. Provision of energy storage.
Noise	Lower impact of noise impacts to sensitive receptors.	Increased number of potential sensitive receptors impacted by the presence of the Hydrogen Plant Site. However, the noise addition is low and the equipment will be housed in suitable structures and/or designed to minimise the impact.
Material Assets	Lower land take without Hydrogen element.	Higher impact of land take with addition of Hydrogen Plant Site.

Criteria	Alternative Process; No Hydrogen Plant	Firlough Wind Farm Co-location with Hydrogen Plant
Landscape & Visual	Reduced number of potential sensitive visual receptors without hydrogen production plant.	Additional potential sensitive receptors and increased landscape and visual impact. However, the Hydrogen Plant Site has been designed to look like a large agricultural shed, screening, landscaping, planting and the natural topography of the Hydrogen Plant Site reduces visual impacts.
Cultural Heritage	Reduced footprint means lower risk of impact to undiscovered cultural artifacts.	Larger footprint would result in a bigger impact on undiscovered cultural artifacts.
Traffic and Transport	No increase of hydrogen transportation trucks on national road network.	Higher impact from hydrogen transportation via tube-trailers. This is assessed in **Chapter 15: Traffic and Transport** which finds that during the operational phase of the Hydrogen Plant a maximum of 26 HGVs plus 10 light vehicles will access the Hydrogen Plant each day.
Major Accidents and Natural Disasters	Reduced risks from additional construction site. Reduce operational risks of Major Accidents and Natural Disasters.	Increased construction risk due to second construction site. Increased operational risk of Major Accidents and Natural Disasters. However, the Hydrogen Plant Site will adhere to all HSA requirements, including COMAH. In addition, the facility will be constructed and operated in accordance with applicable design standards and operational processes. To date, a Preliminary Hazard Analysis, Major Accidents Prevention Policy and Quantitative Risk Assessment have been completed and shared with the HSA. The Safety Management Plan outlines the tasks to be completed throughout the project lifecycle to help identify, avoid and mitigate hazards.

The pressing, urgent need to address climate change and reach renewable energy and emissions reductions targets, the grid constraints in the region, the need to address impacts to energy security from the Russian invasion of Ukraine and the proposed amendment to the Renewable Energy Directive to assume renewable energy is of overriding public interest means that the addition of the Hydrogen Plant Site offers the opportunity for an overall more positive impact. This is not withstanding the larger footprint and use of water as natural resource and production of waste water, the addition of the Hydrogen Plant Site will increase the indirect positive impacts that reducing emissions and displacing fossil fuels have on wider biodiversity, ecosystem resilience and climate change mitigation. During the EIAR process, as any adverse affects of the Hydrogen Plant have been identified, these have been eliminated or mitigated as part of the design process.

3.8 ALTERNATIVE TURBINE NUMBERS AND MODEL

The Existing Permission included 21 wind turbines with a tip height of 120.5 m and rotor diameter of 71 m. A comparison of the proposed Firlough Wind Farm and the Existing Permission is outlined in **Table 3.5.**

Table 3.5: Comparative Table of Existing Permssion and Proposed Wind Farm

	Existing Permission	Proposed Firlough Wind Farm
No. of WTGs	21	13
Turbine	c. 2.3 MW	c.5-6 MW
Rotor Ø	71 m	149 m to 155 m
Tip Height	120.5 m	177 m to 185 m
Capacity	c.48 MW	c. 65 - 78 MW

It was considered at an early stage to retain the originally permitted wind turbine density. However, developments in wind turbine design and efficiency enabled consideration of a redesign which uses fewer, taller wind turbines. This improves energy efficiency, increasing the output to the grid per wind turbine and reducing the cost of energy to the consumer. A higher number of smaller wind turbines would require a larger footprint and larger land take, potentially leading to additional environmental impacts. It was considered that the smaller number of taller wind turbines would have a lower visual impact compared to the impact of a higher number of smaller wind turbines. Utilising fewer, taller wind turbines with a greater output is in line with industry trends. An outline of recent examples of consented wind farms which include taller wind turbines can be found in **Table 3.6.**

Table 3.6: Recently Permitted Wind Farms with Tall Turbines

Name	Location	No of Turbines	Tip height	Planning reference
Coole Wind Farm	Co. Westmeath	13	175 m	ABP ref. PL25M.300686
Ardderroo Wind Farm	Co. Galway	25	178.5 m	ABP ref. PL07.303086
Derryadd Wind Farm	Co. Armagh	24	185 m	ABP ref. PA14.303592
Derrinlough Wind Farm	Co. Offaly	21	185 m	ABP ref. PA19.306706
Oweninny Wind Farm	Co. Mayo	61	176 m	ABP ref. PA16.PA0029

A comparison of the potential environmental impacts of the installation of a larger number of smaller wind turbines compared to the option of installing a smaller number of larger wind turbines is presented in **Table 3.7**.

Table 3.7: Comparative table of the Environmental impacts of the Existing Permission and the proposed Firlough Wind Farm.

Criteria	Permitted Development; 21 smaller turbines	Proposed Firlough Wind Farm; 13 larger turbines
Population & Human Health (incl. Shadow Flicker)	Greater potential for shadow flicker impact on nearby sensitive receptors.	Lower potential for shadow flicker with fewer turbines.
Terrestrial Ecology	Larger footprint would result in greater habitat loss and bigger impact to biodiversity. The number of turbines is the main factor in relation to the impact to bat mortality[6]. A higher number of turbines increases impact on bats.	Lower footprint reduces impact. A smaller number of turbines reduces the impact to bats.
Aquatic Ecology	Larger footprint would result in greater impact to water quality and aquatic ecology.	Lower footprint reduces impact.

[6] DEFRA. (2016). Understand the Risks to Bat Populations Posed By Wind Turbines. https://randd.defra.gov.uk/ProjectDetails?ProjectID=16734&FromSearch=Y&Status=3&Publisher=1&SearchText=wc0753&SortString=ProjectCode&SortOrder=Asc&Paging=10%20-%20Description

Criteria	Permitted Development; 21 smaller turbines	Proposed Firlough Wind Farm; 13 larger turbines
Ornithology	The presence of more turbines would increase the potential collision risk for birds.	Fewer wind turbines reduce potential collision risk for birds. Larger wind turbines spin more slowly reducing impact to birds.
Soils & Geology	Larger footprint would result in greater volumes of peat and spoil to be excavated and managed.	Lower footprint reduces impact.
Hydrology & Hydrogeology	Larger footprint increases the potential for silt laden runoff to enter receiving watercourses.	Lower footprint reduces impact.
Air & Climate	Increased potential for vehicle emissions and dust emissions due to an increased volume of construction material and turbine component deliveries to the Wind Farm Site. Lower output increases carbon payback period and lowers contribution to climate targets.	Lower impact from delivery vehicles due to reduced number of turbines. Higher output means faster carbon payback period and higher contribution to climate targets.
Noise	Potential for increased noise impacts on nearby sensitive receptors.	Reduced noise impacts to nearby sensitive receptors.
Material Assets	Potential for increased impact on existing telecommunication links traversing the Wind Farm Site.	Reduced impact.
Landscape & Visual	It was considered that the higher number of smaller wind turbines would have a higher visual impact compared to the lower number of larger wind turbines.	It was considered that the smaller number of higher wind turbines would have a lower visual impact compared to the impact of a higher number of smaller wind turbines.
Cultural Heritage	Larger footprint would increase the potential for impacts on unrecorded, subsurface archaeology.	Lower footprint reduces impact.
Traffic and Transport	Potential for greater traffic volumes during construction phase due to larger footprint and requirement for more construction materials and wind turbine components.	Lower footprint reduces impact. Larger wind turbine components have a higher potential for disruption along haul route.

Criteria	Permitted Development; 21 smaller turbines	Proposed Firlough Wind Farm; 13 larger turbines
Major Accidents and Natural Disasters	Extended construction period increases construction accident risks.	Shorter construction period reduces construction risks.

Fewer, but taller turbines were selected for the final design due to the lower overall footprint and associated reduced environmental impacts to biodiversity, hydrology and hydrogeology, soils and geology, the reduced visual and shadow flicker impacts and better energy efficiency leading to more positive impacts in terms of climate change mitigation and energy security than with a higher number of smaller turbines.

3.9 ALTERNATIVE LAYOUT DESIGNS

The layout and design of the Wind Farm Site and the Hydrogen Plant Site were an iterative process which followed the constraints-led design approach. The constraints-led design approach consists of the identification of environmental sensitivities within the Proposed Development by the design team with a view to identifying suitable areas in which wind turbines may be located. The resulting area is known as the 'Developable Area'. The wind turbine layout is discussed in **Section 3.9.1** and Hydrogen Plant Site layout in **Section 3.9.4.**

The design and layout of the Wind Farm Site follows the recommendations and industry guidelines set out in the 'Wind Energy Development Guidelines' (Department of the Environment, Heritage and Local Government, 2006), 'Best Practice Guidelines for the Irish Wind Energy Industry' (Irish Wind Energy Association, 2012) and the Draft Revised Wind Energy Development Guidelines, December 2019.

The constraints identification process included the gathering of information through detailed desk-based assessments, field surveys and consultation. Sensitive receptors were mapped and the design constraints were applied. Setback buffers were placed around different types of constraints to clearly identify the areas within which no development works will take place. The size of the buffer zone for each constraint for the Wind Farm Site and Hydrogen Plant Site has been assigned using guidance presented in the Department of the Environment, Heritage and Local Government Wind Energy Guidelines (DoEHLG, 2006) and other relevant Best Practice standards, which are identified in each chapter of this EIAR. The proposed set-backs comply with the Draft Wind Energy Guidelines 2019 requirements.

The constraints map for the Wind Farm Site, as shown in **Figure 3.3** encompasses the following constraints and associated buffers:

- 740 m buffer of residential inhabited houses (exceeding the requirement for a four times tip height separation distance from the curtilage of properties in line with the new draft guidelines). There is one inhabited house located within 740 m of the turbines (4 x maximum tip height), which is located 710 m from T3. The owner and occupier of this house is financially involved in the project and has provided written agreement accepting the reduced setback distance and has no objection to the proposed wind energy development.
- Operator specific buffer of Telecommunication Links
- 50 m buffer of Watercourses (25 m to manmade drains)
- 100 m buffer of Archaeological Sites or Monuments
- Peat and slope stability were also taken into account and areas with steep gradients or with potential for peat slippage were discounted from the Developable Area
- The use of cutaway areas rather than intact peatland

This demonstrates the avoidance of significant impacts on the receiving environment through mitigation by design.

The Wind Farm Site and the Hydrogen Plant Site layout designs build on the existing site characteristics and include the following:

- Available lands for development
- Distance from designated sites
- Avoidance of environmental constraints identified from desk studies
- Use of existing roads where possible to reduce footprint

In addition, the Wind Farm Site layout builds on the following:

- Separation distance from landowners not involved in the Firlough Wind Farm
- Good wind resource
- Distance to neighbouring wind turbines
- Existing access points and general accessibility of all areas of the Wind Farm Site due to existing road infrastructure

In addition, the Hydrogen Plant Site layout builds on the following:

- Avoidance of Sensitive Rural Landscape to the south of the site
- Separation distance from dwellings

The inclusion of the constraints for the Wind Farm Site on a map of the study area allowed for a viable developable area for the Firlough Wind Farm to be identified. An initial turbine layout was then developed to take account of all the constraints mentioned above and their associated buffer zones and the separation distance required between the turbines.

Following the mapping of all known constraints for the Wind Farm Site and the Hydrogen Plant Site, detailed site investigations were carried out by the project team. The ecological assessments encompassed habitat mapping and extensive surveying of birds and other fauna.

Similarly, the hydrological and geotechnical investigations informed the proposed locations for wind turbines, roads, the Hydrogen Plant and other components of the Proposed Development, such as the Wind Farm Substation and the Wind Farm Site Temporary Construction Compound and Hydrogen Plant Site Temporary Construction Compound. This included peat depth and peat stability analysis and the identification of watercourses, groundwater constraints, flood risk and wells.

Existing access points and general accessibility of all areas of the Proposed Development due to existing road infrastructure were considered in Hydrogen Plant layout and the placing of wind turbines to avoid locating elements on uncut areas of bog.

In relation to the Wind Farm Site, where specific areas were deemed as being unsuitable (e.g., unstable peat) for the siting of wind turbines or roads, etc., alternative locations were proposed and assessed, taking into account the areas that were already ruled out of consideration. The wind turbine layout for the Firlough Wind Farm has also been informed by wind data which has been collected from an on-site meteorological mast and the results of noise assessments as they became available.

3.9.1 Wind Turbine Layout

Alternative wind turbine layouts were considered, and the final turbine layout of the Wind Farm takes account of all site constraints and the distances to be maintained between wind turbines and from houses, roads, etc. The layout is based on the results of all site investigations that have been carried out during the EIAR process.

