Appendix 16.1

Climate Change Policy Review

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National Energy and Climate Change Policy and Legislation

National Policy Position on Climate Action and Low Carbon Development (2014)

1.1 The National Policy Position on Climate Action and Low Carbon Development was published on the 23 April 2014. The policy sets a fundamental national objective to achieve the transition to a competitive, low-carbon, climate-resilient and environmentally sustainable economy by 2050. The policy states that greenhouse gas (GHG) mitigation and adaptation to the impacts of climate change are to be addressed in parallel national strategies – respectively through a series of mitigation plans and a series of climate change adaptation frameworks.

1.2 The National Policy Position envisages that development of national mitigation plans will be guided by a long-term vision of low carbon transition, including achieving *'an aggregate reduction in CO_2 emissions of at least 80% (compared to 1990 levels) by 2050 across the electricity generation, built environment and transport sectors',* in line with broader EU objectives.

1.3 In January 2018, Ireland's first statutory National Adaptation Framework (NAF) was published, which has been developed under the Climate Action and Low Carbon Development Act 2015. As laid out in the National Policy Position, the aim of the NAF is to build upon the work carried out under Ireland's first non-statutory National Climate Change Adaptation Framework (NCCAF) which was published in 2012. The NCCAF framework aimed to ensure that adaptation actions are carried out across key sectors and at local level to reduce the country's vulnerability to climate change. The NAF outlines a governmental and societal approach to climate adaptation in Ireland, setting out a national strategy to reduce the vulnerability of Ireland to the adverse effects of climate change and to take advantage of positive impacts.

Climate Action and Low Carbon Development Act 2015

1.4 The Climate Action and Low Carbon Development Act 2015 ensures developments are compliant in pursuing the transition to a low carbon, climate resilient and environmentally sustainable economy. Section 15 provides the following obligations:

- "*15. (1) A relevant body shall, in so far as practicable, perform its functions in a manner consistent with—*

  (a) the most recent approved climate action plan,

  (b) the most recent approved national long term climate action strategy,

  (c) the most recent approved national adaptation framework and approved sectoral adaptation plans,

  (d) the furtherance of the national climate objective, and

  (e) the objective of mitigating greenhouse gas emissions and adapting to the effects of climate change in the State."

1.5 The Climate Action Plan 2024, Ireland's Long-term Strategy on Greenhouse Gas Reduction 2024, and National Adaptation Framework: Planning for a Climate Resilient Ireland 2024 are the most recent plans at the time of writing, and are detailed within sections below.

Climate Action and Low Carbon Development (Amendment) Act 2021

1.6 The 2021 Amendment Act builds on the Climate Action and Low Carbon Development Act 2015, embedding the process of setting ambitious and binding emissions-reduction targets in law. In addition, the Act provides for a national climate objective, which commits the State to pursue and achieve no later than 2050, the transition to a climate resilient, biodiversity-rich, environmentally sustainable and climate-neutral economy. The Act provides that the first two five-year carbon budgets proposed by the Climate Change Advisory Council should equate to a total reduction of 51% over the period to 2030, relative to a baseline of 2018.

1.7 Ireland's 2030 target under the EU's Effort Sharing Regulation (ESR) is to deliver a 30% reduction in emissions compared to 2005 levels by 2030. There are also annual binding emission allocations over the 2021-2030 period to meet that target.

1.8 The Climate Action and Low Carbon Development (Amendment) Act 2021 provides for the establishment of carbon budgets to support in achieving Ireland's climate ambition. The carbon budget programme, comprising three five-year budgets came into effect on 6 April 2022 for the following periods:

- Budget 1 from 2021-2025 has been set at 295 $MtCO_2e$ (Million tonnes of Carbon dioxide equivalent) representing an average of 4.8% reduction per annum for the first budget period.
- Budget 2 from 2026-2030 has been set at 200 $MtCO_2e$ representing an average of 8.3% reduction per annum for the second budget period.
- Budget 3 from 2031-2035 has been set at 151 $MtCO_2e$ representing an average of 3.5% reduction per annum for the third provisional budget.

1.9 To deliver these targets, in July 2022 the Government established Sectoral Emissions Ceilings which set maximum limits on GHG emissions for each sector of the Irish economy to the end of the decade. For electricity, the 2030 ceiling is 3 $MtCO_2e$ which represents a 75% reduction on 2018 levels (10 $MtCO_2e$). For the industry, the 2030 ceiling is 4 $MtCO_2e$ which represents a 35% reduction on 2018 levels (7 $MtCO_2e$).

1.10 Consistent with the Carbon Budgets, Emissions Ceilings are also provided within the budget periods:

- Budget Period 1 from 2021-2025 has been set at 40 $MtCO_2e$ for the electricity sector, and 30 $MtCO_2e$ for the industry sector.
- Budget Period 2 from 2026-2030 has been set at 20 $MtCO_2e$ for the electricity sector, and 24 $MtCO_2e$ for the industry sector.

1.11 Further details are provided in the September 2022 Sectoral Emissions Ceilings Summary Report (Government of Ireland, 2022) and the Climate Action Plan 2024 (Government of Ireland, 2024a).

Climate Action Plan 2021 (CAP21)

1.12 The Climate Action Plan 2021 (CAP21) contains data centre-specific policies. According to document figures, it is forecasted that the data centre sector is expected to grow by up to 9 TWh (terawatt-hours) by 2030, which would result in the sector consuming around 23% of the country's total energy demand. As a result of this, the CAP21 states that *'the government will review its strategy on data centres to ensure that the sector will be in alignment with sectoral emissions ceilings and support renewable energy targets* [62%-81% reduction in emissions by 2030]*'*. Please see paragraph 1.41 for the Government's statement of the role of data centres.

1.13 The CAP21 recognises that *'the forecast growth of data centres clearly represents a challenge to Ireland's emissions targets. To deal with this, the government will review its strategy on data centres to ensure that growth of such users can only happen in alignment with our sectoral* *emissions ceilings and renewable energy targets. The impact of data centre growth on security of supply will also be considered. Further regulatory measures will be considered to manage demand from large users, such as data centres, in the context of climate targets and future network needs.'*

1.14 *'Unlocking the flexibility of large electricity demand users will be a key challenge as the electricity system is decarbonised. Energy demand, including data centres, will be expected to operate within sectoral emissions ceilings and further signals will be required to locate demand where existing or future electricity grid is available and close to renewable energy generation. Research and development (such a science challenge to industry), to put Ireland on a pathway to net-zero-carbon data centres, will be required.'*

1.15 Section 12.3.3 describes the Sustainable Energy Authority Ireland (SEAI) Initiatives which the CAP21 supports, being:

- *'The Large Industry Energy Network (LIEN), a network of 199 of Ireland's largest energy users (some of which are in the EU ETS), together consume 21% of the entire energy demand in Ireland. LIEN members are companies with an annual energy spend of €1 million or more. These are supported by SEAI through mentoring, energy management systems, training and networking, and compliance with legal requirements. Through SEAI, we will continue to support and promote decarbonisation by the members of this network.*
- *Investments by enterprises in energy efficiency increase their competitiveness, protect the environment, boost their reputation and elevate their branding. Through SEAI, we will continue to support energy audits, provide free training for businesses and provide financial supports to those who want to invest in energy efficiency, particularly SMEs.*
- *SEAI will continue to expand the Excellence in Energy Efficient Design (EXEED) Programme to deliver new best practices in design, construction, and commissioning processes for new investments and upgrades to existing assets, with the focus now on greenhouse gas emissions reductions.*
- *Through the Government-funded Support Scheme for Renewable Heat, SEAI will continue to support the adoption of renewable heating systems by commercial and industrial heat users not covered by the EU ETS.'*

1.16 Section 13.3.3: Decarbonising Our Commercial Buildings, includes measures to support and incentivise the increased energy efficiency and decarbonisation of commercial buildings, such as:

- *'Continuing to develop and implement a suite of services such as energy audits, technical supports, training and advice.*
- *Acting on the outcome of the SEAI's National Heat Study, which will inform the development of targeted future policies and supports for the commercial building sector.*
- *Providing capital funding which, subject to the availability of Exchequer resources, will support the decarbonisation of the commercial buildings sector.*
- *Implementing a revised Energy Efficiency Obligation Scheme (EEOS) from 2022, to support energy users (financially or otherwise) to implement energy saving practices or to carry out energy upgrades on their properties.'*

1.17 The CAP21 has also set a target of achieving at minimum a 10% (and up to 60%) decrease in embodied carbon in construction materials.

Climate Action Plan 2023 (CAP23)

1.18 The Climate Action Plan 2023 (CAP23) provides a detailed plan for taking decisive action to achieve a 51% overall reduction in Ireland's greenhouse gas emissions by 2030 (from a 2018 baseline) and carbon neutrality by 2050. Ireland's national climate objective and 2030 targets are aligned with Ireland's obligations under the Paris Agreement, to set the long term goal to limit warming to below 2°C above pre-industrial levels, and to pursue efforts to limit the temperature increase to 1.5°C.

1.19 The CAP23 states '*decarbonised gases such as biomethane and green hydrogen are a critical component for Ireland's energy ecosystem'* and recognises they *'provide a decarbonisation pathway for combustion emissions arising [from] medium and high temperature processes'.*

1.20 The Plan also sets key targets for the decarbonisation of the energy sector. It has targeted that renewable energy will account for 50% of the energy share by 2025, with this target increasing to 80% by 2030.

1.21 It recognises that '*as electrification and decarbonisation of the other sectors continues, there will be an increase in electricity demand and a transferring of emissions from those sectors to the electricity sector. Limiting peak demand when renewable resources are unavailable, through improved flexibility and demand management, will be vital… In the short- and medium-term, new demand growth from large energy users, such as data centres, will have to be moderated to protect security of supply and ensure consistency with the carbon budget programme'.* Key measures to manage electricity demand flexibility and growth include a Demand Side Strategy, delivered by CRU with the aim of:

- *'20 to 30% of electricity demand to be flexible by 2030 (15-20% flexibility by 2025), facilitating active participation by citizens and businesses in the energy market. Large Energy Users (LEUs) will be expected to make a higher proportional contribution to the target, and a review will be carried out of the gas and electricity connection policies for new LEUs'*

1.22 The Plan identifies the need for Long Duration Storage technologies and increased zero emission gas generation as key measures for 2031-2035 to deliver abatement in electricity.