The selection of wind turbine numbers and layout has had regard to wind-take by siting the wind turbines to achieve optimal performance (three times the rotor diameter (3d) in the crosswind direction and seven times the rotor diameter (7d) in the prevailing downwind direction), noise by ensuring no wind turbines are constructed in a location that would lead to noise impacts, shadow flicker by maintaining a 740 m buffer from sensitive receptors and when the control system detects that the sunlight is strong enough to cast a shadow, and the shadow falls on a property or properties, then the turbine will automatically shut down.) The EIAR and wind farm design process was an iterative process. As information regarding the Wind Farm Site was compiled and assessed, the number of wind turbines and the proposed layouts have been revised and amended to take account of the physical constraints of the Wind Farm Site. The requirement for buffer zones and other areas in which no wind turbines could be located was also compiled and assessed. Findings at each stage of the assessment were used to further refine the design, always with the intention of minimising the potential for environmental impacts.

The resulting final wind farm layout has been achieved following feedback from the various studies and assessments carried out as well as ongoing negotiations and discussions with landowners and the local community. The specific locations of the various wind turbines were reviewed during the optimisation of the Wind Farm layout. This was achieved by strictly adhering to the developable area for the location of the wind turbines and avoiding known constraints for the Firlough Wind Farm infrastructure.

Preliminary Layouts

The initial constraints study identified a significant viable area within the overall study area, suitable for approximately 15 no. wind turbines.

The initial wind turbine layout, shown in **Figure 3.4** occupied the viable area within the wider study area.

The proposed wind turbine layout was refined following feedback from the project team and the Developer and to take account of the environmental and technical constraints set out above. The number of wind turbines was reduced, and turbines were moved further from the eastern boundary of the Wind Farm Site and to the south due to the adjoining, Carrowleagh Wind Farm in line with the draft wind development guidelines. Turbines were also moved further from residential inhabited houses to the west and moved to increase the set back distance to the megalithic tomb in the southwest of the Wind Farm Site. The second iteration of the wind turbine layout, shown in **Figure 3.5**, considered a 12 no. wind turbine layout taking these constraints in to account.

The third and final iteration is the proposed layout and involved repositioning all wind turbine locations to achieve greater separation distances between wind turbines and to increase inter wind turbine spacing. It also included the addition of a wind turbine to bring the total to 13 no. wind turbines. Due to the proximity of the Ox Mountains Bogs SAC and the higher quality of the bog habitat in the south of the Wind Farm Site, wind turbines were moved out of this area.

The chosen wind turbine layout is considered optimal as it lessens the potential for environmental effects. This layout is clear and simple incorporating a degree of symmetry and order. The layout thus represents the most visually sympathetic arrangement possible for a viable wind energy development. This layout takes account of all Wind Farm Site constraints (e.g. ecology, ornithology, hydrology, peat depths etc.) and design constraints (e.g. setback distances from houses and third party lands/infrastructure and distances between turbines on-site etc.). The layout as presented in **Figure 3.6** also takes account of the results of all site investigations and baseline assessments that have been carried out during the EIAR process.

A comparison of the potential environmental effects of the layout as presented in the initial, first and second iterations when compared against the final layout, (Iteration Three), are presented in **Table 3.8.**

Table 3.8: Environmental effects from first and second layout iteration compared to the final layout (Iteration Three).

Criteria	Design iteration One; 15 no. wind turbines	Design Iteration Two; 12 no. wind turbines, relocated to reduce impact to neighbouring windfarm and avoiding deep peat	Design Iteration Three; 13 no. wind turbines, greater separation distance between wind turbines, improved symmetry, further from inhabited houses to the west
Population & Human Health (incl. Shadow Flicker)	Higher impact to inhabited houses on west of Wind Farm Site.	Increased set back distance to inhabited houses to the west of the Wind Farm Site reduces potential impacts.	Increased set back distance to inhabited houses to the west of the Wind Farm Site reduces potential impacts.
Terrestrial Ecology	Higher impact due to larger footprint. Larger deep peat habitat loss. Larger impact to higher quality bog habitat in	Reduction in peat disturbance impact due to lower footprint and removal of turbines from areas of deeper peat.	Medium impact due to Proposed Development area size, but also avoiding deep peat.

Criteria	Design iteration One; 15 no. wind turbines	Design Iteration Two; 12 no. wind turbines, relocated to reduce impact to neighbouring windfarm and avoiding deep peat	Design Iteration Three; 13 no. wind turbines, greater separation distance between wind turbines, improved symmetry, further from inhabited houses to the west
	the south of the Wind Farm Site due to proximity of turbine.	Larger impact to higher quality bog habitat in the south of the Wind Farm Site due to proximity of turbine.	Reduced impact to higher quality bog habitat in the south of the Wind Farm Site.
Aquatic Ecology	Higher impact due to higher number of turbines and larger footprint causing a higher potential for run off and water quality impact.	Slight reduction due to lower no of turbines and smaller footprint.	Medium impact with addition of one turbine to footprint. Minimum distances to all watercourses remain in place to mitigate potential impacts.
Ornithology	Greater potential impact due to proximity of turbines to peatland habitat.	Greater potential impact due to proximity of turbines to peatland habitat.	Lower impact due to larger separation distance between peatland habitat and turbines.
Soils & Geology	Some turbines located in area of deeper peat, greater potential for stability issues. Slight increase in the volume of peat and spoil to be managed.	Reduced no of turbines has a lower footprint and so less impact on soils. Layout was amended following initial geotechnical investigations to reduce areas of deep peat and reduce the volume of peat and spoil to be managed, removing turbines from deep peat also reduces impacts to stability. Greater potential impact due to proximity of turbines to higher quality peatland soils in the south of the Wind Farm Site	Slightly larger footprint with addition of one turbine. Deep peat avoided, lower impact to stability issues. Lower impact to higher quality peatland soils in the south of the Wind Farm Site due to increased separation distance to turbines.
Hydrology & Hydrogeology	An increase in the volume of peat and spoil to be managed on the Wind Farm Site would increase the	Reduced volume of peat to be impacted	Reduced volume of peat to be impacted

Criteria	Design iteration One; 15 no. wind turbines	Design Iteration Two; 12 no. wind turbines, relocated to reduce impact to neighbouring windfarm and avoiding deep peat	Design Iteration Three; 13 no. wind turbines, greater separation distance between wind turbines, improved symmetry, further from inhabited houses to the west
	potential for silt laden runoff to enter receiving watercourses.		
Air & Climate	Lowest carbon payback time due to higher output of 15 turbines. However increased impact to deep peat which sequesters carbon.	Slight increase in carbon payback time due to reduction in turbine numbers.	Medium carbon payback time with 13 turbines. Lower impact on deep peat, which reduces carbon losses and improves carbon payback time.
Noise	Potential for impact to inhabited houses on west of Wind Farm Site.	Reduced impact to inhabited houses on West of Wind Farm Site.	Reduced impact to inhabited houses on West of Wind Farm Site.
Material Assets	Potential for impact to exiting adjacent wind farm.	Reduced impact to adjoining wind farm.	Reduced impact to adjoining wind farm.
Landscape & Visual	Higher potential impacts to inhabited houses to the west of the Wind Farm Site. Highest number of turbines slightly increase visual impact.	Slightly lower overall visual impact due to lower number of turbines.	Medium impact compared to alternative in terms of visual effects of number of turbines.
Cultural Heritage	higher potential impacts due to proximity to megalithic tomb.	Reduced potential impacts due to increased set back from megalithic tomb.	Reduced potential impacts due to increased set back from megalithic tomb.
Traffic and Transport	Slight increase to short term impacts on local road network due to higher amount of construction required and higher amount of turbine components to be delivered to the Wind Farm Site.	Lower impact to traffic due to smallest construction required and lowest number of components requiring delivery.	Medium impact compared to alternatives of volume of construction and delivery traffic.

Criteria	Design iteration One; 15 no. wind turbines	Design Iteration Two; 12 no. wind turbines, relocated to reduce impact to neighbouring windfarm and avoiding deep peat	Design Iteration Three; 13 no. wind turbines, greater separation distance between wind turbines, improved symmetry, further from inhabited houses to the west
Major Accidents and Natural Disasters	slightly higher potential impact to peat stability due to deeper peat.	Avoidance of deep peat reduces risks of peat instability.	Avoidance of deep peat reduces risks of peat instability.

The final layout was chosen due to its avoidance of deep peat, which improved the ground stability risk and reduced impacts to hydrology and hydrogeology, the increased distances to higher quality habitats, its reduced impact on nearby dwellings and increased setbacks to the neighbouring wind farm which has enabled optimal performance of all turbines.

3.9.2 Wind Farm Site Access Roads

Wind Farm Site access roads are required on the Wind Farm Site to enable transport of infrastructure and construction materials within the Wind Farm Site. Roads must be of a gradient and width sufficient to allow safe movement of equipment and vehicles. It was decided during the initial design of the Proposed Development, that existing roads would be utilised where possible to minimise the potential for impacts by constructing new roads as an alternative.

As the overall Wind Farm Site layout was finalised, the most suitable routes between each component of the Proposed Development were identified, taking into account the existing roads and the physical constraints of the Wind Farm Site. Locations were identified where upgrading of the existing road would be required. This included where sections of new roads would need to be constructed, to ensure suitable access to and linkages between the various project elements, and efficient movement around the Wind Farm Site.

An alternative option to utilising the existing road network within the Wind Farm Site would be to construct a new road network, having no regard to existing roads. This approach was considered unfavourable, as it would require unnecessary disturbance to the Wind Farm Site and create the potential for additional environmental impacts to occur. It would also result in an unnecessary requirement for additional cut and fill material to be used in the construction of these new roads. A comparison of the potential environmental effects of constructing an entirely new road network when compared against maximising the use of the existing road network in the Wind Farm Site is presented in **Table 3.9**.

Table 3.9: Environmental effects from utilising existing access tracks and creating new access roads where required compared to constructing a new Wind Farm access road network.

Criteria	Creating new access roads	Utilising existing access tracks
Population & Human Health (incl. Shadow Flicker)	Neutral	Neutral
Terrestrial Ecology	Larger footprint will result in greater habitat loss.	Lower footprint reduces impact.
Aquatic Ecology	Larger footprint will result in greater impact to water quality	Lower footprint reduces impact.
Ornithology	Larger footprint will result in greater habitat loss which could impact birds.	Lower footprint reduces impact.
Soils & Geology	Larger footprint would result in greater volumes of peat and spoil to be excavated and stored. Larger volume of stone required from on-site borrow pit for road construction.	Lower footprint reduces impact.
Hydrology & Hydrogeology	Larger footprint and increased number of new watercourse crossings, therefore, increasing the potential for silt laden runoff to enter receiving watercourses.	Lower footprint reduces impact.
Air & Climate	Potential for greater vehicular emissions due to increased volume of construction traffic.	Lower footprint reduces requirement of stone and reduces impact.
Noise	Potential for increased noise impacts on nearby sensitive receptors during the construction of the new roads.	Lower footprint reduces impact.
Material Assets	Larger footprint will result in greater land-take and a change in land use.	Lower footprint reduces impact.
Landscape & Visual	Potential for greater visual and landscape impacts due to the construction of new roads.	Lower footprint reduces impact.
Cultural Heritage	Larger footprint would increase the potential for impacts on unrecorded, subsurface archaeology.	Lower footprint reduces impact.

Criteria	Creating new access roads	Utilising existing access tracks
Traffic and Transport	Potential for greater traffic volumes during construction phase due to larger Footprint and requirement for more construction materials.	Lower footprint reduces impact.
Major Accidents and Natural Disasters	Neutral	Neutral

Using the existing access was selected as the preferred design as it maximised the use of the materials already on site, reducing the overall materials needed for the project. It also reduces habitat disturbance, soil excavation and impacts to hydrology.

3.9.3 Hydrogen Plant Site Access Road Layout

An alternative Hydrogen Plant Site access roads layout was initially considered (see **Figure 3.7**). However, this included land take to the north of the existing road and the potential loss of up to 10 mature trees due to sight line requirements on the roads. Upon analysis it was also thought that this initial road layout could potentially cause HGVs to have to queue at a right turn to enter the Hydrogen Plant Site, which could cause a queue of entering HGVs to backup on to the N59.

The preferred design was developed to include a roundabout off the L-6612-1, **Figure 3.8**. This preferred design removed the necessity to acquire land to the north of the existing road, meant that mature trees could be left in-situ. Having a roundabout means that HGVs entering the Hydrogen Plant Site have right of way, reducing the risk of queues forming. More detail on this can be found in **Chapter 15: Traffic and Transportation**.

Table 3.10: Environmental effects of the initial Hydrogen Plant Site access road layout compared to the access road with roundabout

Criteria	Initial Road Layout	Access road with roundabout
Population & Human Health (incl. Shadow Flicker)	Neutral	Neutral
Terrestrial Ecology	Loss of mature trees increases impact of habitat loss.	Lower impact due to retention of mature trees.
Aquatic Ecology	Neutral	Neutral

Criteria	Initial Road Layout	Access road with roundabout
Ornithology	Loss of mature trees increases impact of habitat loss.	Lower impact due to retention of mature trees.
Soils & Geology	Neutral	Neutral
Hydrology & Hydrogeology	Neutral	Neutral
Air & Climate	Neutral	Neutral
Noise	Slightly lower noise impact.	Slightly increased construction noise due to roundabout, potential higher impact to sensitive receptors.
Material Assets	Neutral	Positive impact with addition of roundabout and new layout
Landscape & Visual	Removal of mature trees results in a higher visual impact of the Proposed Development.	Lower visual impacts associated with removal of mature trees.
Cultural Heritage	Neutral	Neutral
Traffic and Transport	Higher potential impact of traffic due to potential for queuing on national road	Resolves issue of queuing on national road – reduced impact.
Major Accidents and Natural Disasters	Neutral	Neutral

The proposed layout was selected due to the improved safe access on to the national road and reduction in impacts to biodiversity and landscape and visual.

3.9.4 Hydrogen Plant Layout

The Hydrogen Plant will comprise of a number of components including an electrolyser package (incorporating electrolyser stacks and gas processing equipment), the Hydrogen Plant Substation, water treatment, compressors, buffer storage cylinders, a dispensing station and cooling units. The electrolyser package will be contained within a specially designed building that resembles a large agricultural shed for security and to reduce noise and negative visual impact. The hydrogen will be stored in tube trailers prior to transport.

The layout of the Hydrogen Plant has had two iterations. The initial layout, shown in **Figure 3.9**, was a broadly north/south aligned layout of 51,400 m^2, with the tube trailer parking area to the south in a natural dip in the topography, the water treatment in the centre of the site and the electrolyser building in the north. However, it was identified that there was a "Sensitive Rural Landscape" in the southern section of the site as per the Sligo County Development Plan 2017-2023. This area is a mixture of cutover and semi degraded bog and rough grassland. The layout was redesigned to a broadly east/west aligned arrangement of 47,650 m^3 as shown in **Figure 3.10**. The amended layout extended the Hydrogen Plant Site further west but reduced the area to the south. The amended layout also moved the location of the fire water tanks closer to the site access on guidance from the Sligo Fire Department regarding accessibility.

The environmental Impacts of the first and final layout are shown in **Table 3.11.**

Table 3.11: Environmental effects of the initial Hydrogen Plant Site layout compared to final layout

Criteria	Initial Hydrogen Plant Site layout	Final Hydrogen Plant Layout
Population & Human Health (incl. Shadow Flicker)	Footprint of development is closer to a watercourse to the south of the site which is potentially hydrologically linked at a distance downstream to the River Moy SAC which has important fisheries habitat. This could potentially cause higher water quality impacts during the construction phase to fisheries and the tourism industry. Use of construction best practice, mitigation and monitoring reduces this impact to imperceptible.	Increased distance to watercourse to the south of the site during construction reduces potential impacts to water quality further downstream and so reduces negative potential impacts to fisheries and tourism.
Terrestrial Ecology	Higher impact to biodiversity by habitat destruction and disturbance due to infrastructure location in cutover peatland. Larger footprint will result in greater habitat loss and disturbance.	Reduced impact due to location of site within agricultural field. Smaller footprint has a lower impact to habitat loss and disturbance.
Aquatic Ecology	Potentially higher impact on water quality during construction due to proximity to watercourse to the south of the Hydrogen Plant site. Larger footprint will result in greater potential impact to water quality through run off.	Potentially lower impact on water quality during construction due to increased distance to watercourse to the south of the Hydrogen Plant site. Smaller footprint has a lower potential impact to water quality through run off.

Criteria	Initial Hydrogen Plant Site layout	Final Hydrogen Plant Layout
Ornithology	Slightly higher potential impact due to loss of small area of cutover peatland habitat. Larger footprint will result in greater habitat loss which could impact bird habitat.	Slightly lower impact due to reduction in cutover peatland habitat loss. Smaller footprint, lower potential impact to bird habitat.
Soils & Geology	Higher potential impacts to peat soils. Larger footprint would result in greater volumes of peat and spoil to be excavated and stored, having a higher potential impact to soils.	Layout change moves infrastructure out of cutover peatland and reduces the volume of peat soils impacted. Smaller footprint results in a lower potential impact to soils.
Hydrology & Hydrogeology	Hydrogen Plant layout closer to watercourse to the south of the site, potentially higher construction phase impacts to hydrology and hydrogeology. Larger footprint increases the potential for silt laden runoff to enter receiving watercourses.	Layout change increases distance to watercourse to the south of the site which reduces the construction phase potential impacts to water quality. Smaller footprint results in a lower potential impact to hydrology and hydrogeology.
Air & Climate	Increased peat soil removal slightly increases the carbon payback time of the Proposed Development, slightly reducing the positive climate change mitigation impacts.	Reduced peat soil excavation slightly improves carbon payback time.
Noise	Slightly lower noise impacts due to marginally higher distance between compressors and closest sensitive receptor to the northwest.	Slightly increased potential noise impacts as compressors moved marginally closer to dwellings to the northwest however mitigation by design makes impact neutral.
Material Assets	Lower impacts as less agricultural land required for Hydrogen Plant.	Higher land take as additional agricultural field required to the west, however this is currently generally underutilised.
Landscape & Visual	Hydrogen Plant Site in area identified as a "Sensitive Rural Area", higher potential impacts.	Reduced impacts due to location in "Normal Rural Landscape"
Cultural Heritage	Neutral	Neutral
Traffic and Transport	Neutral	Neutral

Criteria	Initial Hydrogen Plant Site layout	Final Hydrogen Plant Layout
Major Accidents and Natural Disasters	Slightly higher impact due to location of fire water tanks in the east of the Hydrogen Plant Site, which is further from the access road.	Slightly reduced impact due to change in location of fire water tanks to closer to the access road providing better accessibility in the event of a major accident or natural disaster.

The final layout was selected based on the reduced impacts to a designated sensitive rural landscape, reduced impacts to hydrology, hydrogeology and aquatic ecology during the construction phase due to the increased distance to the watercourse at the south of the site and distance from peatland soils and improved health and safety due to the easier access of the fire water tanks. The second iteration also has a smaller footprint, which reduces environmental impacts.

3.9.5 Location of Ancillary Structures

The ancillary infrastructure required for the Proposed Development includes temporary construction compounds, Wind Farm Substation, Hydrogen Plant Substation, Grid Connection, Interconnector and borrow pits.

3.9.5.1 Wind Farm Substation and Control Building

While the operational lifespan of the proposed turbines is expected to be 40 years (following which they may be replaced or decommissioned). The Wind Farm Substation and accompanying Control Building and associated infrastructure will become an ESB asset. They will then be permanent features as they will form part of the electrical infrastructure of the area. There were two potential locations identified for the Wind Farm Substation:

- Alternative location; A site of 4.8 ha adjacent to the southwest of the Wind Farm Site, 0.88 km south of the proposed location of the Wind Farm Substation, as shown in **Figure 3.11**. It is located in a cut over peatland area, 1.12 km northwest of the Ox Mountains Bogs SAC and Ox Mountains Bogs pNHA. There is an order 1 watercourse adjacent to the south, this has "good" status, but is at risk of not meeting the WFD objectives. The groundwater is a "Locally Important Aquifer – Bedrock which is Moderately Productive only in Local Zones" with moderate vulnerability and not at risk of meeting WFD objectives. The subsoil is peat. The landcover is classed as peat in the Corine 2018 index.
- Proposed Wind Farm Substation location; A site of 5.57 ha, to the north of the Wind Farm Site entrance in an area currently used for commercial forestry. It is 2.07 km

northwest of the Ox Mountains Bogs SAC and Ox Mountains Bogs pNHA. There is an order 2 watercourse, approximately 50 m to the north, this has a "good" status and is not at risk of meeting the WFD objectives. The groundwater is a "Locally Important Aquifer – Bedrock which is Moderately Productive only in Local Zones" with moderate vulnerability the groundwater and is not at risk of meeting WFD objectives. The subsoil is peat. The landcover is classed as Coniferous Forest in the Corine 2018 index.

The environmental impacts of these two options are considered in **Table 3.12.**

Table 3.12: The environmental impacts of initial location and final location of the Wind Farm Substation.

Criteria	Alternative location	Proposed location
Population & Human Health (incl. Shadow Flicker)	Neutral	Neutral
Terrestrial Ecology	Location on cutaway bog of low ecological value so impacts low. No removal of commercial forestry habitat. Higher impacts of habitat disturbance due to closer proximity to SAC and pNHA	Location in Sitka Spruce Forestry. Removal of Conifer Forestry area has potential for some impact to terrestrial ecology, however this habitat is of low value as commercial species and will be replanted. Increased separation distance to SAC and pNHA reduces impacts of habitat disturbance.
Aquatic Ecology	Closer to watercourse higher potential of impacts to water quality and aquatic ecology.	Further from water courses, lower potential for impacts.
Ornithology	Neutral	Neutral
Soils & Geology	Neutral	Neutral
Hydrology & Hydrogeology	Closer to water course higher potential of impacts.	Further from water courses, lower potential for impacts.
Air & Climate	Neutral	Neutral
Noise	Neutral	Neutral

Criteria	Alternative location	Proposed location
Material Assets	Proximity of turbines poses risk to Wind Farm Substation. There is an existing grid connection for the Carrowleagh Wind Farm in the road leading to the Wind Farm Site. This location has the potential to impact this underground grid cabling.	Reduced impact of risk to Wind Farm Substation at approved distance from turbines. Existing wind farm grid connection not impacted.
Landscape & Visual	Both sites have screening due to commercial forestry so impacts are neutral.	Both sites have screening due to commercial forestry so impacts are neutral.
Cultural Heritage	Slightly higher potential impacts due to closer proximity to registered Megalithic court tomb thought outside zone of notification so impacts minimal.	Slightly lower impacts due to increased distance to registered archaeological site.
Traffic and Transport	Neutral	Neutral
Major Accidents and Natural Disasters	Higher risk to Wind Farm Substation from turbines.	Larger separation distance between Wind Farm Substation and turbines reduces risk of major accidents.

The location of the Wind Farm Substation in an area of commercial forestry north of the Wind Farm Site entrance was selected due to the increased separation distances between the Wind Turbines and the substation buildings which reduces impacts to major accidents and material assets and improves health and safety. This location also avoids impacts to the existing underground grid connection for the neighbouring Carrowleagh Wind Farm. It has a lower impact on water quality, aquatic ecology and hydrology and hydrogeology due to the increased distance to water courses in the vicinity and due to the larger separation distance to nearby protected areas, it has lower impacts on ecology.

3.9.5.2 Grid Connection

A key consideration in determining the Grid Connection method for a proposed wind energy development is whether cabling is Under Ground Cabling (UGC) or run as an Over Head Line (OHL). While OHLs are less expensive and allow for easier repairs, UGC will have no visual impact.

For this reason, it was considered that UGC would be the preferable alternative. The draft Wind Energy Guidelines 2019 also indicate that UGC is the preferred option for connection of a wind energy development to the national grid.

The existing Glenree – Moy 110 kV OHL was identified as the closest Grid Connection point. The selected Grid Connection method will, as much as possible be UGC, with a minor section of above ground works in the vicinity of the Glenree - Moy 110 kV OHL Tie In towers. An Alternative of connecting in to Glenree Substation was considered, however this substation does not have the capacity to accommodate the required connection and would require an extension. Glenree substation is surrounded by third party lands and neither the Developer, ESB nor EirGrid has a right to extend into these land or lay cables across those lands. It was therefore not considered a reasonable alternative.

The design process for the Proposed Development identified three alternative grid connection routes to the Glenree – Moy 110 kV OHL outlined in **Figure 3.12.** A fourth potential alternative route heading south along the Stockane rd (L-5137-9), was identified, however the presence of the Blacklough Wind Farm grid connection cable in the road meant that this route was not considered a reasonable alternative.