1.23 Further, the Plan lists a number of market incentives that will be developed to match electricity demand with renewable energy generation, including the following:

- *'Develop policies that support extra-large energy users to achieve carbon-free demand in Ireland so that electricity decarbonisation, demand efficiency and flexibility, and enterprise growth can go hand in hand. To include connection agreements; hybrid connections; non-firm connections where appropriate; onsite dispatchable generation; onsite storage; emissions reporting; and renewable PPAs in particular within the scope of this work;*
- *In line with the Roadmap on Corporate Power Purchase Agreements, the SEAI, the CRU[1], and the System Operators, will work with LEUs and enterprise development agencies to increase the demand flexibility of LEUs through enhanced reporting and matching of demand with usage of lower carbon energy sources, including increased transparency of emissions data, and regulatory incentives and disincentives.'*

Climate Action Plan 2024 (CAP24)

1.24 The most recent approved Climate Action Plan 2024 (CAP24), furthers what is detailed within the CAP23 (see above) by updating the strategic direction for meeting Ireland's climate targets. The CAP24 highlights that estimated emissions reductions fall short of the level of abatement required to meet national and international targets. Corrective actions by sector are detailed, and include the acceleration of renewable electricity generation, and increased focus on the decarbonisation of cement and construction.

1.25 Consistent with CAP23, CAP24 states *'decarbonised gases such as green hydrogen and biomethane can provide a decarbonisation pathway for reducing emissions arising from medium and high temperature processes'.* Additional focus is given to the importance of green hydrogen,

[1] Commission for the Regulation of Utilities

which *'represents a distinct longer-term pathway for zero-emission gas in Ireland'* and will play an important role in decarbonising Ireland's energy system.

1.26 The Plan sets key targets for the decarbonisation of the energy sector. Consistent with CAP23, CAP24 has targeted that renewable energy will account for 50% of the energy share by 2025, with this target increasing to 80% by 2030. *'The EPA* [Environmental Protection Agency] *projects that the electricity sector emissions are currently not aligned to Climate Action Plan 2023 (CAP23) pathways and targets. The projections forecast an overshoot of ~5.2 $MtCO_2$eq. in the period 2021 to 2025, and ~8.2 $MtCO_2$eq. in the period 2026 to 2030'.*

1.27 *'Achieving further emissions reductions between now and 2030 requires a major step up across three key measures:*

- *Accelerate and increase the deployment of renewable energy to replace fossil fuels;*
- *Deliver a flexible system to support renewables and demand;*
- *Manage demand'.*

1.28 Increasing the deployment of renewable energy will be achieved through measures such as increasing grant funding for non-utility scale generation and community projects, investment in transmission and distribution systems, deliver streamlined electricity generation grid connection policy and process, and enhancing green hydrogen production from renewable electricity surplus generation.

1.29 Accelerating the delivery of a flexible system will be achieved through new flexible gas-fired power generation, increase deployment of medium to long-term storage technologies, and establish a competitive market needed to deliver zero carbon system services.

1.30 Regarding managing electricity demand, this will be achieved by increasing flexibility of the electricity system, with measures to incentivise Large Energy Users (such as the Project) to increase the flexibility in their electricity demand thereby enabling low/zero carbon demand growth. Power demand by data centres was highlighted within CAP24, which states that there should be a potential focus on managing energy demand from such users.

1.31 The plan details recommendations for decarbonisation of the industrial sector, including through pairing low-carbon power supply with onsite energy storage or renewable self-generation. Together this should contribute to electricity demand response and flexibility. It also sets out how embodied carbon in construction materials, in particular concrete and steel, should be reduced, alongside optimised design and modern methods of construction.

1.32 Industrial energy efficiency is also a key element of the action plan, including development of energy management systems for Large Energy Users.

1.33 The Plan also details recommendations for decarbonisation of the built environment, with focus on the expansion of district heating networks, biomethane production, and increased energy efficiency.

UN Climate Change Conference of Parties (COP27) (2022)

1.34 The CoP are (typically) annual climate summits, attended by world leaders globally, where the effects of measures introduced to limit climate change are discussed.

1.35 At the COP26 summit in November 2021, parties voted to adopt the draft COP26 report (United Nations Framework Convention on Climate Change (UNFCC), 2021), known as the Glasgow Climate Pact. This included commitments to phase down the use of coal and supports a common timeframe and methodology for national commitments on emissions reductions. Countries were tasked to return in 2022 with more ambitious 2030 emissions reductions targets.

1.36 However, the COP27 summit in November 2022 made very little progress on emissions reduction ambitions made at COP26. Global ambition could limit warming 2°C, but targets are not being sufficiently backed by action.

1.37 Instead, COP27 saw progress on agreements to establish a loss and damage fund to assist developing countries that are particularly vulnerable to the adverse effects of climate change to address impacts which cannot or have not been adapted to. Some progress was made with regards to adaptation to climate change, and nature-based solutions.

National Development Plan 2021-2030 (2021)

1.38 The National Development Plan sets out the Government's over-arching investment strategy and budget for the period 2021-2030. Chapter 3 focuses on climate action and the environment, specifically section 3.7: Investing for low carbon, resilient electricity systems, states the following:

- *'The NDP Review commits to increasing the share of renewable electricity up to 80% by 2030. This is an unprecedented commitment to the decarbonisation of electricity supplies. To put this figure in some perspective, onshore wind generation capacity in Ireland stood at 4.1GW at end 2019.'*
- *'In tandem with this grid-scale renewable electricity, the NDP Review commits to the creation of a Microgeneration Support Scheme whose primary aim is to incentivise citizens and businesses to produce and consume their own electricity. It will include a guaranteed payment for the export of excess electricity to the grid.'*

1.39 Chapter 13, Strategic Investment Priorities – Energy states:

- *'The use of energy for the purposes of electricity, heat and transport generates almost 60% of Ireland's greenhouse gas emissions. Action in the energy sector will be critical to the achievement of Ireland's climate targets and the transformation to a high-renewable, net-zero emissions future. This will require a fundamental shift in the means by which we supply, store and use energy. We need to plan our energy system as a whole to create greater links between different energy carriers (such as electricity and hydrogen); infrastructures; and consumption sectors (such as transport and heating). The long-term objective is to transition to a net-zero carbon, reliable, secure, flexible and resource-efficient energy services at the least possible cost for society by mid-century.'*
- *'At the same time, rapidly increasing electricity demand from large energy users, as well as the electrification of end user sectors such as transport and heating, presents a significant challenge. Electricity demand from large energy users, including data centres is forecast to grow to up to 27% of total power demand in 2030.'*

Project Ireland 2040 National Planning Framework (2019)

1.40 Project Ireland 2040 is the Government's long-term overarching strategy to build a more resilient and stable future. The strategy is a planning framework to guide development and investment, and ensures the alignment of investment plans with National Strategic Outcomes as stated within the framework.

1.41 With regards to data centres, the Framework details the following: *'Ireland is very attractive in terms of international digital connectivity, climatic factors and current and future renewable energy sources for the development of international digital infrastructures, such as data centres. This sector underpins Ireland's international position as a location for ICT and creates added benefits in relation to establishing a threshold of demand for sustained development of renewable energy sources. There is also greater scope to recycle waste heat from data centres for productive use, which may be off-site.'*

Ireland's Long-term Strategy on Greenhouse Gas Emissions Reduction (2024)

1.42 Ireland's Long-term Strategy on Greenhouse Gas Emissions Reduction (Government of Ireland, 2024b) has been prepared to meet national, European Union, and international law, and is consistent with the Climate Action Plan 2024 (Government of Ireland, 2024a).

1.43 The Strategy sets out indicative pathways, beyond 2030, towards achieving carbon neutrality for Ireland by 2050. The Strategy provides a pathway to a whole-of-society transformation and links shorter-term Climate Action Plans and Carbon Budgets, and the longer-term objective of the European Climate Law and Ireland's National Climate Objective.

1.44 The Strategy states that *"the exact pathways to achieving longer term sectoral targets will evolve over time, as some technologies mature and become more cost-effective in response to innovation and increased investment, or as new technologies emerge,,, reaching climate neutrality will require Ireland's carbon dioxide emissions from fossil fuel energy use in power generation, heating, and transport to reduce effectively to zero".*

1.45 The Strategy details pathways to climate neutrality by sector, building upon the decarbonisation pathways detailed within the Climate Action Plan 2024 (Government of Ireland, 2024a). Key points in relation to the electricity and built environment sectors are detailed below, as these are of most importance to the Project.

1.46 With regards to the electricity sector, the Strategy states that "*the core measures necessary to deliver a net zero emissions electricity sector are to deliver significantly higher renewable power capacity mostly through onshore wind, offshore wind and solar PV".* This should be accompanied with the following measures to enable the grid to function with high levels of intermittent sources of power:

- Power storage: long duration storage technologies such as battery storage and the storage of renewable power as gas (e.g. green hydrogen); and
- Power to gas: conversion of electrical power into renewable gases.

1.47 Data centres *"will be expected to operate within sectoral emissions ceilings"*, and energy storage and flexibility will be a requirement to ensure Ireland is on a pathway to net zero carbon data centres.

1.48 With regards to the built environment, the Strategy highlights the importance of promoting the use of lower carbon alternatives in construction.

1.49 The circular and bioeconomy are detailed within the Strategy, which states that patterns of consumption must change in order to reduce the amount of waste produced as an economy I "*in the circular economy, resources are kept in use for as long as possible, the maximum value is extracted from them while in use before residual resources are then recovered and regenerated into new products and materials at the end of each lifecycle. The circular economy is, therefore, an inherently regenerative system, which minimises or avoids the emissions and other negative environmental impacts associated, by replacing linear lifespan with a closed loop for materials".* The bioeconomy is a component of the circular economy, and relates to the production of renewable biological resources such as bio-energy.