The four grid route reasonable alternatives are as follows:

1. Grid route 1; Proposed Grid Connection. The proposed 110 kV underground grid connection which extends over a length of 6.65 km, from the Wind Farm Substation to the Glenree – Moy 110 kV over-head line. Leaving the Wind Farm Substation, the Grid Connection route follows the access road for 250 m and turns north on to the L5137-9 for 60 m. The route turns west to converge on to the L-5136-0 where the UG cables will be required to cross beneath existing ESBN cables and existing water utilities. It continues on the L-5136-0 for 2.66 km. It then turns south on the L-1102-30 for 610 m where it crosses underneath the Loughnagore stream by Horizontal Directional Drill (HDD). It re-joins the roadway, now the L1102-0 for 585 m where it crosses the Glenree river by HDD. It continues south for 575 km crossing beneath the Fiddaun Stream by HDD then back into the roadway of the L-1102-0. It then continues south for a further 1.14 km before crossing the Srafaungal River by HDD then back into the roadway of the L-1102-0 for 385 m. The route then turns in an easterly direction along a permanent access track for 355 m to the tie in towers beneath the existing Moy to Glenree OHL in the townland of Rathreedane. The route passes through the zone of notification of two Ringforts on the Sites and Monuments Record.

2. Grid route option 2 (blue). Underground grid route of 6.62 km which travels from the Wind Farm Substation in private lands through an area of cutover bog in a southwest direction for 1.56 km crossing an order 1 stream in the vicinity of the Wind Farm Site. It then crosses local road Stockane rd (L-5137-9) and continues in private lands through commercial forestry and agricultural fields before crossing the Glenree River. It then joins a local road that roughly travels parallel to the Glenree River. This section passes through the zone of notification of a Ringfort on the Sites and Monuments Record. It then joins the L-1102-0 heading south for 1.84 km, passing into the zone of notification for a second registered ringfort. It then turns east into private lands where it connects to the OHL.

3. Grid route option 3 (pink); Underground grid route of 5.34 km which travels from the Wind Farm Substation in private lands through an area of cutover bog in a southwest direction crossing an order 1 stream in the vicinity of the Wind Farm Site. It then joins local road the Stockane road (L-5137-9) where it crosses the Glenree River via a bridge. It then turns left and heads southeast along the L87022 for 3.58 km, crossing the Sligo County boundary and joining the OHL 0.83 km north of the Lough Hoe Bog Special Area of Conservation. Towards the eastern end, the elevation of the route rises towards the Ox Mountains, this area has sections of high vulnerability to landslides and past landslide events, there are also areas where the bedrock is at or near the surface with extremely high groundwater vulnerability. The location of the tie in towers is in a Geological Heritage Site; The Gap (northwest of Lough Talt). This area in the Mayo Landscape Appraisal of County Mayo from the Mayo CDO 2022-2028, close to a "Vulnerable Feature - Skylines" along the ridge and there is a designated scenic route along the R294, approximately 60 m from the location of the tie in towers.

4. Grid route option 4 (green) Underground grid route of 8.17 km which travels from the Wind Farm Substation south, within the Wind Farm Site leaving the site at the southwest corner and passing through private lands in an area of peat bog 0.25 km west of the Lough Hoe Bog Special Area of Conservation, for 0.94 km to the L87022 where it crossed the Glenree River by bridge. It then joins a local road that roughly travels parallel to the Glenree River. This section passes through the zone of notification of a Ringfort on the Sites and Monuments Record. It then joins the L-1102-0 heading south for 1.84 km. This section of the route passes within the zone of notification of a Ringfort on the Sites and Monuments Record. It then turns east into private lands where it connects to the OHL.

A comparison of the four reasonable alternatives are outlined in **Table 3.13**.

Table 3.13: The environmental effects of the four alternative Grid Route Options.

Criteria	Grid route 1; Proposed Grid Connection	Grid route option 2	Grid route option 3	Grid route option 4
Population & Human Health (incl. Shadow Flicker)	Potentially slightly higher disruption and nuisance caused by a larger proportion of works located along roads. Grid connection point 0.47 km of the village of Bunnyconnellan, which has a higher housing density that the surrounding areas, potentially higher disruption due to higher number of sensitive receptors.	Slightly lower disruption to roadways due to partial location in private lands, slightly lower impact to people. Grid connection point 0.47 km of the village of Bunnyconnellan, which has a higher housing density that the surrounding areas, potentially higher disruption due to higher number of sensitive receptors.	Slightly lower disruption to roadways due to partial location in private lands, slightly lower impact to people. Lower impact due to lower number of sensitive receptors along route due to lower housing density.	Slightly lower disruption to roadways due to partial location in private lands, slightly lower impact to people. Grid connection point 0.47 km of the village of Bunnyconnellan, which has a higher housing density that the surrounding areas, potentially higher disruption due to higher number of sensitive receptors.
Terrestrial Ecology	Route travels along public roads, resulting in less habitat loss and disturbance and so has a lower impact.	Higher short term construction phase impacts due to habitat loss and disturbance in cutover bog, commercial	Higher short term construction phase impacts due to habitat loss and disturbance in bog. Higher potential impact to SAC due to close proximity.	Higher short term construction phase impacts due to habitat loss and disturbance in bog. Higher potential impact to SAC due to close proximity.

Criteria	Grid route 1; Proposed Grid Connection	Grid route option 2	Grid route option 3	Grid route option 4
		forestry and agricultural grassland.		
Aquatic Ecology	Lower impact due to route along existing roadways	Higher potential impact due to two no. off road watercourse crossings. Higher risk of runoff from excavations entering watercourses and impacting water quality.	Higher potential impact due to one no. off road watercourse crossing. Higher risk of runoff from excavations entering watercourses and impacting water quality. Higher impact due to proximity of SAC which has White-clawed Crayfish as a qualifying interest which depend on high water quality.	Higher impact to water quality due to excavations of peatland for the cable trench which has a higher potential impact to aquatic ecology. Higher impact due to proximity of SAC which has White-clawed Crayfish as a qualifying interest which depend on high water quality.
Ornithology	Lower impact due to the majority of works being in roadway and greatest distance from intact peatland habitat in SAC.	Higher potential habitat disturbance and loss due to cutover peatland, commercial forestry and agricultural lands being used for route.	Higher potential habitat disturbance and loss due to cutover peatland lands being used for route. Higher impact of habitat disturbance due to proximity of intact peatland habitat to the east.	Higher potential habitat disturbance and loss due to cutover peatland, commercial forestry and agricultural lands being used for route. Higher impact of habitat disturbance due to proximity of intact peatland habitat to the east.

Criteria	Grid route 1; Proposed Grid Connection	Grid route option 2	Grid route option 3	Grid route option 4
Soils & Geology	Lower impact to soils and geology due to less disturbance because most of the route is located in the roadway.	Higher impact due to disturbance of more soils including peat soils.	Higher impact due to disturbance of more soils including peat soils. Higher risk of ground instability during construction due to proximity of areas of high landslide susceptibility. Trench excavations could potentially require removal of bedrock as bedrock is at or close to the surface in areas, this could cause higher impacts to geology. Location of the tie in towers in in a Geological Heritage Site, which could result in higher impacts to soils and geology.	Higher impact due to disturbance of more soils including peat soils.
Hydrology & Hydrogeology	Preferred route avoids water crossings apart from those already crossed by bridges along the road, lower impact.	Higher impact to water quality due to excavations of peatland for the cable trench. Higher potential impact to hydrology and	Higher impact to water quality due to excavations of peatland for the cable trench. Higher potential impact due to one no. off road watercourse crossing.	Higher impact to water quality due to excavations of peatland for the cable trench.

Criteria	Grid route 1; Proposed Grid Connection	Grid route option 2	Grid route option 3	Grid route option 4
		hydrogeology due to two no. off road watercourse crossings. Higher risk of runoff from excavations entering watercourses and impacting water quality.	Higher potential risk to groundwater due to area of extremely high groundwater vulnerability.	
Air & Climate	Slightly lower impact due to reduction in peatland soil disturbance.	Slightly higher carbon payback due to excavations of peat soils.	Slightly higher carbon payback due to excavations of peat soils.	Slightly higher carbon payback due to excavations of peat soils.
Noise	Neutral	Neutral	Potentially higher noise impacts due to requirement to remove bedrock, though this is in a sparsely populated area with few sensitive receptors.	Neutral
Material Assets	Less disturbance to local landowner's agricultural land.	Larger land take required in private lands.	Larger land take required in private lands.	Larger land take required in private lands.
Landscape & Visual	Neutral	Neutral	Higher impact of tie in towers due to sensitivity of the landscape in	Neutral

Criteria	Grid route 1; Proposed Grid Connection	Grid route option 2	Grid route option 3	Grid route option 4
			the area and proximity to a scenic route.	
Cultural Heritage	Lower impact as roads already developed. Route passes within the zone of notification of two no. registered monuments, however due to the excavations being confined to the roads, impacts are expected to be minimal.	Higher impact to undiscovered artifacts as more undeveloped area needs to be excavated along route in private lands. Route passes within the zone of notification of two no. registered monuments, however due to the excavations being confined to the roads, impacts are expected to be minimal.	Higher impact to undiscovered artifacts as more undeveloped area needs to be excavated along route in private lands. No zones of notification for registers monuments along route, lower impacts.	Higher impact to undiscovered artifacts as more undeveloped area needs to be excavated along route in private lands. Route passes within the zone of notification of one no. registered monuments, however due to the excavations being confined to the roads, impacts are expected to be minimal.
Traffic and Transport	Potentially slightly higher traffic disturbance due to location of majority of the route in roadways. Potentially higher impacts due to route proximity to	Slightly lower impact as less roadways used. Potentially higher impacts due to route proximity to	Slightly lower impact as less roadways used. Potentially higher impacts due to requirement to remove bedrock from the site requiring more vehicles.	Longest route, higher impacts to traffic disruption. Potentially higher impacts due to route proximity to Bunnyconnellan village 0.47 km south.

Criteria	Grid route 1; Proposed Grid Connection	Grid route option 2	Grid route option 3	Grid route option 4
	Bunnyconnellan village 0.47 km south.	Bunnyconnellan village 0.47 km south.	Lower impacts due to sparsely populated area for the majority of the route and avoidance of coming in close proximity to any settlements.	
Major Accidents and Natural Disasters	Neutral	Neutral	Higher risk of ground instability during construction due to proximity of areas of high landslide susceptibility.	Neutral

The preferred route was selected due to its location within the roadway for the majority of its length, this reduces impacts to peatland soils, habitat loss and disturbance and potential impacts to water quality and aquatic ecology. It avoids coming in close proximity to ecological and geoheritage protected areas, reducing potential impacts to these. It avoids areas of high ground instability reducing risks of major accidents and natural disasters and improves the health and safety of the construction phase. The proposed tie in towers are not in a sensitive landscape area or in close proximity to scenic routes which reduces the operational landscape impacts compared to alternative options.

3.9.5.3 Borrow Pits

Fill material required for the construction of Wind Farm Site access roads and Turbine Foundations and Hardstands will be obtained from local authorised quarries. An alternative option of sourcing materials from on-site borrow pits at the Wind Farm Site was considered. There are three small borrow pits already on the Wind Farm Site, used in the creation of the turbary tracks, however after investigations, these were considered to be unsuitable as a source of stone due to limited useable material remaining. New borrow pit creation was considered. However, the environmental impacts were considered to be unacceptably high when compared to sourcing material from off-site quarries. It was therefore decided to source stone from local suppliers rather than from on-site borrow pits.

A comparison of the potential environmental effects of using on-site borrow pits in comparison to using an offsite quarry is presented in **Table 3.14**.

Table 3.14: The environmental impacts from utilising local quarries compared to on-site borrow pits

Criteria	Use of on-site borrow pits for stone materials	Use of local quarries to supply stone materials
Population & Human Health (incl. Shadow Flicker)	Utilising on-site borrow pits would reduce vehicular and dust emissions from transporting material from offsite quarry locations.	Higher potential dust emissions due to increased haulage of stone needed.
Terrestrial Ecology	Creation of on-site borrow pits creates a larger developed area and more habitat disturbance and loss.	Lower impact of disturbance and habitat loss on Wind Farm Site.

Criteria	Use of on-site borrow pits for stone materials	Use of local quarries to supply stone materials
Aquatic Ecology	Creation of on-site borrow pits creates a larger developed area and higher potential for run off into water courses, impacting water quality.	Lower impact due to smaller Footprint
Ornithology	Creation of on-site borrow pits creates a larger developed area and more habitat disturbance and loss.	Lower impact of disturbance and habitat loss on Wind Farm Site
Soils & Geology	On-site borrow pits could damage peatland soils and result in greater volumes of peat and spoil to be excavated and stored.	Lower impact due to smaller Footprint.
Hydrology & Hydrogeology	Creation of on-site borrow pits creates a larger developed area and higher potential for run off into water courses, impacting water quality.	Lower impact due to smaller Footprint.
Air & Climate	Utilising on-site borrow pits would reduce dust and vehicle emissions associated with off-site vehicle movements. However, dust emissions from excavations could also potentially cause issues.	Higher dust and vehicle emissions associated with off-site vehicle movements.
Noise	On-site borrow pits could generate more noise on the Wind Farm Site however there is a potential that transportation of materials from offsite quarry	Deliveries and activities at quarries could potentially increase noise, but potentially a reduction in noise associated with removing rock

Criteria	Use of on-site borrow pits for stone materials	Use of local quarries to supply stone materials
	locations could increase noise emissions.	from borrow pits would reduce noise on the Wind Farm Site.
Material Assets	Neutral	Neutral
Landscape & Visual	Increased visual impact on Wind Farm Site due to presence of borrow pits.	No borrow pits on-site leaves the landscape more intact and reduces visual impact of the Proposed Development.
Cultural Heritage	Creation of on-site borrow pits creates a larger developed area increasing the potential for impacts on unrecorded, subsurface archaeology.	Lower impact due to smaller Footprint.
Traffic and Transport	Lower traffic impact as material sourced on Wind Farm Site.	Potential for increased vehicular movement on local roads.
Major Accidents and Natural Disasters	Neutral	Neutral

Using rock sourced from quarries was selected rather than on site borrow pits due to the reduction in the footprint of the Proposed Development and the reduced excavations on peat soil, resulting in lower long-term impacts to habitat disturbance and loss, hydrology and hydrogeology (including water quality) and soils and geology. This option also has lower potential impacts to undiscovered cultural heritage. It was considered these reduced long-term impacts were preferable to the higher potential short-term impacts to traffic and transport and potential construction haul route disruptions to population and human health.

3.10 ALTERNATIVE WIND FARM SITE ACCESS

In assessing the most suitable route for transport of construction materials to the Wind Farm Site, cognisance was taken of the haul route used for the neighbouring Carrowleagh Wind Farm, which involved widening works to the access road to the Wind Farm Site from the public roadway. The inspectors report for the Existing Permission EIS for Firlough Wind Farm stated:

"*Given the presence of a number of wind energy developments in the wider area, with particular reference to the neighbouring scheme at Carrowleagh, it would appear that the surrounding road network is capable of accommodating the likely traffic movements associated with the construction of the proposed development. Indeed, it would be prudent for delivery traffic associated with the subject proposal to utilise the same haul route as that utilised during the construction of the Carrowleagh Wind Farm, however, I would suggest that the selection of the final haul route can be best addressed by way of condition in order to permit the review of same closer to the time of construction in conjunction with Mayo and Sligo County Councils thereby providing for the least amount of disruption as possible*."

The access route for all deliveries for the extant permission is shown in **Figure 3.13.**

When assessing the options for haul routes for the Proposed Development, the route for the consented project was largely followed, however after analysis it was considered that a separate construction haulage route to and from the Wind Farm Site would cause less disruption to traffic and transport and a part one-way system would be a safer alternative to construction traffic using a single route to and from the Wind Farm Site, and so reducing the risk of a major accident. These chosen routes are shown in **Figure 2.6**.

3.11 ALTERNATVIE TECHNOLOGIES TO HYDROGEN

The primary driver for the Developer considering a hydrogen plant at or near the Wind Farm was to address the issue of constraint in the North Mayo and Sligo region of the national electricity network. Constraint is a geographic phenomenon where the full renewable energy generation potential in an area cannot be realised due to physical shortcomings or restrictions in the electricity network in an area. In EirGrid's Shaping our Electricity Future report[7] constraint is defined as "a change to any generator's output from the planned *"market schedule"* due to transmission network limitations or operating reserve requirements". EirGrid is developing a new piece of electrical infrastructure in the region known as the North Connacht 110 kV Project which will connect the Moy substation near Ballina, Co. Mayo to the Tonroe substation in Ballaghaderreen, Co. Roscommon. Even once the North Connacht 110 kV Project is commissioned, EirGrid expects constraint in the North-West to be 11% - 20%[8]. These levels of constraint are a distinct economic disadvantage for new wind electricity generation in North Mayo compared to new wind electricity generation in parts of the electricity network where constraint is estimated to be

[7] https://www.eirgridgroup.com/site-files/library/EirGrid/Shaping_Our_Electricity_Future_Roadmap.pdf
[8] https://www.eirgridgroup.com/site-files/library/EirGrid/ECP-1-Solar-and-Wind-Constraints-Ireland-Summary.pdf

between 0% - 1%. This makes it challenging to compete in securing offtake arrangements in price sensitive processes such as RESS auctions or bilaterally negotiated corporate power purchase agreements.

In order to alleviate the constraint forecast for the Wind Farm, the Developer considered the following alternatives:

1. **Green hydrogen produced by electrolysis**

   Electrolysis is the process of splitting water (H_2O) into its basic components, hydrogen (H_2) and oxygen (O_2), using an electric current in an electrolyser. Through this process, electrical energy can be stored as chemical energy in the resulting hydrogen. The newly formed chemical energy can be utilised as a fuel or converted back to electricity when required. Water is an ideal source for producing hydrogen because it only releases oxygen as a by-product. The hydrogen produced by electrolysis using a renewable energy source is called green hydrogen.

2. **Battery Energy Storage System**

   A Battery Energy Storage System ("BESS") located on the site of the Wind Farm was considered to consume all constrained power that could not be exported onto the national electricity network. In determining the required size of BESS, the Developer estimated that of the approximate annual average generation of 240,000M Wh[9], if 11% was constrained, the minimum BESS would need to be 26,400 MWh. Based on prevailing BESS technology with discharge rates of 1MW / MWh, this would imply an installed capacity BESS of 26,400 MW. Each MW of battery energy storage requires approximately 0.1 ha, therefore 1,320 ha would be required to accommodate 26,400 MW of BESS.

   Furthermore, the above BESS sizing methodology assumed the charged batteries could be immediately discharged once full. Which may not be possible during periods of consistently high wind. The Developer had already collected wind data demonstrating days of consistently high wind measurements during winter months where the BESS system would be fully charged, but may be unable to fully discharge to the electricity network due to the continuing wind generation in the area. By comparison, hydrogen at the proposed Hydrogen Plant can be produced whenever there is sufficient water and renewable energy available. The hydrogen produced at the

[9] $78MW \ x \ 35\% \ Utilization \ Rate \ x \ 8760hrs/yr = 240{,}000MWh$

Hydrogen Plant is intended to be used in transport and other industries and is not competing for capacity on the national electricity network.

3. **Electric Vehicle Fleet Charging**

Due to the excessively large BESS requirement, the Developer considered the possibility of supplementing the BESS with a local fleet of public service vehicles, busses, taxis, food trucks and mobile shops, etc. The isolated location of the Wind Farm combined with the poor local grid network and relatively small size of a potential EV fleet meant this did not address the forecast constraint issues facing the Wind Farm and was not progressed beyond concept stage.

4. **Liquid Air Storage**

Liquid Air Storage is a nascent form of long duration energy storage. During periods of high renewable energy generation, air is compressed and cooled to liquid form using excess power. The liquid air is stored in cryogenic chambers and when renewable energy generation is low can be reconverted to gas form, releasing the stored energy through expansion, driving a turbine to generate electricity that can be distributed back to the electricity network. The technology is still awaiting commercial demonstration at utility scale.

A comparison of the environmental impacts of green hydrogen, BESS, BESS and electric vehicle charging, and liquid air storage are show in **Table 3.15.**

Table 3.15: Comparison of the environmental impacts of green hydrogen, BESS, BESS and electric vehicle charging and liquid air storage

Criteria	Green hydrogen	Battery Energy Storage System	Battery Energy Storage System combined with Electric Vehicle Fleet Charging	Liquid Air Storage
Population & Human Health (incl. Shadow Flicker)	Increased positive impacts; Addition of hydrogen skills and employment opportunities, transportation jobs and potential of attracting hydrogen-based enterprise to the region. Growth of zero emissions green hydrogen use in transport and industry sectors, reduction in emissions and related improvement of air quality. Production of a second renewable energy type; green hydrogen. This improves energy security by diversifying supply and reduces constraint and curtailment of the Wind Farm, maximising the renewable energy that can be produced. Hydrogen production requires a water supply, potential impacts to local aquifer. However, analysis of data collected shows that water required can be sourced sustainably with no negative impacts to the aquifer and nearby wells. Rainwater harvesting will be utilised to reduce reliance on groundwater.	No positive impacts of a second renewable energy type produced by the project. No further increases to energy security and air quality improvement beyond additional renewable electricity. No addition of hydrogen skills, employment, enterprise or growth of transport and industry market to the region. No water element to Proposed Development so no potential impact on aquifer or wells nearby.	Potentially higher positive impacts to the local economy of the availability of electric vehicle charging facilities to households and businesses. No positive impacts of a second renewable energy type produced by the project. No further increases to energy security and air quality improvement beyond additional renewable electricity. No addition of hydrogen skills, employment, enterprise or growth of transport and industry market to the region. Higher potential negative impacts of additional vehicles on local roads. No water element to Proposed Development so no potential impact on aquifer or wells nearby.	No positive impacts of a second renewable energy type produced by the project. No further increases to energy security and air quality improvement beyond additional renewable electricity. No addition of hydrogen skills, employment, enterprise or growth of transport and industry market to the region. No water element to Proposed Development so no potential impact on aquifer or wells nearby.
Terrestrial Ecology	Smaller footprint has a lower impact to habitat loss and disturbance.	Larger footprint will result in greater habitat loss and disturbance.	Larger footprint will result in greater habitat loss and disturbance.	Smaller footprint has a lower impact to habitat loss and disturbance.

Criteria	Green hydrogen	Battery Energy Storage System	Battery Energy Storage System combined with Electric Vehicle Fleet Charging	Liquid Air Storage
Aquatic Ecology	Smaller footprint has a lower potential impact to water quality through run off. Wastewater from hydrogen production potentially poses a risk to aquatic ecology. The water treatment process, controlled discharge and assimilative capacity of the receiving waters will mitigate risks to water quality which could aquatic biology.	Larger footprint will result in greater potential impact to water quality through run off. No requirement for water abstraction or discharge lower impacts to water quality and aquatic ecology during operation.	Larger footprint will result in greater potential impact to water quality through run off. No requirement for water abstraction or discharge lower impacts to water quality and aquatic ecology during operation.	No requirement for water abstraction or discharge lower impacts to water quality and aquatic ecology during operation.
Ornithology	Smaller footprint, lower potential impact to bird habitat.	Larger footprint will result in greater habitat loss and disturbance which could impact bird habitat.	Larger footprint will result in greater habitat loss and disturbance which could impact bird habitat.	Smaller footprint, lower potential impact to bird habitat.
Soils & Geology	Smaller footprint results in a lower potential impact to soils.	Larger footprint would result in greater volumes of peat and spoil to be excavated and stored, having a higher potential impact to soils.	Larger footprint would result in greater volumes of peat and spoil to be excavated and stored, having a higher potential impact to soils.	Smaller footprint results in a lower potential impact to soils.
Hydrology & Hydrogeology	Smaller footprint results in a lower potential impact to hydrology and hydrogeology. Site investigations and the conclusion of the Ground Water Supply Assessment found that the ground water extraction from two boreholes was sufficient to supply the expected water demand of the Hydrogen Plant Site without depleting the aquifer or impacting the wells nearby. Rainwater harvesting will be utilised to reduce	No requirement for water abstraction or discharge. Larger footprint increases the potential for silt laden runoff to enter receiving watercourses.	No requirement for water abstraction or discharge. Larger footprint increases the potential for silt laden runoff to enter receiving watercourses.	Smaller footprint results in a lower potential impact to hydrology and hydrogeology. No requirement for water abstraction or discharge lower impacts to hydrology and hydrogeology.

Criteria	Green hydrogen	Battery Energy Storage System	Battery Energy Storage System combined with Electric Vehicle Fleet Charging	Liquid Air Storage
	the reliance on groundwater for the production of green hydrogen. A waste water treatment system and ongoing monitoring will minimise impacts of wastewater on the receiving environment. This process will be in line with EPA guidelines. Displacement of fossil fuel transport and industry emissions improves water quality on a wider scale.			
Air & Climate	Maximum production of 31.2 tonnes of zero emissions green hydrogen per day to displace fossil fuels to be used in transport, heating or industry, which are all traditionally hard to abate sectors. If used to displace diesel HGVs, green hydrogen also reduces NOx and Sox and improves air quality. Reduced carbon payback period. Higher contribution to climate change mitigation strategies and targets. Higher contribution to renewable energy targets including renewable gas/hydrogen targets laid out in Ireland's Climate Action Plan 2023. Improved energy security by addition of new type of locally produced renewable energy.	Lower positive impacts due to no continued discharge of stored energy and a lower output of renewable energy available to displace fossil fuels. No colocation of second type of renewable energy; green hydrogen. Production only of renewable electricity. No benefits of displacing fossil fuels in hard to abate sectors such as heavy transport and industry.	BESS and Electric vehicle fleet would not address constraint issues and would result loss of renewable energy generation. This would reduce the benefits of the Proposed Development including displacing fossil fuels and the related positive impacts to air quality and climate change mitigation. No colocation of second type of renewable energy; green hydrogen. Production only of renewable electricity. No benefits of displacing fossil fuels in hard to abate sectors such as heavy transport and industry.	Longer term, intra-day storage available compared to batteries so less energy is wasted when the grid is constrained. No colocation of second type of renewable energy; green hydrogen. Production only of renewable electricity. No benefits of displacing fossil fuels in hard to abate sectors such as heavy transport and industry.