1.50 The Strategy includes detail on climate risk and adaptation, and identifies the most immediate climate risks to Ireland are associated with changes in extremes, such as droughts, floods, precipitation and storms.

National Adaptation Framework: Planning for a Climate Resilient Ireland (2024)

1.51 The statutory National Adaptation Framework (NAF) sets out a national adaption strategy which aims to reduce the vulnerability of Ireland's economy and society to the impacts of climate change. It outlines how various sectors and local authorities can implement adaptation measures to minimise Ireland's vulnerability to climate change's adverse effects while taking advantage of any beneficial impacts. The NAF emphasises the importance of integrating adaptation strategies into all levels of policy making, infrastructure development, and local planning.

1.52 The Framework highlights that Environmental Impact Assessments (EIA) should integrate the consideration of climate resilience within the design and implementation of a development scheme.

1.53 Key guiding principles included within the NAF regarding adaptive design and planning include the following:

- "*Avoiding Maladaptation: Ensure that adaptation actions do not inadvertently create new vulnerabilities or exacerbate existing ones*";
- "*Sustainability: Ensure that adaptation measures promote long-term sustainability, minimising negative environmental and social impacts*";
- "*Ecosystem-based / nature-based options for adaptation: Employ ecosystem based or nature-based adaptation options, to reflect the biodiversity-rich ambition of the national climate objective*";
- "*Consideration of Climate Mitigation: Ensure that climate mitigation outcomes are considered alongside adaptation planning where appropriate*"; and
- "*Integrated Approach: Adopt a holistic, cooperative, and cross-sectoral approach that considers the interconnectedness of climate change impacts and adaptation measures*".

Sectoral Adaptation Planning (2020)

1.54 The Government of Ireland developed 12 Sectoral Adaption Plans (SAPs) under the National Adaption Framework. The plans outline how the different sectors must prepare for and adapt to the risks associated with climate change. The plans currently available and relevant to the Project are summarised below. It should be noted that revised and/or new SAPs are currently being developed under Ireland's second statutory NAF (Government of Ireland, 2024c).

1.55 The Electricity & Gas Networks Sector Climate Change Adaptation Plan has identified the following risks to electricity and gas networks:

- The main risk to transmission systems will be from flooding and high wind speeds. Temperature rise and extreme high temperatures may also impact asset lifetime and equipment ratings;
- Increased occurrence of storms and high winds may reduce the generation capacity for wind farms;
- The effects of climate change may impact the levels of degradation of critical gas assets that are above ground, thereby reducing the lifetime of assets and increasing the frequency of refurbishment and replacement. The gas transmission network is largely resilient to weather events as it is an underground network. However, an increase in extreme flood events may impact transmission pipelines;
- Conventional electricity generation uses significant amounts of water in their cooling systems, which may become increasingly under pressure due to drought and water shortages; and

- Elevated temperatures are likely to reduce the output capacity of gas-fired combustion turbines.

1.56 The following measures have been identified to adapt to such risks:

- Increased resilience in the electricity network should be achieved through the diversification of generation sources, including the greater deployment of solar PV and increased flexibility of the grid through the installation of battery storage systems;
- Increased production of biomethane to be injected into the natural gas grid;
- Gas networks should have *'on-going adherence to all relevant Irish and European gas standards when designing and planning assets noting that these standards have in-built tolerances which ensure that gas infrastructure is capable of comfortably enduring severe weather events'* that may arise as a result of climate change; and
- Further consideration of weather events in the planning and design of new electricity generation infrastructure should be considered.

1.57 The Communications Sector Climate Change Adaptation Plan also highlights the impacts that extreme weather events may have in the immediate future on the communications sector and the importance of ensuring climate-proofing in strategic emergency planning. The following risks to communications have been identified:

- Overhead copper and fibre lines suspended on poles are the most exposed section of the electronic communications network, as such they are most at risk from extreme storm events and high winds;
- Underground fibre cabling may be at risk from increased incidence of flooding; and
- Extreme weather events may inhibit access to remote infrastructure, delaying possible maintenance or repair work.

1.58 The following measures have been identified to adapt to such risks:

- Consideration of weather events and climate change trends in the planning and design of new infrastructure (i.e. accounting for increased possibility of flooding);
- Where underground network infrastructure is requried to be constructed within flood plains, particular consideration should be given to mitigating any potential damage caused by flooding;
- Detailed identification of vulnerable areas where exiting critical transmission and distribution infrastructure is located; and
- Monitoring and inventory of overhead lines to minimise potential damage caused by extreme weather events.

Government Statement on the Role of Data Centres in Ireland's Enterprise Strategy (2022)

1.59 The Government's statement of the role of data centres in Ireland's enterprise strategy sets out the following 'Principles for Sustainable Data Centre Development' which are intended to be used as a set of national principles that should inform and guide decisions on future data centre development.

- ***'Economic Impact*** *-The Government has a preference for data centre developments associated with strong economic activity and employment.*
- ***Grid Capacity and Efficiency*** *- The Government has a preference for data centre developments that make efficient use of our electricity grid, using available capacity and alleviating constraints.*

- ***Renewables Additionality*** - *The Government has a preference for data centre developments that can demonstrate the additionality of their renewable energy use in Ireland.*
- ***Co-Location or Proximity with Future-Proof Energy Supply*** - *The Government has a preference for data centre developments in locations where there is the potential to co-locate a renewable generation facility or advanced storage with the data centre, supported by a Corporate Power Purchase Agreements, private wire or other arrangement.*
- ***Decarbonised Data Centres By Design*** - *The Government has a preference for data centres developments that can demonstrate a clear pathway to decarbonise and ultimately provide net zero data services.*
- ***SME Access and Community Benefits*** - *The Government has a preference for data centre developments that provide opportunities for community engagement and assist SMEs, both at the construction phase and throughout the data centre lifecycle.*'

Irish Academy of Engineering: Electricity Sector Investment for Data Centres in Ireland (2019)

1.60 The note on Electricity Sector Investment for Data Centres in Ireland details the projected growth in Ireland's electricity demand and associated increase in carbon emissions. '*As 30% of the projected data centre electricity demand is assumed to be produced from thermal generation this will result in significant additional carbon emissions. For the purposes of this analysis, it is assumed that this generation will be predominantly supplied from highly efficient gas-fired combined cycle gas turbine units, but emissions could be significantly higher if the use of oil fired open cycle gas turbines is necessary. On the basis of these assumptions data centre development is projected to add at least 1.5 million tonnes to Ireland's carbon emissions by 2030 – about a 13% increase on electricity sector emissions at present*'.

Other Regulations

Climate Neutral Data Centre Pact - Self-Regulatory Initiative Policy Proposal

1.61 The Climate Neutral Data Centre Pact is a pledge in response to the European Green Deal that aims to ensure data centres are an integral part of the sustainable future of Europe. Data centre operators and trade associations can be signatories to the pact, meaning they agree to take the following actions to make data centres climate neutral by 2030:

1.62 **Energy Efficiency: '***Data centres and server rooms in Europe shall meet a high standard for energy efficiency, which will be demonstrated through aggressive power use effectiveness (PUE) targets':*

- '*By January 1, 2025 new data centres operating at full capacity in cool climates will meet an annual PUE target of 1.3, and 1.4 for new data centres operating at full capacity in warm climates.*'

1.63 **Clean Energy:** *'Data centres will match their electricity supply through the purchase of clean energy'*

- '*Data centre electricity demand will be matched by 75% renewable energy or hourly carbon free energy by December 31, 2025 and 100% by December 31, 2030*'.

1.64 **Water:** *'Data centres at full capacity will meet a high standard for water conservation, demonstrated through the application of a location and source sensitive water usage effectiveness (WUE) target.'*

- *'By January 1, 2025 new data centres at full capacity in cool climates that use potable water will be designed to meet a maximum WUE of 0.4 L/kWh in areas with water stress.*
- *The limit for WUE can be modified based on climate, stress and water type to encourage the use of sustainable water sources for cooling'.*

1.65 **Circular Economy: '***The reuse, repair and recycling of servers, electrical equipment and other related electrical components is a priority for data centre operators*'

- *'Data centres will set a high bar for circular economy practices and will assess for reuse, repair, or recycling 100% of their used server equipment.*
- *Data centre operators will increase the quantity of server materials repaired or reused and will create a target percentage for repair and reuse by 2025.'*

1.66 **Circular Energy System:** *'The reuse of data centre heat presents an opportunity for energy conservation that can fit specific circumstances. Data centre operators will explore possibilities to interconnect with district heating systems and other users of heat to determine if opportunities to feed captured heat from new data centres into nearby systems are practical, environmentally sound and cost effective.'*

Towards Nearly Zero Energy Buildings in Ireland - Planning For 2020 And Beyond (2012)

1.67 This outline plan recognises the significant energy use and CO_2 emissions associated with the built environment and the importance in achieving nearly zero energy buildings. Nearly zero-energy building is defined by Directive 2010/31/EU as: *'a building that has a very high energy performance, as determined in accordance with Annex I. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby*'.

Local Energy and Climate Change Policy

Kildare County Development Plan 2023-2029

1.68 This Development Plan sets out an overall strategy for the proper planning and sustainable development of County Kildare. It has been prepared having regard to those matters that must be included in a County Development Plan (i.e. mandatory objectives) as well as those matters that may be included (discretionary objectives) as required by the Planning and Development Acts 2000 (as amended). The main mandatory objective of the Planning Acts that are mentioned in the Plan and relevant to the Project is as follows:

- *'Promotion of sustainable settlement and transportation strategies, including measures to reduce energy demand, greenhouse gas emissions and address the necessity of adaptation to climate change in particular having regard to the location, layout and design of new development.'*

1.69 The key principles for the Development plan which are relevant to the Project are as follows:

- *'To develop a county that is resilient to climate change, plans for and adapts to climate change and flood risk, facilitates a low carbon future, supports energy efficiency and conservation, and enables the decarbonisation of our lifestyles and economy;*
- *To support, facilitate and promote the sustainable development of renewable energy sources in the county.'*

1.70 **Chapter 4 Resilient Economy and Job Creation** has the overarching aim to '*provide for the future well-being of the residents of the county by creating a strong and resilient economic base,* *providing expanded opportunities for employment and facilitating a good quality of life within vibrant and attractive places to live, work, visit and invest'*.