Criteria	Green hydrogen	Battery Energy Storage System	Battery Energy Storage System combined with Electric Vehicle Fleet Charging	Liquid Air Storage
			Increased positive benefits of providing charging for electric personal and light duty commercial vehicles which could displace traditional fossil fuel vehicles.	
Noise	Potentially higher impacts due to presence of compressors, though the facility would be designed to minimise noise and adhere to noise restrictions.	Potentially lower noise impacts due to low noise creation by batteries.	Potentially slightly higher impact of additional vehicles on local roads, though these vehicles would be electric and so have a lower noise impact than traditional fossil fuel vehicles.	Potentially higher impacts due to presence of compressors, though the facility would be designed to minimise noise and adhere to noise restrictions.
Material Assets	Lower impacts to land take due to smaller footprint required.	Larger land take required, higher impacts to agriculture, forestry and/or other land uses due to development footprint.	Larger land take required, higher impacts to agriculture, forestry and/or other land uses due to development footprint.	Lower impacts to land take due to smaller footprint required.
Landscape & Visual	Potentially higher visual impacts due to height of Hydrogen Plant buildings. However, the Hydrogen Plant has been designed to look like a large agricultural shed, screening, landscaping, planting and the natural topography of the Hydrogen Plant Site reduces visual impacts.	Potentially higher impacts due to larger footprint of development. However, batteries have a lower profile than the hydrogen plant buildings and therefore could potentially be better screened from view.	Potentially higher impacts due to larger footprint of development. However, batteries have a lower profile than the hydrogen plant buildings and therefore could potentially be better screened from view.	Potentially higher visual impact due to construction of building to house equipment. However this would be design to look like a large agricultural shed screening, landscaping, planting would reduce visual impacts. Potentially higher visual impacts from large storage tanks required.

Criteria	Green hydrogen	Battery Energy Storage System	Battery Energy Storage System combined with Electric Vehicle Fleet Charging	Liquid Air Storage
Cultural Heritage	Smaller footprint means lower risk of impact to undiscovered cultural artifacts.	Larger footprint would result in a bigger impact on undiscovered cultural artifacts.	Larger footprint would result in a bigger impact on undiscovered cultural artifacts.	Smaller footprint means lower risk of impact to undiscovered cultural artifacts.
Traffic and Transport	Higher impact from hydrogen transportation via tube-trailers.	No increase of hydrogen transportation trucks on road network, lower impacts to traffic and transport.	Higher impact from high volume of additional vehicle fleets on local roads.	Lower impacts to traffic and transport as less vehicles on roads.
Major Accidents and Natural Disasters	Increased operational risk of Major Accidents and Natural Disasters. However, the Hydrogen Plant Site will adhere to all HSA requirements, including COMAH. In addition, the facility will be constructed and operated in accordance with applicable design standards and operational processes. To date, a Preliminary Hazard Analysis, Safety Management Plan and Quantitative Risk Assessment have been completed and shared with the HSA. The Safety Management Plan outlines the tasks to be completed throughout the project lifecycle to help identify, avoid and mitigate hazards.	BESS facility would adhere to all safety design standards and operating requirements. Potential risks of batteries include fire and electrical faults, though these would be minimised through use of safe design, monitoring and fire suppression systems.	BESS facility and charging equipment would adhere to all safety design standards and operating requirements. Potential risks of batteries include fire and electrical faults, though these would be minimised through use of safe design, monitoring and fire suppression systems.	The Liquid Air Storage facility would adhere to all safety design standards and operating requirements. Handling liquid air which contains liquid oxygen, can pose safety risks as pure oxygen pose fire and explosion risks. This can be managed by using well insulated systems, monitoring the oxygen content in the liquid air and by keeping organic material away from where oxygen enrichment occurs. The very low operating temperatures required for the process can be hazardous to both people and materials.

Hydrogen production by electrolysis was selected as the preferred energy storage technology, this was due to it being a 100 year old, well understood and proven technology with numerous OEMs building manufacturing facilities to supply electrolyser demand. Despite its potentially smaller footprint and associated lowered environmental impacts, Liquid Air Storage is still awaiting commercial demonstration at utility scale which was deemed too great a risk to proceed and therefore not technically viable. Hydrogen is referred to in the Irish Government's Climate Action Plan 2023, indicating that it is being considered as a key technology to achieve Ireland's Net Zero targets. The Hydrogen Plant would have a significantly smaller footprint than a BESS, resulting in lower negative impacts to habitat loss and disturbance, as well as lower impacts to hydrology and hydrogeology and soils and geology due to reduced run off and excavations. The lower footprint also decreases the land use take and impacts to material assets such as agriculture and forestry. Even with the addition of charging electric vehicles, reducing the area required for the BESS, grid constraint issues remain and the footprint is still unacceptably large. Electric vehicles also increase the number of additional vehicles on local roads in the vicinity of the project which was considered undesirable.

3.12 ALTERNATIVE HYDROGEN PLANT PROCESSES

3.12.1 Electrolyser technology

Electrolysis is the process of splitting water into hydrogen and oxygen using electricity in an electrochemical cell. Electrolysers come in a variety of capacities and chemistries, but the fundamental concept remains the same. Electrolysers, like fuel cells, have electrodes (anodes and cathodes) separated by an electrolyte. The combination of electrodes and electrolyte vary by the type of chemical reactions taking place. Unlike steam methane reforming for hydrogen production from fossil fuels, electrolysers are considered "green" sources of hydrogen when the electricity consumed is provided by a renewable energy resource. Instead of using carbon as an energy carrier, electrolysis-derived hydrogen uses the splitting and combining of water.

Early in the design phase a feasibility study was carried out by Black and Veatch, into the suitability of the alternatives of Proton Exchange Membrane (PEM) and Alkaline Water (AWE) electrolysers.

In a PEM electrolyser, water is split into oxygen and hydrogen, with the proton (H+) travelling from the anode to the cathode, through a solid polymer membrane, and exiting out the cathode side. Oxygen, in turn, exits out of the anode side without passing through the membrane. The membrane allows for the separation of the two gases, hydrogen and oxygen, and makes them easy to collect without mixing of the gases. Catalysts at the anode and cathode help lower the activation energy required for the splitting of water. The capital investment costs for PEM are approximately 1.6 times that of AWE. Recent research and development (R&D) initiatives are focussed on optimising the catalytic activity of the cell while minimizing the amount of expensive electrocatalysts, thereby lowering the cost.

Alkaline water electrolysers fundamentally function similarly to PEM electrolysers; however, the ion transported in the electrolyte is OH- and travels from the cathode to the anode through an aqueous solution (typically Potassium Hydroxide). The hydrogen then exits out the cathode side and the oxygen exits at the anode. AWE technology typically uses non-noble metal catalyst electrodes which are less expensive than the catalysts used in PEMs. AWEs also have a lower current density compared to PEM, and as such require a larger footprint.

It should be noted that PEMs typically have a fast response ramp-up and ramp-down capability and a wide operating range (0-100%). As such, they are well suited to a variable input electricity such as wind.

The impacts of the two technologies are outlined in **Table 3.16.**

Table 3.16: Impacts of the Two Technologies

Criteria	PEM	AWE
Population & Human Health (incl. Shadow Flicker)	PEM shorter life cycle of equipment, equipment will need to be replaced sooner so higher nuisance impacts of replacement delivery and wastes. Less maintenance required so slightly lower positive impact to employment.	Longer lifecycle of equipment means it doesn't need to be replaced as often so lower impact from delivery of new replacement and lower waste produced. More complex maintenance means slightly higher employment opportunity, though slightly higher related traffic. Potassium hydroxide (KOH), also known as lye, has been selected as the electrolyte for the electrolyser stacks. There are potential human health impacts of this should it enter drinking water or the air in large quantities. However, the relatively small volume required, design standards and operational health and safety procedure reduce this risk.
Terrestrial Ecology	Smaller footprint, lower impact to habitat loss.	Larger footprint of electrolyser, which is a small part of the Hydrogen Plant Site increases the developed footprint slightly, resulting in a higher impact to habitat loss.

Criteria	PEM	AWE
Aquatic Ecology	Smaller footprint means lower impact to run off and water quality.	Larger footprint of electrolyser, makes the developed footprint slightly larger resulting in a higher impact to run off and potential impact to water quality. Potassium hydroxide (KOH), also known as lye, has been selected as the electrolyte for the electrolyser stacks. However, the relatively small volume required, design standards and operational health and safety procedure reduce this risk.
Ornithology	Smaller footprint, lower impact to habitat loss.	Larger footprint resulting in a higher impact to habitat loss.
Soils & Geology	Smaller footprint, lower impact to soils and geology.	Larger footprint resulting in a higher impact soils and geology. There is a potential risk of soil contamination with the presence of Potassium hydroxide required as an electrolyte. However, the relatively small volume required, design standards and operational health and safety procedure reduce this risk.
Hydrology & Hydrogeology	Smaller footprint, lower impact to hydrology and hydrogeology.	Larger footprint resulting in a higher impact hydrology and hydrogeology through increased run-off. Potassium hydroxide (KOH), also known as lye, has been selected as the electrolyte for the electrolyser stacks. There is a potential for this to impact water quality should it enter the local hydrology or hydrogeology. Potassium hydroxide is used only in the closed-loop electrolysis process and will not enter the waste water stream. The water treatment system, monitoring and regulated discharge with the ability to stop discharge should contamination occur reduces this risk.
Air & Climate	Shorter lifecycle so higher impact of waste production. Higher energy efficiency (80-90%) so less energy wasted in production. Lower operational temperature so lower cooling demand. Faster response to input power changes, stronger adaptability to renewable energy with load	Longer lifecycle so less waste and associated emissions. Slightly lower energy efficiency (70-80%) so more energy wasted in production. Higher operational temperature so higher demand for cooling. Longer start up time, potential loss of production. Tried and tested at commercial production volume, lower risk of failure and requirement to replace equipment.

Criteria	PEM	AWE
	fluctuation, and is more suitable for renewable energy power generation and hydrogen generation.	
Noise	Neutral	Neutral
Material Assets	Smaller developed area, slightly smaller impact to land use change.	Larger developed area, slightly higher impact to land use change.
Landscape & Visual	Neutral	Neutral
Cultural Heritage	Smaller Proposed Development area, potential smaller impact to undiscovered cultural artifacts.	Larger Proposed Development area, potential higher impact to undiscovered cultural artifacts.
Traffic and Transport	Will need to be maintained/replaced more often, higher impact to traffic during delivery.	Longer life cycle, will need to be replaced less often and lower impacts to traffic and transport.
Major Accidents and Natural Disasters	Slightly lower impact due to no electrolyte required.	Slightly higher impact due to presence of Potassium hydroxide (KOH).

Both alternative electrolysis technologies were found to be potentially viable options, however PEM is a newer technology at this stage in the design process and less commercially proven. It was decided that despite its larger footprint and the addition of lye as the electrolyte solution used, AWE technology was selected as the preferred alternative as it is the most reliable and viable option due to maturity of the technology and lower production costs.

3.12.2 Hydrogen Storage and Transport Options

Due to wind farms generally being located in upland areas due to wind resources, and remote areas due to required setback distances, green hydrogen produced from wind energy is likely to be generated at a distance from demand areas, such as industrial or urban centres. Therefore, hydrogen needs to be stored and transported.

Three alternatives were considered to store and transport the green hydrogen to end users:

- **Compressed storage**; Compressed hydrogen storage is the most established hydrogen storage technology; it involves the physical storage of compressed hydrogen gas in high-pressure vessels which can be transported via road by tube trailers.
- **Liquified storage**; Hydrogen stored as a liquid. The hydrogen has to be cooled to -253°C and stored in insulated tanks to maintain this low temperature and minimize evaporation and can then be transported by road. This requires complex equipment and

is expensive. Complexity and cost have limited the use of liquified hydrogen to date. Some of the biggest users include the semiconductor chip industry.

- **Pipeline Hydrogen Storage;** Gaseous hydrogen can be transported through pipelines much the way natural gas is today. This is a low-cost option for delivering large volumes of hydrogen but with high capital costs. There is a potential that the existing gas pipeline in Ireland can be adapted to carry a blend of natural gas and hydrogen.

The environmental impacts of the three storage and transportation alternatives are considered in **Table 3.17**.

Table 3.17: Alternative Hydrogen Storage and Transport Option

Criteria	Liquefied storage	Pipeline Hydrogen Storage	Compressed storage
Population & Human Health (incl. Shadow Flicker)	More potential uses of hydrogen in industry and transport. More flexibility in where hydrogen can be transported to due to use of the road network rather than a pipeline. More positive benefits to local community by availability of hydrogen locally.	Higher short term disturbance due to pipeline construction. Lower local positive benefits as pipeline transports hydrogen to fixed locations.	More potential uses of hydrogen in industry, home heating and transport. More flexibility in where hydrogen can be transported to due to use of the road network rather than a pipeline. More positive benefits to local community by availability of hydrogen locally.
Terrestrial Ecology	Higher impacts due to larger footprint and more habitat disturbance and loss. Higher impacts due to liquid nitrogen refrigeration system which could pose a hazard if leaks occur.	Higher impact to habitat loss due to pipeline excavations.	Lower impact due to smaller Footprint.
Aquatic Ecology	Larger developed area and higher potential for run off into water courses, impacting	Higher impact to water quality during construction of pipeline.	Lower impact due to smaller footprint.

Criteria	Liquefied storage	Pipeline Hydrogen Storage	Compressed storage
	water quality and aquatic ecology. Higher impacts due to liquid nitrogen refrigeration system which could pose a hazard if leaks occur.		
Ornithology	Higher impacts due to larger footprint and more habitat disturbance and loss. Higher impacts due to liquid nitrogen refrigeration system which could pose a hazard if leaks occur.	Higher impact of habitat disturbance along pipeline route.	Lower impacts due to smaller footprint and less habitat disturbance and loss.
Soils & Geology	Higher impacts due to larger footprint and higher volume of materials to be excavated. Presence of liquid nitrogen on Hydrogen Plant Site increases risk of contamination.	Higher impact due to soil excavations for pipeline.	Lower impact due to smaller footprint.
Hydrology & Hydrogeology	Larger developed area and higher potential for run off into water courses, impacting water quality. Presence of liquid nitrogen on Hydrogen Plant Site increases risk of contamination.	Higher impacts to hydrology from excavations for pipeline.	Lower impact due to smaller footprint.
Air & Climate	Higher energy requirement so loss of some renewable energy produced. More equipment is needed and equipment lasts less time and so produces more waste.	Increased pay back time due to increased soil excavations for pipeline.	Longer lifecycle of equipment, reduction in waste.
Noise	Higher noise impact due to high demand cooling requirements and additional auxiliary equipment required.	Lower impact due to less compressors required.	Noise impacts from compressors, however the equipment will be housed in suitable structures and/or designed to minimise the impact.

Criteria	Liquefied storage	Pipeline Hydrogen Storage	Compressed storage
Material Assets	Larger footprint, more land take required, higher impacts to material assets, including agriculture and forestry.	Negative impacts to land take for pipeline	Smaller footprint, less land take required.
Landscape & Visual	Liquefied gas is stored in large tower, potential for higher negative visual impacts due to visibility.	Lower impacts, during operational phase as pipeline under ground.	Compressors and filling equipment have a low profile so are less visible and have a lower impact.
Cultural Heritage	Slightly higher risk to undiscovered cultural heritage due to larger footprint.	Higher potential for impacts to undiscovered cultural heritage along pipeline route.	Slightly lower risk to undiscovered cultural heritage due to smaller footprint.
Traffic and Transport	Higher density so less tube trailers on roads.	Disruption during construction works for pipeline. Lower operational impacts and no additional vehicles on road network.	Less dense than liquid hydrogen so more tube trailers required, higher impacts to traffic and transport.
Major Accidents and Natural Disasters	Higher impacts due to liquid nitrogen refrigeration system. Hydrogen stored in volume limited by the size of the tube trailers, lowers impacts.	Potential risk of under ground leak in pipeline. Volume of stored hydrogen in the pipeline increases risks of major accidents.	Hydrogen stored in volume limited by the size of the tube trailers, lowers impacts.

Compressed hydrogen storage was selected due to it being the most commonly used and best understood method of storage and transport for the green hydrogen produced. Compressed gas storage is currently used to transport a number of compressed gas products on Ireland's roads including natural gas, compressed air, nitrogen and oxygen. It is the most economical for shorter transport distances and allows for scaling of the project as storage cylinders and tube-trailers can be added as the project reaches maximum capacity. Liquified storage and transport was considered due to its higher density and thus lower storage volume, requiring fewer transportation vehicles. However, it requires a higher energy input and a cooling system such as vapor-compression cycle which introduces additional hazards such as liquid nitrogen, an increased facility footprint, greater visual impact and greater noise implications. Pipeline transport is economical over large distances and volumes however it was not considered a viable alternative due to the distance to the gas network in Ireland (5.9 km southwest in Ballina) and the current regulatory restrictions regarding injecting hydrogen into the gas network in Ireland. Compressed storage offers the flexibility of delivering the green hydrogen anywhere with road access and the reduced footprint reduces impacts to ecology, hydrology and hydrogeology and soils and geology. The lower height of compressed storage has a lower visual impact than liquefied storage and the reduction in cooling requirements makes the process more efficient and the process is quieter, reducing noise impacts on sensitive receptors.

3.12.3 Cooling system

Electrolysers require cooling systems, a fin fan cooling system was selected as the preferred technology at the Hydrogen Plant Site. During the design process an alternative process was considered which utilized a water-based cooling system. This system required a higher demand of water in addition to the water required for electrolysis The environmental impacts of fin fan cooling and water based cooling systems are considered in **Table 3.18**.

Table 3.18: Environmental Impacts of Fin Fan Cooling And Water Based Cooling

Criteria	Fin Fan Cooling System	Water based cooling system
Population & Human Health (incl. Shadow Flicker)	No additional water requirements, lower impacts to downstream fisheries.	Water inputs and outputs have a potential to impact nearby watercourses and habitat for salmon fisheries which is an important part of the local tourism industry.
Terrestrial Ecology	No additional water requirements, lower impacts to terrestrial ecology.	Water inputs and outputs have a potential to impact nearby habitat including degraded peatland.
Aquatic Ecology	No additional water requirements, lower impacts to aquatic ecology.	Additional water input needed, potentially higher impacts to water dependent habitats. Additional potential impact of water discharge from cooling system, higher impacts to water quality and change in temperature.
Ornithology	No additional water requirements, lower impacts to ornithology.	Potentially higher impacts to bird habitat due to water inputs.
Soils & Geology	No additional water requirements, lower impacts to peat soils.	Potentially higher impacts to peat soils due to water inputs and outputs.
Hydrology & Hydrogeology	No additional water requirements, lower impacts to hydrology and hydrogeology.	Additional water input needed, potentially higher impacts to nearby water courses due to abstraction. Additional potential impact of water discharge from cooling system, higher impacts to water quality and change in temperature.
Air & Climate	Neutral	Neutral

Criteria	Fin Fan Cooling System	Water based cooling system
Noise	Slightly higher impacts due to fin fan noise.	Slightly lower impacts due no fan noise.
Material Assets	Neutral	Neutral
Landscape & Visual	Neutral	Neutral
Cultural Heritage	Neutral	Neutral
Traffic and Transport	Neutral	Neutral
Major Accidents and Natural Disasters	Reduced risk of leaks damaging electrical equipment.	Increased risk of leaks potentially damaging electrical equipment.

A fin fan cooling system was selected due to the reduced water requirement and the related reduction in potential impacts to ecology, hydrology, hydrogeology and soils compared to a water-based cooling system.

3.12.4 Water for hydrogen production

A number of potential sources of water for the hydrogen production process were considered:

- Abstracting groundwater by drilling boreholes and combining with a rainwater harvesting system
- Abstracting water from a nearby watercourse (e.g. Glenree River)
- Desalination and transporting water in from the sea, for example near Enniscrone
- Connection to watermain from local group water scheme

The Environmental impacts of obtaining water from Glenree River, Transporting Desalinated Water in, Connecting to Irish Water and using groundwater complemented by rainwater harvesting is compared in **Table 3.19.**

Table 3.19: The environmental impacts from obtaining water from Glenree River, Transporting Desalinated Water in, Connecting to Uisce Éireann and using groundwater complemented by rainwater harvesting.

Criteria	Water from Glenree river	Transporting desalinated water in	Connection to Uisce Éireann	Groundwater complimented by rainwater harvesting
Population & Human Health (incl. Shadow Flicker)	Higher potential impacts downstream by reducing water flow in local watercourse could include impacts to water supply for agriculture and fishing. This could also potentially negatively impact the tourism industry.	Higher volume of traffic to Hydrogen Plant Site. Slightly higher positive impact to employment through water transportation.	Neutral	The conclusion of the Ground Water Supply Assessment was that the combination of the two boreholes was sufficient to supply the expected water demand of the Hydrogen Plant Site without depleting the aquifer or impacting the wells nearby. Impact on the aquifer can be further reduced by harvesting rainwater and management of onsite storage volumes to reduce the need to abstract groundwater at peak flow rates.
Terrestrial Ecology	Potentially higher impacts downstream to terrestrial habitats due to reduce flow in local rivers.	Neutral	Neutral	Neutral
Aquatic Ecology	Potentially higher impact to aquatic ecology by reducing watercourse flow and higher risks to integrity of aquatic habitats in the water course.	Neutral	Neutral	Neutral
Ornithology	Potential impacts to wetland bird species down stream due to reduced flow.	Neutral	Neutral	Neutral

Criteria	Water from Glenree river	Transporting desalinated water in	Connection to Uisce Éireann	Groundwater complimented by rainwater harvesting
Soils & Geology	Potential impact to downstream soils.	Neutral	Neutral	Minor soils and geology impact due to drilling boreholes.
Hydrology & Hydrogeology	Reduction in flow of local water course could potentially have negative impacts to local hydrology.	Neutral	Neutral	The conclusion of the Ground Water Supply Assessment was that the combination of the two boreholes and the rainwater harvesting was sufficient to supply the expected water demand of the Hydrogen Plant Site without depleting the aquifer or impacting the wells nearby.
Air & Climate	Neutral	Emissions from transportation vehicles increase negative impacts to air quality and climate.	Neutral	Neutral
Noise	Neutral	Higher noise impacts from transportation vehicles.	Neutral	Water abstraction equipment slightly increases noise impact and will be assessed along with all other equipment.
Material Assets	Neutral	Neutral	Neutral	Neutral
Landscape & Visual	Neutral	Higher potential visual impact from transportation vehicles.	Neutral	Neutral
Cultural Heritage	Neutral	Neutral	Neutral	Neutral

Criteria	Water from Glenree river	Transporting desalinated water in	Connection to Uisce Éireann	Groundwater complimented by rainwater harvesting
Traffic and Transport	Neutral	Negative traffic and transport impacts from higher volume of vehicles on the roads.	Neutral	Neutral
Major Accidents and Natural Disasters	Neutral	Neutral	Neutral	Neutral

The connection to Uisce Éireann (Irish water), while having minimal environmental impacts would be a metered connection and the costs would be prohibitive if the Hydrogen Plant were to entirely rely on this for the long term. It was also considered that any faults, leaks or issues with the water network in the local area could potentially impact the production of hydrogen, so the Uisce Éireann connection alone was not considered adequately resilient. It was considered that taking water from nearby watercourses could potentially impact aquatic ecology and downstream hydrology, aquatic ecosystems and fishing. Transporting water in would have negative impacts to traffic and transport and introduce higher emissions from vehicles.

Groundwater abstraction was deemed to be the most suitable and reliable method of obtaining water for the plant. The conclusion of the Ground Water Supply Assessment, that can be found in **Appendix 9.8**, was that the two boreholes can supply the expected water demand of the Hydrogen Plant without materially depleting the aquifer or impacting the wells nearby. Hydrochemical testing on the groundwater was carried out during site investigations, the results show that the water quality is suitable for the electrolysis process following water treatment. The addition of rainwater harvesting reduces the volume that needs to be pumped from underground.

It was decided that a metered connection to the watermain from Uisce Éireann will be used as backup in the event that monitoring indicates that the aquifer is being impacted due to groundwater abstraction for the Hydrogen Plant.

Therefore, it was considered that abstracting groundwater from boreholes, supplemented with harvested rainwater and with a backup supply to Uisce Éireann was the most favourable option. This method does not require additional vehicles on the road, reducing impacts to traffic and transport. It also avoids impacts to aquatic habitats and hydrology by not abstracting water from the nearby watercourse. The impacts to hydrogeology and local water sources (wells) and agricultural lands of ground water abstraction were considered, and site investigations have shown the groundwater to have the capacity to sustainably supply enough water for the Hydrogen Plant without materially depleting the aquifer and impacting lands or water sources in the locality.