1.71 **Objective RE 071** – It is an objective of the Council to '*require data centres to consider the use of sustainable renewable sources of energy to fuel their operations in whole in the first instance or in part (minimum of 30%) where this is not possible and where it has been satisfactorily demonstrated not to be possible, subject to all relevant and cumulative environmental assessments and planning conditions*'.

1.72 **Chapter 7 Energy and Communications** has the overarching arching aim to *'encourage and support energy and communications efficiency and to achieve a reasonable balance between responding to EU and National Policies on climate change, renewable energy and communications and enabling resources to be harnessed in a manner consistent with the proper planning and sustainable development of the county'.*

1.73 **Policy EC P1** - It is the policy of the Council to *'reduce our carbon footprint in line with national targets for climate policy mitigation and adaptation objectives, as well as targets for greenhouse gas emission reductions.'*

1.74 **Objective EC O1** – It is an objective of the Council to *'ensure that energy intensive sectors incorporate significant renewable energy sources to reduce their carbon footprint.'*

1.75 **Objective EC O3** - It is an objective of the Council to *'support initiatives for limiting emissions of greenhouse gases through energy efficiency and the development of renewable energy sources which make use of the natural resources in an environmentally and socially acceptable manner.'*

1.76 **Objective EC O4** – It is an objective of the Council *to 'support infrastructural renewal and development of electricity and gas networks in the county, subject to safety and amenity requirements.'*

1.77 **Objective EC O5** - It is an objective of the Council to *'support and encourage the sustainable development of renewable energy auto production units (the production of energy primarily for on-site usage) for existing and proposed developments in line with relevant design criteria, amenity and heritage considerations and the proper planning and sustainable development of the area.'*

1.78 **Policy EC P18** - It is a Policy of the Council to *'support the accommodation of Data Centres at appropriate locations in line with the objectives of the National Planning Framework and the principles for Sustainable Data Centre Development of the Government Statement on the Role of Data Centres in Ireland's Enterprise Strategy (July 2022) subject to appropriate Transport, Energy and Environmental Assessments and all relevant planning conditions.'*

1.79 **Objective EC O61** – It is an objective of the Council to *'require data centres to include strong energy efficiency measures to reduce their carbon footprint in support of national targets towards a net zero carbon economy, through the use of sustainable sources of energy generation in the first instance and then the use of renewable sources of energy to power their operations, where on site demand cannot be met in this way, to provide evidence of engagement with power purchase agreements (PPA) In Ireland. All data centre developments shall provide evidence of sign up to the Climate Neutral Data Centre Pact.'*

1.80 **Objective EC O62 -** It is an objective of the Council to ensure *'all data centre development applications shall have regard to the DECLG guidance document 'Towards nearly Zero Energy Buildings in Ireland – Planning for 2020 and Beyond', which promotes the increase of near Zero Energy Buildings (nZEB).'*

1.81 **Objective EC O63 -** It is an objective of the Council to *'ensure that all significant development proposals for Data Centres are accompanied by an Energy Analysis that explores the potential for the development of low carbon district heating networks'*.

1.82 **Policy EC P19** – It is a policy of the Council to *'support the development, reinforcement, renewal and expansion of the electricity transmission and distribution grid to provide for the future physical and economic development of Kildare'.*

1.83 **Objective EC O65 -** It is an objective of the Council to *'support the reinforcement and strengthening of the electricity transmission and distribution network, including the installation of Battery Energy Storage System plants.'*

1.84 **Policy EC P21** – It is a policy of the council to *'support the infrastructural renewal and development of the gas networks in the county, subject to proper planning, heritage, environmental and amenity requirements'.*

Local Authority Climate Action Plan 2024-2029 (2024)

1.85 The ambition of this Plan is aligned to the Government's National Climate Objective which seeks to achieve the transition to a climate resilient, biodiversity rich, environmentally sustainable and climate neutral economy by 2050. The Climate Action and Low Carbon Development (Amendment) Act 2021 frames Ireland's legally binding climate ambition to deliver a reduction in greenhouse gas emissions by 51% by 2030. To secure this sustainable future for the citizens of Kildare, the Council has prepared this Climate Action Plan for the period 2024 to 2029 to create a low carbon and climate resilient County, by delivering and promoting best practice in climate action in Kildare.

1.86 The Plan sets out how the Council is responsible for enhancing climate resilience, increasing energy efficiency and reducing GHG emissions across its own assets, services and infrastructure, whilst also demonstrating a broader leadership role of influencing advocating and facilitating other sectors to meet their climate targets.

1.87 The Plan identifies climate hazards that may negatively impact Kildare, including an evaluation of historic climate hazards (i.e. from extreme precipitation, drought, fluvial flooding, pluvial flooding, severe windstorms and above average surface temperatures).

1.88 Future climate risks were also considered to 2060. In summary the results predict increasing average temperatures leading to increased frequency of heatwave and reduced frequency of frost, snow and ice days. Average precipitation is predicted to decrease, however more intense rainfall events and potential flooding are anticipated to increase. Average wind speed and energy are predicted to decrease slightly.

1.89 The Plan also details a baseline emissions inventory for County Kildare, totalling 1,678,583 tCO_2e (2018). The sector that generated the greatest emissions were transport, comprising 38.2% of baseline emissions.

Naas Local Area Plan 2021-2027

1.90 The Naas Local Area Plan sets out an overall local strategy for the proper planning and sustainable development for the town of Naas.

1.91 **Objective EDO 1.12** – It is an objective of the Council to '*(a) Facilitate the location of Data Centre development on land designated P: Data Centre at Caragh Road South and Jigginstown for the identified land use only subject to appropriate environmental assessments, heat mapping, transport impact assessments and consideration of the cumulative impact on the electricity network supply capacity and targeted reductions in greenhouse gas emissions. (b) Any data centre project will be required to include measures to generate energy (sustainable, then renewable in the first instance) on site as part of the overall development proposal.'*

1.92 **Objective WH 1.1** – It is an objective of the Council to '*support developments which deliver energy efficiency and the recovery of energy that would otherwise be wasted through the use of district heating systems, particularly in the Northwest Quadrant and sites designated specifically for Data*

Centres, ensuring such developments will not negatively impact upon the surrounding landscape, environment, biodiversity or local amenities.'

1.93 **Objective WH 1.2** – It is an objective of the Council to *'ensure that all significant development proposals on the sites, designated for Data Centres carry out an Energy Analysis and explore the potential for the development of low carbon district heating networks.'*

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Appendix 16.2

Climate Change Risk

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HERBATA DATA CENTRE, NAAS

Environmental Statement: Appendix 16.2 - Climate Risk

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Contents

Tables

1 CLIMATE CHANGE RISK

1.1 Overview

1.1.1 This appendix to Chapter 16: Climate Change summarises potential changes in climatic parameters at the Project location and considers whether there is potential for likely significant environmental effects.

1.1.2 Besides climate risks to the Project itself, there are potential inter-relationships between climate change and several other environmental topic areas reported in other chapters of the EIAR, most notably flood risk. The climate projections summarised in this appendix have been provided to all ES chapter authors in order that any changes in the future baseline or sensitive receptors due to climate change can be evaluated if relevant to the respective impact assessments.

1.2 Climate Change Projections

1.2.1 Climate change projections have been established using the Climate Impact Explorer (CIE) (Climate Analytics, 2022). The CIE provides continental, national and subnational level projections of a range of climate impact indicators (such as increased maximum air temperature) to the end of the century under a series of global warming scenarios. The information is derived from an ensemble of climate and climate impact models that have been used in international model intercomparison initiatives. The aim of the tool is to show climate impact outcomes for different emissions scenarios, also providing the associated full uncertainty ranges across global warming levels.

1.2.2 The CIE draws data from two main sources, the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP) and CLIMADA. However, projections used in this assessment has utilised projections drawn from ISIMIP data, a description of which is given below:

- ISIMIP –a community-driven initiative with the aim of offering a consistent climate change impact modelling framework. By early 2021, more than 100 models had contributed to the initiative. The CIE makes use of data from ISIMIP phase 2b in their models. ISIMIP2b is available at a spatial resolution equivalent to 50km, hence the highest level of accuracy it can attain is the regional (provincial) level. The ISIMIP2b climate input data was obtained using four General Circulation Models (GCMs) from the fifth phase of the Coupled Model Intercomparison Project (CMIP5). They have been bias-adjusted, meaning that biases between the values simulated by each GCM and those from an observation-based reference dataset over a common period have been corrected. ISIMIP modelling has been utilised throughout Intergovernmental Panel on Climate Change (IPCC) reporting.

1.2.3 Climate projections used for this assessment focus on County Kildare, Ireland, and consider the Representative Concentration Pathway (RCP) 8.5 scenario[1], compared to a 1986-2006 baseline reference period. This is a conservative (worst-case) approach for the assessment.

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[1] The RCPs are greenhouse gas concentration scenarios that are commonly used in the climate modelling community. Produced within CMIP5, they were officially adopted by the IPCC and provide a low-high range in potential global GHG reduction initiatives and resulting rate of climatic effects over a given time period. They have been used as a basis for the projections and predictions of the Fifth Assessment Report of the IPCC. The RCPs are defined by the approximate level of radiative forcing (in W/m^2) by the end of the 21st century, relative to the pre-industrial level. The use of radiative forcing allows the calibration of different warming potentials of various greenhouse gases. The word “representative” signifies that each pathway is an archetype of several scenarios sharing similar radiative forcing and emission characteristics.

1.2.4 The Project is expected to have an initial 50 year design life. Climate change projections have been sourced in 5 year time slices from 2020-2080 to ensure full coverage of the Project's life, and are summarised within Table 1.1 to Table 1.7.

1.2.5 In summary, the data within the tables below show that temperatures are anticipated to increase across the year. There will be increased intensity in precipitation trends: precipitation is predicted to increase during the winter season and decrease during the summer season. Additionally, humidity is anticipated to increase. The tables below indicate that these trends will continue and amplify towards the end of the century.

1.2.6 Table 1.1 shows that under the median RCP8.5 scenario, annual maximum air temperatures in County Kildare are projected to steadily increase across the Project's lifetime.

Table 1-1: Maximum Air Temperature†(°C)

Year	2.5th percentile	Median	97.5th percentile
2020	0.23	0.59	1.08
2025	0.29	0.69	1.46
2030	0.38	0.91	1.65
2035	0.45	1.15	1.83
2040	0.63	1.35	2.04
2045	0.72	1.47	2.24
2050	0.89	1.57	2.57
2055	0.96	1.80	2.87
2060	1.03	1.92	3.47
2065	1.05	2.23	3.62
2070	1.13	2.40	4.05
2075	1.23	2.68	4.32
2080	1.27	3.04	4.32

† daily mean, maximum or minimum, as applicable, averaged over time period specified
n.b. 2.5th and 97.5th percentile and median values for scenario RCP8.5

1.2.7 Table 1.2 shows that under the median RCP8.5 scenario, annual minimum air temperatures in County Kildare are projected to steadily increase across the Project's lifetime.

Table 1-2: Minimum Air Temperature† (°C)

Year	2.5th percentile	Median	97.5th percentile
2020	0.17	0.45	1.15
2025	0.20	0.50	1.45
2030	0.24	0.68	1.59
2035	0.27	0.90	1.76
2040	0.40	1.06	1.86
2045	0.50	1.21	2.02
2050	0.64	1.31	2.33
2055	0.69	1.45	2.69
2060	0.79	1.58	3.12
2065	0.82	1.93	3.31
2070	0.86	2.15	3.63
2075	0.91	2.47	3.75
2080	0.95	2.75	3.75

† daily mean, maximum or minimum, as applicable, averaged over time period specified
n.b. 2.5th and 97.5th percentile and median values for scenario RCP8.5

1.2.8 Table 1.3 shows that under the median RCP8.5 scenario, annual mean air temperatures in County Kildare are projected to steadily increase across the Project's lifetime.

Table 1-3: Mean Air Temperature† (°C)

Year	2.5th percentile	Median	97.5th percentile
2020	0.25	0.52	1.21
2025	0.30	0.59	1.50
2030	0.35	0.78	1.63
2035	0.40	0.99	1.78
2040	0.53	1.15	1.94
2045	0.62	1.29	2.11
2050	0.76	1.39	2.41
2055	0.81	1.62	2.67
2060	0.90	1.75	3.06
2065	0.92	2.09	3.23
2070	0.99	2.26	3.60
2075	1.11	2.50	3.80
2080	1.14	2.76	3.80

† daily mean, maximum or minimum, as applicable, averaged over time period specified
n.b. 2.5th and 97.5th percentile and median values for scenario RCP8.5

1.2.9 Table 1.4 shows that under the median RCP8.5 scenario, annual precipitation change in County Kildare is projected to steadily increase across the Project's lifetime.

Table 1-4: Annual Precipitation Change† (%)

Year	2.5th percentile	Median	97.5th percentile
2020	-2.08	1.61	7.39
2025	-1.64	1.07	7.26
2030	-2.52	0.16	7.71
2035	-1.64	1.44	8.23
2040	-2.52	2.26	7.71
2045	-2.21	2.84	8.29
2050	-0.66	2.11	10.16
2055	-0.38	2.21	11.16
2060	0.17	2.71	10.83
2065	0.17	4.71	13.45
2070	-0.80	5.34	13.21
2075	-0.35	5.86	13.34
2080	-0.11	5.51	13.34

† daily mean, maximum or minimum, as applicable, averaged over time period specified
n.b. 2.5th and 97.5th percentile and median values for scenario RCP8.5

1.2.10 Table 1.5 shows that under the median RCP8.5 scenario, summer precipitation change in County Kildare is projected to steadily decrease across the Project's lifetime, leading to dryer summers.

Table 1-5: Summer Precipitation Change† (%)

Year	2.5th percentile	Median	97.5th percentile
2020	-6.98	2.45	36.68
2025	-11.61	1.31	35.47
2030	-13.11	1.52	33.89
2035	-13.58	-2.82	32.19
2040	-14.98	-4.31	31.28
2045	-17.21	-4.21	28.86
2050	-16.85	-5.22	23.43
2055	-18.13	-6.38	23.22
2060	-17.21	-8.35	22.20
2065	-17.41	-7.96	21.10
2070	-29.83	-7.63	19.02
2075	-26.16	-7.15	17.25
2080	-26.16	-4.31	16.15

† daily mean, maximum or minimum, as applicable, averaged over time period specified
n.b. 2.5th and 97.5th percentile and median values for scenario RCP8.5

1.2.11 Table 1.6 shows that under the median RCP8.5 scenario, winter precipitation change in County Kildare is projected to steadily increase across the Project's lifetime, leading to wetter winters.

Table 1-6: Winter Precipitation Change† (%)

Year	2.5th percentile	Median	97.5th percentile
2020	-2.61	3.92	14.29
2025	-1.82	3.34	15.96
2030	-3.19	2.34	17.83
2035	-1.82	5.79	17.59
2040	-3.19	7.73	18.25
2045	-1.81	8.24	21.26
2050	0.00	7.01	24.11
2055	1.46	9.79	27.57
2060	1.59	11.49	30.26
2065	0.77	14.46	24.11
2070	0.07	16.87	31.01
2075	2.22	18.57	28.24
2080	3.06	20.48	29.86

† daily mean, maximum or minimum, as applicable, averaged over time period specified
n.b. 2.5th and 97.5th percentile and median values for scenario RCP8.5

1.2.12 Table 1.7 shows that under the median RCP8.5 scenario, specific humidity in County Kildare is projected to steadily increase across the Project's lifetime.

Table 1-7: Specific Humidity† (%)

Year	2.5th percentile	Median	97.5th percentile
2020	1.66	3.14	7.12
2025	1.79	3.72	8.97
2030	2.01	5.08	10.14
2035	2.36	6.22	11.79

Year	2.5th percentile	Median	97.5th percentile
2040	3.26	7.39	13.54
2045	3.62	8.55	15.01
2050	4.27	9.56	17.95
2055	4.66	11.39	20.58
2060	5.37	12.25	23.86
2065	5.62	15.20	25.79
2070	6.24	16.60	28.01
2075	7.06	18.69	29.97
2080	7.29	20.39	29.97

† daily mean, maximum or minimum, as applicable, averaged over time period specified
n.b. 2.5th and 97.5th percentile and median values for scenario RCP8.5

1.2.13 No clear trend for change in wind speed during this time period is shown in the regional projections data, with trends leaning towards a decrease in wind speeds in the long term.

Limitations of the analysis

1.2.14 These results were obtained with established climate models, which nevertheless depict a simplified, hence imperfect representation of the evolution of the climate systems in response to natural and anthropogenic forcings. A limited number of climate model simulations were used to derive them; therefore short-term fluctuations can reflect the influence of natural climate variability rather than the response to anthropogenic climate change.

1.3 Climate Risk and Resilience Scoping

1.3.1 Based on the information available for the Project, a high level risk assessment has been undertaken, considering the hazard, potential severity of effect on the development and its users, probability of that effect, and level of influence the development design can have on the risk. The severity of effect score considers the potential consequences of the hazard and the sensitivity of the receptor(s) affected. Each element of the risk assessment has been scored on a scale of one to three, representing low, medium or high; the scores are then summed to give a total risk score. Table 1.8 defines each of these terms.

1.3.2 Given the variability in the nature of the potential effects of climate change on the development, receptors have been identified on a risk-specific basis, whereby all receptors relate to the continued safe and effective operation of the Project. In line with IEMA (2020) guidance, the vulnerability and susceptibility have been considered in determining the severity of risk.

1.3.3 A risk score of five or more has been defined as a risk that could lead to a significant effect of or on the development, prior to mitigation, as this is the minimum score where at least two elements of the risk assessment score are above 'low'.

1.3.4 By considering the good practice design measures incorporated into the Project, professional judgement is used in determining whether the potentially significant effects would result in significant adverse of beneficial effects.

Table 1-8: Severity, Probability and Influence Factor Definitions

Factor	Score definitions
Severity: the magnitude and likely consequences of the impact should it occur.	**1 =** unlikely or low impact: for example, low-cost and easily repaired property damage; small changes in occupiers' behaviour.
	2 = moderate impacts with greater disruption and/or costs
	3 = severe impact, e.g. risk to individual life or public health, widespread property damage or disruption to business
Probability: reflects both the range of possibility of climatic parameter changes illustrated in CP18 projections and the probability that the possible changes would cause the impact being considered	**1 =** unlikely or low probability of impact; impact would occur only at the extremes of possible change illustrated in projections
	2 = moderate probability of impact, plausible in the central range of possible change illustrated in projections
	3 = high probability of impact, likely even with the smaller changes illustrated as possible in the projections
Influence: the degree to which design of the Project can affect the severity or probability of impacts	**1 =** no or minimal potential to influence, outside control of developer, e.g. reliance on national measures or individuals' attitudes/actions; or hypothetical measures would be impracticable
	2 = moderate potential to influence, e.g. a mixture of design and user behaviour or local and national factors; measures may have higher costs or practicability challenges
	3 = strong potential to influence through measures that are within the control of the developer and straightforward to implement

1.3.5 Table 1-9 shows the climate change risks to the Project that have been identified and the risk scores assigned, following the approach set out in paragraph 1.17 and Table 1.8.