3.12.5 Water storage alternative options

Consideration was given to storing water on at the Hydrogen Plant for the electrolysis process. The alternative options considered were:

- Pumping abstracted water directly from groundwater into the water treatment system

- Using an above ground tank providing 636 m^3 volume of stored water adjacent to the water treatment building to store water prior to treatment.
- Using large, underground storage tanks consisting of two cylindrical underground precast concrete storage tanks with a diameter of 46.65 m and a depth of 5 m, giving a total usable storage volume of 12,816 m^3 volume of water (providing for 1 in 100 year attenuation void). These will be located under the tube trailer parking area. Water will be transferred to the water treatment building as and when needed.

The environmental impacts of the three water storage alternatives are considered in **Table 3.20**.

Table 3.20: Environmental Impacts of the three water storage alternatives.

Criteria	Below ground water storage	Above ground water storage	Water pumped directly to water treatment system
Population & Human Health (incl. Shadow Flicker)	Neutral	Neutral	Neutral
Terrestrial Ecology	Tanks are underground so above ground footprint is reduced, resulting in smaller habitat loss and disturbance impacts.	Larger footprint will result in greater habitat loss and disturbance.	Smaller footprint has a lower impact to habitat loss and disturbance.
Aquatic Ecology	Smaller footprint has a lower potential impact to water quality through run off.	Larger footprint will result in greater potential impact to water quality through run off.	Smaller footprint has a lower potential impact to water quality through run off.
Ornithology	Smaller footprint has a lower impact to habitat loss and disturbance.	Larger footprint will result in greater habitat loss and disturbance.	Smaller footprint has a lower impact to habitat loss and disturbance.
Soils & Geology	Higher impact due to more excavations required for underground tanks.	Lower impact due to smaller excavations required.	Lower impact due to no excavations required for tanks.
Hydrology & Hydrogeology	Smaller footprint results in a lower potential impact to hydrology and hydrogeology.	Larger footprint increases the potential for silt laden runoff to enter receiving watercourses.	Smaller footprint results in a lower potential impact to hydrology and hydrogeology.
Air & Climate	Storing large a volume of water significantly improves the resilient of the project and reduces the risk of hydrogen production being impacted by water	Storing water improves the resilient of the project and reduces the risk of hydrogen production being impacted by water fluctuations and equipment breakdown	Any disruptions to water supply could potentially result in reduced output or stopping operations leading to reduced positive impacts of green hydrogen supply to

Criteria	Below ground water storage	Above ground water storage	Water pumped directly to water treatment system
	fluctuations and equipment breakdown. This increases the output of renewable energy, improving the contribution of the project to improving air quality, renewable energy targets and climate change mitigation.	somewhat. This increases the output of renewable energy, improving the contribution of the project to improving air quality, renewable energy targets and climate change mitigation.	displace fossil fuels. This reduces the contribution of the project to improving air quality, renewable energy targets and climate change mitigation.
Noise	Higher short term noise impacts during the construction phase due to excavations for the water tank.	Lower short term noise impacts during construction phase.	Lower noise impacts during construction phase.
Material Assets	Underground storage reduces the footprint and the land take. The large volume of water storages reduces the risk that the backup water connection to Irish Water will be required.	Larger footprint results in a slightly larger land take.	Smaller footprint results in a lower land take.
Landscape & Visual	Low impact due to storage tank being underground.	Higher impact due to water tanks being above ground.	Low visual impact.
Cultural Heritage	Larger area of excavation required results in a bigger potential impact on undiscovered cultural artifacts.	Larger footprint would result in a bigger impact on undiscovered cultural artifacts.	Reduced footprint means lower risk of impact to undiscovered cultural artifacts.
Traffic and Transport	Higher impact to traffic and transport due to larger volume of spoil required to be removed from site due to excavations for underground tank and increased number of delivery vehicles required for precast concrete tank sections.	Lower volume of spoil excavated and removed from site, lower impact to traffic and transport.	Lower volume of spoil excavated and removed from site, lower impact to traffic and transport.
Major Accidents and Natural Disasters	Neutral	Neutral	Neutral

It was considered that without a large volume of stored water, the electrolysis process was potentially vulnerable to fluctuations in water supply. The preferred alternative of utilizing underground water storage was selected due to its potential of providing a larger amount of water storage and increasing the resilience of the project to fluctuations in supply and mitigating against equipment breakdown. This is despite its higher impacts to soils and geology due to the increased excavations required, and the related increases in traffic during construction. By moving the storage underground, the footprint of the Hydrogen Plant is reduced, this reduces the impacts to habitat loss and disturbance and slightly reduces the visual impact.

3.12.6 Waste water discharge

Wastewater is generated from the Hydrogen Plant water treatment process. This wastewater will be treated by means of a septic tank (welfare waste) and series of constructed wetland and regulated discharge (combined welfare and processes wastewater). Apart from the discharge of the trade effluent from the Hydrogen Plant and effluent from welfare facilities on site, there are additional risks to aquatic environment from the accidental spillage or release of chemicals or other pollutants. A range of chemicals will be used within the Hydrogen Plant which include:

- Potassium Hydroxide (KOH) for the electrolysis process (lye).
- Sodium bisulphite for de-chlorination of mains water, should it be used for process.
- Antiscalant used to prevent/reduce scaling of water treatment equipment (i.e. from build-up of salts and calcite).
- Glycol for coolant.
- Oils used by hydraulic systems, compressors and transformers and diesel,
- Facility cleaning chemicals.

The wastewater arising from the Hydrogen Plant will be treated through constructed wetlands and regulated discharge rates before being discharged to the Dooyeaghny River to the south of the Hydrogen Plant. Unmitigated discharging to surface waters will potentially impact adversely on the receiving surface water quality and potentially human health and the aquatic environment if these enter drinking water supplies or surface/ground water. The water treatment process, controls to avoid risks of accidental spillage or release of chemicals, controlled discharge and assimilative capacity of the receiving waters will mitigate this risk.

Alternative methods of discharging this wastewater considered were :

- Removal offsite for treatment and disposal by licenced contractor.
- Wastewater treatment on site by watering down with harvested rainwater to dilute mineral content and recharge to groundwater.

- Wastewater treatment on site by constructed wetland and discharge into local watercourse.

A comparison of the environmental impacts of the three options is shown in **Table 3.21.**

Table 3.21: The environmental impacts of removing wastewater off-site to a treatment facility, recharging wastewater to groundwater and using a constructed wetland wastewater treatment process and discharging to local watercourse.

Criteria	Discharge to offsite treatment	Recharge to Groundwater	Constructed Wetland and Discharge to local watercourse.
Population & Human Health (incl. Shadow Flicker)	Increased volume of traffic during operational phase of Hydrogen Plant higher impacts to traffic and potential nuisance to people.	Potentially higher risk of aquifer and therefore water supply contamination.	Potentially higher impact to aquatic habitats which could impact fishing and tourism downstream. However water treatment systems and emissions regulations reduce these impacts to imperceptible. Reduced risks of groundwater contamination due to no discharge to the aquifer, this reduces potential impacts to local wells used for drinking supplies and agricultural uses.
Terrestrial Ecology	Without a water treatment system on site, the Hydrogen Plant has a smaller footprint, which results in a lower impact to habitat loss and disturbance.	Groundwater discharge after dilution results in a smaller footprint with a lower impact to habitat loss and disturbance.	Constructed wetlands have a larger surface area and increase the Hydrogen Plant footprint which results in a higher impact to habitat loss and disturbance.
Aquatic Ecology	Lower risk to water quality as wastewater transported off the Hydrogen Plant Site.	Potentially higher risk of aquifer contamination and therefore water quality and higher impacts to aquatic ecology.	Potentially higher impact to aquatic habitats downstream. However water treatment systems, compliance with discharge licence and monitoring reduce these impacts to imperceptible.
Ornithology	Smaller footprint results in lower impacts to habitat loss and disturbance.	Smaller footprint results in lower impacts to habitat loss and disturbance.	Larger footprint results in higher impacts to habitat loss and disturbance.

Criteria	Discharge to offsite treatment	Recharge to Groundwater	Constructed Wetland and Discharge to local watercourse.
Soils & Geology	Smaller footprint requires less excavations and soil disturbance, lower impact to soils and geology.	Minor increased impact to soils and geology due to drilling additional boreholes to allow discharge to groundwater.	Larger footprint increases soil disturbance, higher impact to soils and geology. No additional boreholes required, slight reduction in impacts to soils and geology.
Hydrology & Hydrogeology	No discharge of wastewater on site reduces the impacts to local hydrology and hydrogeology.	Potentially higher risk of aquifer contamination and higher potential impacts to groundwater quality.	Creation of constructed wetlands provides nature-based water attenuation on the Hydrogen Plant Site, reducing the potential for rapid run off and the release of suspended soils reducing the impacts to hydrology and hydrogeology and flood risk. Potentially higher impacts to water quality downstream. However, water treatment systems, compliance with discharge licence and monitoring reduce these impacts to imperceptible. Lower impacts to hydrogeology as no wastewater is recharged to the aquifer, this reduces the impacts to groundwater quality and reduces the risks of contamination of water sources.
Air & Climate	Increased vehicle requirement increases the dust and vehicle emissions and increases impacts to air quality and climate.	No additional vehicles, reduced effects of dust and emissions and reduced impacts to air quality and climate	No additional vehicles, reduced effects of dust and emissions and reduced impacts to air quality and climate.
Noise	Increased operational phase traffic increases long term noise impacts on nearby sensitive receptors.	Slightly increased noise impacts during construction of additional boreholes. Potentially slightly increased noise impacts on nearby sensitive receptors.	Increased construction phase noise impacts due to creation of constructed wetlands. Potentially increased noise impacts on nearby sensitive receptors.

Criteria	Discharge to offsite treatment	Recharge to Groundwater	Constructed Wetland and Discharge to local watercourse.
Material Assets	Higher impact to licenced wastewater treatment facilities by increasing volumes to be treated.	Dealing with the wastewater onsite reduces the wastes that are required to be processed elsewhere.	Dealing with the wastewater onsite reduces the wastes that are required to be processed elsewhere. Larger land take requirement for increased footprint.
Landscape & Visual	Reduced footprint slightly reduces the visual impacts.	Reduced footprint slightly reduces the visual impacts.	On site water treatment slightly increases the visual impacts of the Hydrogen Plant Site by increasing the footprint, however the constructed wetlands are low profile, screened from view and will be designed to assimilated in to the surrounding landscape.
Cultural Heritage	Reduced footprint means lower risk of impact to undiscovered cultural artifacts.	Reduced footprint means lower risk of impact to undiscovered cultural artifacts.	Larger footprint would result in a bigger impact on undiscovered cultural artifacts.
Traffic and Transport	Higher impact from increased vehicles on roads long term during the operational phase of the development.	No additional road vehicles required, reduced impact to traffic and transport.	Slight increase in construction phase vehicles required for constructed wetlands, however no additional operational phase vehicles required.
Major Accidents and Natural Disasters	Neutral	Neutral	Neutral

The volume of wastewater requiring transportation and the associated impacts to traffic and transport, noise and disturbance impacts to local residents deemed the transportation of wastewater off site unacceptable. Transporting wastewater offsite also increased longer term operational costs and impacts to local wastewater facilities. Recharging to groundwater was found to have high potential water quality, hydrology and hydrogeology impacts. It was therefore decided that using constructed wetlands and discharge to the Dooyeaghny River was the preferred option, this is despite its increased footprint and the related impacts to habitat loss and land take.

3.13 SUMMARY AND CONCLUSIONS

This chapter has described the reasonable alternatives considered as part of the iterative design process for Wind Farm and Hydrogen Plant.

There is an existing planning permission on the Wind Farm Site for 21 wind turbines. The proposal is to upgrade these to larger and more efficient wind turbines and reduce the number, to 13 no. wind turbines, increasing the capacity from 48 MW to between 65 MW and 78 MW and introducing a Hydrogen Plant. The Wind Farm Site has been shown to be a suitable location given consideration of the main criteria of distances from inhabited houses, wind speeds and available Grid Connection. The chosen layout and design take into consideration constraints to minimize habitat disruption and loss and maximize wind resource. Alternative wind turbine numbers and layouts were considered through a process of mitigation by design. The Grid Connection route was amended following guidance from EirGrid.

Following extensive consultation with local communities and several design iterations, the Hydrogen Plant Site was located adjacent to the National primary road N59, five reasonable alternatives for the location of the Hydrogen Plant were considered including adjacent to the Wind Farm Site. The selected location avoids high volumes of traffic on local roads, ecologically sensitive areas, proximity to sensitive receptors and has a sustainable water source.

Alternative technologies were considered for the hydrogen production, storage and cooling and the most favourable options selected. Options for processes to obtain the required volume of water were considered as were disposal methods for discharging wastewater. Alternatives were considered for other individual elements of the project including location of the Wind Farm Substation and sourcing of materials.

The final layout and components of the Wind Farm and Hydrogen Plant assessed through this EIAR are considered to represent the optimal design which maximises the potential benefits of producing renewable energy while minimizing the potential environmental impacts.