Table 1-9: Risk Scores for the Project

Risk ID	Risk	Severity	Probability	Influence	Total score	Potentially significant?	Embedded mitigation
1	Flooding of the site	Flood risk is assessed in Chapter 7: Water and Hydrology of the EIAR					
2	High temperatures resulting in overheating within buildings, leading to worker health impacts and reduced data centre performance as cooling equipment is overworked.	2	2	2	6	Yes	Passive design measures will minimise excessive solar gain, such as admin areas, housing office spaces and reception areas being north-west and north-east facing to minimise unwanted solar gains. Cooling will be designed to allow for further water storage adjacent to each building, to accommodate higher temperatures if required. Further, the roof of each building will be provided with a reflective finish to improve solar reflectivity.
3	Elevated temperatures may reduce the output capacity of gas-fired combustion turbines.	1	1	2	4	No	Electricity generation by gas turbines will be capable of exceeding the Project's demand, as such the Project should be resilient to decreases in generation capacity of the gas turbines.
4	Structural damage to buildings from extreme weather (storms or snow loads).	2	1	2	5	Yes	Building regulations for structural design with safety margin.
5	High winds leading to damage to cabling resulting in interruptions in power supply.	1	1	1	3	No	Network operators are required to manage and maintain their assets, this would include keeping overhead power lines clear of vegetation for public safety reasons.
6	Increased specific humidity leading to risk of damage to hardware which may in turn impact reliability and life expectancy.	1	1	2	4	No	Air handling units will ensure appropriate recirculation to ensure appropriate humidity within the data centre buildings is maintained.
7	Consistently decreased precipitation resulting in increased occurrence of drought and reduced accessibility to water for water-based cooling method.	1	1	1	3	No	Rainwater harvesting tanks will be installed per data centre to avoid reliance on Irish Water to supply water for mechanical cooling plant. Further, additional water storage could be installed if appropriate, to ensure increased

							resilience to drought and reduced water availability.
8	Ground subsidence as a result of shrinking and swelling of soils due to excessive rainfall and drought may result in damage to cables or gas infrastructure pipework.	1	1	2	4	No	
9	Structural damage to buildings resulting from subsidence caused by drought (shrinking and swelling of soils due to excessive rainfall and drought)	2	1	1	4	No	

1.3.6 The Government of Ireland Sectoral Adaptation Plans (Government of Ireland, 2020) and the Environmental Protection Agency's (EPA) Climate Change Assessment (EPA, 2023) concluded that future risks to the built environment, electricity and gas networks and communications assets are likely to arise from flooding, extreme weather events (in particular high wind speeds) and heightened temperatures. This could result in damage to assets, power failures, asset lifetime, equipment ratings and reduced output of gas-fired combustion turbines. Risks to sub-surface infrastructure, such as the gas transmission network and underground figure cabling, include increased incidence of subsidence and extreme flood events. Overhead copper and fibre lines suspended on poles are the most exposed section of the electronic communications network and as such they are most at risk from extreme storm events and high winds. Overhead cables are also vulnerable to snow, rainfall or even a prolonged growing season, increasing the threat to cables from calling or growing trees. Additionally, extreme weather events may inhibit access to remote infrastructure, delaying possible maintenance or repair work. These risks have the potential to result in cascading failures from the energy and communications sector into other sectors.

1.3.7 The above risks highlighted within the Government of Ireland Sectoral Adaptation Plans (Government of Ireland, 2020) and the Environmental Protection Agency's (EPA) Climate Change Assessment (EPA, 2023) are accounted for within Table 1-9, alongside embedded mitigation measures included within the design of the Project.

1.3.8 The most significant risk from climate change to the Project arises from flooding. This is assessed in Chapter 7: Water and Hydrology and appropriate flood management and resilience measures have been provided.

1.3.9 With the exception of flood risk, the greatest risks to the Project due to climate change have been identified as those arising from extreme weather events resulting in and heightened temperatures impacting performance and potentially damage to structures.

1.3.10 The risks to infrastructure networks such as overhead cable networks are managed by network operators, who have a statutory requirement to keep overhead powerlines clear of vegetation that may increase risk during storms.

1.3.11 Overall, it is considered that the potentially significant risks screened in Table 1.9 do not represent new or unexpected issues, with historic extreme precipitation, drought, fluvial and pluvial flooding, severe windstorm and above average surface temperature events recorded within Kildare historically (Kildare Climate Action Office, 2024). Best practice for the safe operation of electricity generation facilities would mitigate against the likelihood of significant adverse effects thereby reducing the effect to negligible.

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Appendix 16.3

Green House Gas Calculations

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HERBATA DATA CENTRE, NAAS

EIAR: Appendix 16.3 - GHG Calculations

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1 GHG CALCULATIONS

1.1.1 This appendix includes further technical detail regarding the methodology and calculations outlined within Chapter 16: Climate Change. For ease of understanding, the headings used within this appendix follow those used within the EIAR chapter.

1.2 Characteristics of the Project

1.2.1 The overall development comprises two main elements:

- The Data Centre Application – comprising 6 no. two storey data centre buildings, an administration/management building, car parking, landscaping, energy infrastructure and other associated works. These elements are the subject of the planning application submitted to Kildare County Council (KCC).
- The Substation Application – comprising a grid substation and 110 kV transmission connection. These elements are subject of the Strategic Infrastructure Development (SID) application to An Bord Pleanála.

1.2.2 The Data Centre Application and the Substation Application together constitute the “Project” for the purposes of this assessment.

1.2.3 The characteristics of the Project of relevance to the GHG calculations are detailed below.

Buildings

1.2.4 The Project comprises the following buildings:

- 6 no. Data Centre Buildings, each with a total internal area and height as follows:
  - Total gross internal area (GIA) – 27,261 m^2
  - Height to parapet – 18 m
  - Height to flue – 19 m
- Admin workshop and Water Treatment Plant (WTP) GIA – 818.9 m^2;
- Site security hut GIA – 42.1 m^2;
- District Heating (DH) building GIA - 340.5 m^2;
- Total of 210 no. car parking spaces comprising of 63 electric car charging spaces and 14 no. disabled car parking spaces;
- Total number of 52 no. bicycle spaces (8 per Data Centre building and 4 for the administration workshop);
- Demolition of 5 no. agricultural buildings to the centre of the site; and
- Demolition of 3 no. dwellings along the northern boundary of the site, fronting onto R409 road.

1.2.5 Whilst subject to internal layout requirements of end users, each Data Centre building will consist of the main data hall block with an external plant gantry and an enclosed yard to the rear encompassing the building energy infrastructure. The front of each Data Centre building will comprise of end-user client administration/office areas, plus storage areas and the loading/receiving docks.

1.2.6 The buildings will be steel-framed with insulated metal faced cladding panels to the façade. The rear external yard will also be also enclosed with a metal louvre system to align with the main building form and the building entrance area will have large, glazed windows.

1.2.7 The following measures are committed to within the design of the buildings:

- The design team will seek to source goods, services, or works with a reduced environmental impact throughout their lifecycle. In this regard, tender requests will set out the policies and targets as set in the Resource and Waste Management Plan (RWMP) (HDR, 2023) which must be achieved. Tenders will be assessed and include scoring for proposals demonstrating how compliance will be achieved with the policies and targets of the RWMP (e.g. proposals for use of recycled materials rather than virgin materials, identification of resource efficient options, collaboration with supply chains).
- Materials will aim to reflect local sustainable manufacturing sources and support low carbon green initiatives:
  - All timber and wood-based products will be responsibly sourced (e.g. FSC or PEFC);
  - Insulation materials and building services will be specified with low embodied environmental impact;
  - Locally sourced construction materials will be preferentially used, with priority to the use of prefabricated elements where possible to reduce construction-phase transport emissions;
  - Specification of recycled and reused materials will be a main design consideration where feasible;
  - The buildings will be 'designed for robustness' to ensure that damage to the building due to wear and tear, for example in areas of heavy usage, are minimised and can be repaired with minimal environmental or cost impact;
  - Construction of components off-site and use of pre-fabricated elements where feasible;
  - Concrete for certain types of foundations and preparatory foundations works can be specified with recycled aggregates where feasible; and
  - Where available, reinforcement for concrete is to be specified with 95% recycled content. Similarly, steelwork will be specified with a 95% recycled content where available.
- Energy efficiency measures to reduce energy demand, in line with national data centre guidance and policy requirements:
  - The data halls will be primarily cooled using external air, utilising Ireland's cooler climate. Further cooling required i.e. during higher summer temperatures, will be provided through adiabatic cooling systems;
  - Heat pumps to be installed to serve the data centres' office areas;
  - Admin areas housing office spaces and reception areas to face north-west and north-east to minimise solar gains and reduce cooling demand within such areas;
  - Fabric performance of the buildings to be maximised to reduce the space heating loads in winter and cooling loads in the summer; and
  - Highly efficient LED lighting to be specified to all data halls and office areas. Lighting to all other areas of the buildings to be highly efficient and incorporate occupancy sensors where applicable.
- 30% of the total energy demand will be met by renewable sources, in line with local policy requirements. This will comprise:
  - Solar photovoltaic (PV) arrays located on the roof of each of the six Data Centre buildings; and
  - Corporate Power Purchase Agreements (CPPA) will be used to procure renewable energy from wind / solar farms. In addition to providing energy for the Project, CPPAs will

fund the construction of wind and solar farms. The Applicant has had discussions with various solar and wind renewable energy suppliers with a view to supplying energy through CPPAs, identifying sufficient capacity available from suppliers to meet the 30% operational renewable energy target. CPPAs will be finalised following a grant of permission, along with a connection agreement with Eirgrid, and will be entered into prior to operational requirements. The process and technical aspects of CPPAs are considered fully in Volume II, Appendix 1.3.

Gas Turbines

1.2.8 Mains (Gas Networks Ireland [GNI]) connected, on-site natural gas turbines are the proposed primary energy source for the Project. Generation of electricity is proposed using gas turbines, located within a dedicated, adjoined plant area, to the rear of each Data Centre building. Each Data Centre building will comprise of 8 no. turbines.

Battery Energy Storage Systems

1.2.9 For the purpose of providing uninterrupted and conditioned power, each Data Centre building will have a dedicated battery energy storage system (BESS) located within the adjoined plant area, to the rear of each Data Centre building. The BESS will consist of rack mounted lithium iron phosphate battery modules.

1.2.10 The storage capacity provides a back-up energy source and in addition adds resilience to the wider network, having the capacity to provide immediate export of energy to the national grid, or the capacity to store excess electricity generated externally, if required.

Substation

1.2.11 A 110 kV GIS is proposed to be located to the north west corner of the subject site and will provide the grid connection on site. The provision of the substation and grid connection will enable the export of energy generated onsite to the wider network. The substation will also enable the energy storage facility to be connected to the national grid and add greater capacity and resilience to the national electric energy generation capacity and the national electric grid.

1.3 Construction Effects

1.3.1 The manufacturing of associated materials and construction of the Project would result in both direct and indirect GHG emissions.

1.3.2 The majority of the construction-stage impacts are ‘Scope 3’ (supply chain) emissions resulting from the extraction of raw materials and manufacturing of construction materials, alongside the emissions associated with their transportation to site.

1.3.3 The following sections detail the methodology undertaken to calculate GHG emissions associated with the Project, accounting for the Project elements as described within section 1.2.

Data centre buildings

1.3.4 At this stage in the design of the Project, material estimates have some uncertainty in terms of their quantities. As such, published benchmarks (RICS, 2012) have been used to inform the calculation of embodied carbon associated with the building structures, excluding the server fit out (addressed within paragraphs 1.3.25 to 1.3.28). The benchmark data is expressed in $kgCO_2e/m^2$ of floorspace as an intensity, which has then been scaled by the total applicable floor area for each building.

1.3.5 No benchmark data is yet available specifically for data centre buildings. As such, appropriate alternative building types have been selected and scaled by the relevant floor areas for each area of the data centre buildings (i.e. admin areas, data halls, and external plant yard). Table 1-1 lists each benchmark used, and the floor area by which it has been scaled.

Table 1-1: Data centre building embodied carbon

Data centre area use	Benchmark building type	Embodied carbon intensity ($kgCO_2e/m^2$)	Floor area per data centre (m^2)
Data halls	Other industrial/utilities/specialist uses	545	24,756
Admin area	Low rise offices (1-4 storey building)	925	2,505
External plant yard	Utilities compound	395	6,164

1.3.6 Total embodied carbon associated with all data centre buildings was calculated to total 109,464 tCO_2e.

Admin workshop and water treatment building, site security building, and district heating building

1.3.7 At this stage of design, material estimates have some uncertainty in terms of their quantities and specific products to be used in the final design. As such, a published benchmarks (RICS, 2012) have also been used to estimate possible emissions from the admin workshop and water treatment plant building, site security hut, and district heating building.

1.3.8 Table 1-2 lists each benchmark used, and the floor area by which it has been scaled.

Table 1-2: Admin workshop and water treatment building, site security building, and district heating building embodied carbon

Building	Benchmark building type	Embodied carbon intensity ($kgCO_2e/m^2$)	Floor area (m^2)
Admin workshop and water treatment building	Low rise offices (1-4 storey building)	925	819
Site security hut	Low rise offices (1-4 storey building)	925	42
District heating building	Other industrial/utilities/specialist uses	545	341

1.3.9 Total embodied carbon associated with all buildings was calculated to total 982 tCO_2e.

Gas turbines

1.3.10 There is limited design data and few published LCAs from which to calculate the embodied emissions associated with the gas turbines and associated plant. Data from an environmental product declaration (EPD) for a 5,125 kVA generator (ABB, n.d.) has therefore been used to provide an approximation of the potential order of magnitude of emissions.

1.3.11 The EPD listed a manufacturing GWP of 23.20 $kgCO_2e$ per kVA, which was scaled by the Project's maximum electricity demand of 240 MW to give an estimated embodied emission value of 5,568 tCO_2e.

1.3.12 The turbines are likely to be refurbished every two years. However, given this will not result in the installation of new turbines, just the repair and servicing of the existing turbines, resultant emissions are likely to be immaterial and as such have not been considered further. Additionally, given national decarbonisation requirements, it is likely that any repair work is likely to decarbonise over the Project's lifetime.

BESS

1.3.13 Owing to their charge capability, energy density, round-trip efficiency and falling costs, lithium-ion batteries (LIB) are the most commonly employed battery technology for stationary applications. At this stage in the Project's design, batteries with lithium iron phosphate (LFP) cathode material have been specified. It is the carbon intensity of these materials – and the carbon intensity of the associated manufacturing processes – that have been considered in this assessment.

1.3.14 There are several carbon-intensive processes that take place in the manufacturing of a lithium iron phosphate batteries, that make up the majority of their associated embodied carbon emissions. These processes are as follows.

- The mining and refining of raw materials: the energy intensity varies greatly depending on the type of mine and type of ore being mined.
- Electrode manufacturing, especially the evaporation of solvent used when coating the electrode. Such evaporating process is energy intensive because of the air flow needed to maintain a safe concentration of flammable solvent (Porzio and Scown, 2021).
- Anode production: anodes are composed of graphite and a polyvinylidene difluoride binder; to ensure the absence of any oxygen impurity in the graphite, it is baked at 1100 °C in an inert or reducing atmosphere (Accardo et. al., 2021).
- Dry room: because moisture is detrimental to the electrochemical performance of LIBs, the cell assembly process needs to occur in a dry room with strictly controlled humidity levels. Dry room operation has been identified as a predominant driver of energy use for cell production (Dai et al, 2019).
- Production of non-cell materials: this involves the production of cell containers, separator, battery management system (BMS), cooling system, and final packaging.

1.3.15 The carbon intensity of the production of LFP LIBs used for the purposes of this assessment has been informed by a range of LCAs reported within selected literature. Such findings are summarised within Table 1-3, below. This GHG values account for the emissions associated with the upstream supply of raw materials, battery cell production and battery pack assembly.

Table 1-3: Summary of literature research findings.

Reference	GHG emission (kgCO_2e/kWh)
Hao et al. 2017	109.3
Yudhistira, 2021	169
Pell and Lindsay, 2022	52.0 to 106.7 (reported range when applying uncertainty analysis)
Landi et al. 2022	556.9

1.3.16 Studies by Hao et al. (2017) and Pell and Lindsay (2022) consider batteries for use in electric vehicles, while Yudhistira (2021) and Landi et al. (2022) consider batteries for use in grid electricity storage applications. The latter appears to result in greater emissions than the results associated with electric vehicle (EV) batteries. However, the disparity between values reported for batteries used in grid electricity storage applications are significant, with those reported by Landi et al. (2022) 230% greater than those reported by Yudhistira (2021) and not within the bounds of emissions intensities reported for use in EVs. As such, the use of GHG emissions intensities reported by Landi et al. (2022) have not been used to inform the assessment of embodied carbon associated with the proposed BESS.

1.3.17 A further study analysing the most up-to-date published data regarding the energy use associated with the production of LIBs, using published heat and electricity consumption data for the various processes involved in LIB manufacturing, has also been used to contextualise the above emissions intensities (Emilsson and Dahllöf, 2019). While this study focuses on nickel manganese cobalt oxide (NMC) LIB, it has been reported that the magnitude of emissions associated with the production of NMC LIB and LFP LIB are comparable (Hao et al. 2017).

1.3.18 In order to account for potential uncertainty in estimating NMC LIB production GHG emissions due to the variability of emissions intensities associated with the energy supply mix (both electricity and heat), a range of GHG intensities have been used. When also accounting for further emissions of 59 $kgCO_2e/kWh$ battery capacity owing the sourcing of upstream materials (taken from Dai et al, 2019), a range of 61 – 106 $kgCO_2e/kWh$ battery capacity can be stated.

1.3.19 This range of calculated intensities aligns with those given in Table 1-3, and provides some additional confidence in the values used.

1.3.20 The proposed BESS capacity will match the load of the data centres to provide backup electricity supply with a duration of between 4 and 20 minutes (decreased duration with battery age). To provide a conservative estimate, the total output capacity of 240 MW was scaled by 20 minutes (or 0.33 hours) to give total storage capacity of 79.2 MWh.

1.3.21 The lifetime of the battery packs is dependent on the average depth of discharge (DoD); while in reality this may vary depending on the state of the electricity market at any given moment, the current assumed average DoD for the Project is 80%. Based on published literature values, a DoD of 80% would result in an expected lifetime of 5,000 cycles (IEA, 2020b). Therefore, over the forecasted 50 year assessment period and assuming one full cycle per day, the battery packs would have to be replaced circa four times. This has been accounted for in the embodied carbon values in summarised below. To be conservative, present-day values are used for the carbon intensity of battery pack production even for future replacements.

1.3.22 Accounting for the range of carbon intensities reported within the literature, GHG emission intensities from 52.0 $kgCO_2e/kWh$ to 169 $kgCO_2e/kWh$ were scaled by the storage capacity of the proposed BESS (59.4 MWh) and replacement rate over the lifetime of the Project. This gives a range of 16,474 tCO_2e to 53,539 tCO_2e. The greater value has been assessed in order to provide a more conservative worst-case approach.

Substation (including transformers, busbars and other equipment)

1.3.23 There is limited design data and few published LCAs from which to calculate the embodied emissions associated with the substation, busbars and BoS components, alongside housing structures for the BESS. Data from an EPD for a 16 kVA – 1000 MVA transformer (ABB, 2003) has therefore been used to provide an approximation of the potential order of magnitude of emissions, as transformers are among the major substation plant components and have a relatively high materials and carbon intensity, including the copper or aluminium winding.

1.3.24 The LCA listed a manufacturing GWP of 2,190 $kgCO_2e$ per MVA. This was scaled by the Project's proposed transformer rating (150 MVA) and the maximum number of transformers (4 no.) to give an estimated embodied emission value of 1,314 tCO_2e. This value includes lifecycle stages A1-A3.

Server fit out

1.3.25 The impact of embodied carbon associated with the servers has been estimated using product LCAs for servers appropriate for data centre use. Given the specific servers to be installed within the proposed data centres will be subject to tenant specification, not yet known at this stage in the project design, a range of 1U and 2U servers were considered with power ratings (at 100% load) between 244.2 W and 449.8 W. Associated embodied carbon intensity values reported are between 1,370 $kgCO_2e$ per unit, and 1,770 $kgCO_2e$ per unit (Sphera, 2021).

1.3.26 The total number of servers to be installed across the 6 no. proposed data centres was estimated by scaling each individual server power rating by the total proposed IT load associated with the data centres (180 MW), resulting in an estimated total number of servers of between 400,178 and 737,101.

1.3.27 The lifetime of each server unit was taken into account within the calculations and was assumed to be 4 years as specified by the product LCA. As such, when scaled by the Project's 50 year lifetime, a replacement rate of 13 was estimated. This replacement rate was scaled by the total server number to estimate the number of servers required over the Project's lifetime. This total lifetime server number was then scaled by each embodied carbon factor as appropriate to give an estimate of total embodied carbon. The above is summarised within Table 1-4, below.

Table 1-4: Server embodied carbon.

Server Type	Power rating (at 100% load)	No. units required	Replacement Rate	GWP ($kgCO_2e$ per unit)	Lifetime embodied carbon
1U	244.2	737,101	13	1,375	13,177,597
2U	281.5	639,432	13	1,370	11,385,790
1U	449.8	400,178	13	1,770	9,209,656
2U	389	462,725	13	1,768	10,637,678

1.3.28 Given the specific server type is not currently known, the assessment of embodied carbon has been informed by the greatest estimate of embodied carbon associated with the servers, in order to present the most conservative, worst-case scenario.

Construction transport emissions

1.3.29 Emissions associated with HGV movements and personnel vehicle movements during the construction of the Project have been estimated.

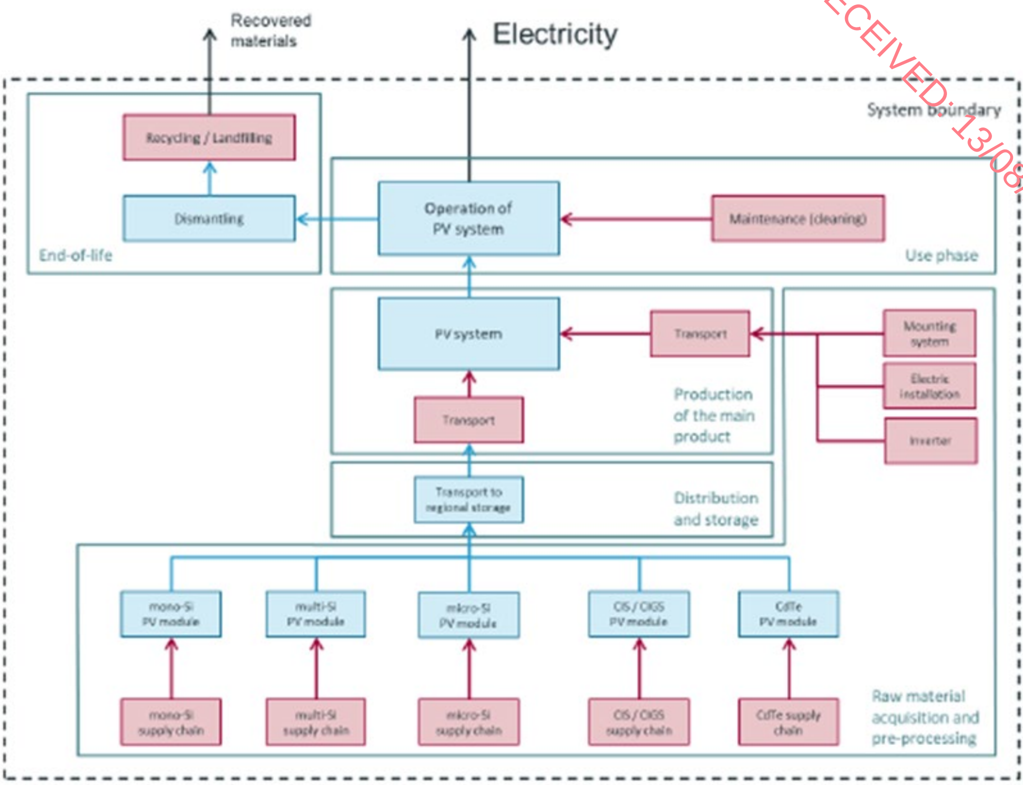
1.3.30 An average of 425 construction staff trips per day, and 47 HGV trips per day (a conservative estimate given this is the likely peak number of trips) were scaled by the number of construction days over the 8 year and 8 month construction period, assumed average distance of travel (50 km, to account for local construction staff and local material sourcing, in addition to internationally procured products which may be delivered by HGV from Dublin Port), and emissions factor for fully laden diesel HGVs (0.98496 $kgCO_2e$/km) and medium petrol car (0.17819 kgCO2e/km) (DESNZ, 2023).

1.3.31 Total emissions associated with construction stage transport movements totals 33,312 tCO_2e.

Solar PV

1.3.32 The quantification of the emissions resulting from these activities requires a GHG Lifecycle Assessment (LCA). Figure 1-1 below displays the system boundaries considered in a typical GHG LCA for a PV development of this nature.

Figure 1-1: System boundaries for a solar PV development (IEA, 2020a)



1.3.33 Currently, 95% of total global PV production is accounted for by crystalline silicon (c-Si) panel technology (84% of which is accounted for by mono-crystalline (mono c-Si) and 16% by multi-crystalline (multi c-Si)) (ISE, 2023).

1.3.34 Emerging technologies for high efficiency c-Si panel types such as passivated emitter and rear contact (PERC), heterojunction (HJT), and interdigitated back contact (IBC) technology, so-called 'third generation' technologies, are becoming more readily available on the market, with PERC designs now the dominant PV technology (IEA, 2022). LCA information on these technologies is beginning to become available (reviewed in Muteri and Curto, 2020), with some evidence to suggest that there are reductions in GHG emissions during the manufacturing process, but the authors of the review highlighted that many construction and end-of-life aspects of third-generation technologies are yet to be evaluated. This limits the conclusions that can be drawn from any attempted LCA for these technologies, and this assessment has therefore considered only established first generation c-Si panel technologies in the assessment of GHG effects, likely to be conservative estimates of the true GHG effect of PV systems manufactured in the present day.

1.3.35 The key GHG emitting process involved in the manufacturing of c-Si panels and associated BoS components are as follows:

- The extraction of quartz, from which metallurgical-grade silicon is extracted. This silicon is then further purified into solar-grade silicon, typically via the energy intensive Siemens reactor method.
- The forming of silicon ingots: an electricity-intensive process requiring 32 kWh per kg of mono-Si ingot (via the Czochralski process), or 7 kWh per kg of multi-Si ingot (IEA, 2020a).
- The extraction of raw materials for and manufacturing of BoS components, e.g. silica for glass, copper ore for cables, iron and zinc ore extraction and refinement for mounting structures and bauxite extraction and refinement for module framing (c-Si modules require circa 2.1 kg of aluminium per m^2 of module) (IEA, 2015).

1.3.36 The emissions resulting from the processes described above, as well as the emissions occurring due to the transportation of materials to site and onsite emissions occurring during the assembly of the Project, account for circa 70% of total lifecycle GHG emissions (not including the avoided emissions resulting from the displacement of more carbon intensive electricity generation) (NREL, 2012).

1.3.37 Solar PV LCAs are a complex process, given the large number of materials and processes involved in the production of PV modules and BoS components. Furthermore, the associated GHG emissions are dependent on the location (and associated energy mix) of where these processes are occurring. As such – and in the absence of greater detail regarding panel types and manufacturer specifications etc – a detailed LCA is beyond the scope of this assessment. Instead, a robust approach has been formulated by considering meta analyses of published solar PV LCAs, thereby accounting for the likely range of magnitude of the Project's construction-stage GHG emissions.

Emissions factors and data sources

1.3.38 The current literature surrounding PV system LCAs is characterised by a high degree of variability in its published GHG figures, and therefore a degree of uncertainty occurs in selecting any one of these figures as a means of analysing the embodied GHGs in constructing a solar array. As a means of dealing with this uncertainty, the primary source of emissions factors used in assessing the embodied carbon effects of the Project was NREL's (2012) 'Life Cycle Greenhouse Gas Emissions of Crystalline Silicon Photovoltaic Electricity Generation'. The study constituted a meta-analysis of over 397 LCAs regarding C-SI PV systems, all of which were subject to a screening process, and for those which passed the screening process, a subsequent harmonisation process. Using the NREL study as a means of acquiring GHG factors for construction-stage[1] GHG emissions partially eliminated the large degree of variability and uncertainty in the published literature surrounding PV LCAs, and ensured the range of construction-stage GHG emissions stated in this chapter represent the most realistic and accurate effects.

1.3.39 The screening process removed the majority of the considered studies, so that the meta-analyses considered in detail only 13 studies (containing a total of 42 lifecycle GHG factors). The screening process ensured that minimum standards for the following criteria were met:

- Quality: the study used an accepted LCA methodology (e.g. ISO 14040 (ISO, 2006));
- Transparency: the study described its methods, sources and values of input data; and
- Relevance: relevant, up-to-date technology was analysed.

1.3.40 As well as the lifecycle GHG implications of PV systems being sensitive to the energy input/mix required for their manufacturing and production, they are also sensitive to other input parameters including module efficiency, solar insolation, system lifetime and performance ratio[2] (Pacca et al, 2007). As a means of accounting for potential variability due to these factors, the LCA studies in NREL's meta study were subject to a harmonisation process. The process involved correcting the considered LCA results following the normalisation of the aforementioned input parameters. Table 1-5 states the input parameters used in the harmonisation process and subsequent generation of improved lifecycle GHG factors for PV systems.

[1] Construction-stage – in this sense – also refers to the emissions associated with maintenance and any EoL treatment-related emissions. It excluded the GHG implication of exporting low carbon power onto the grid.

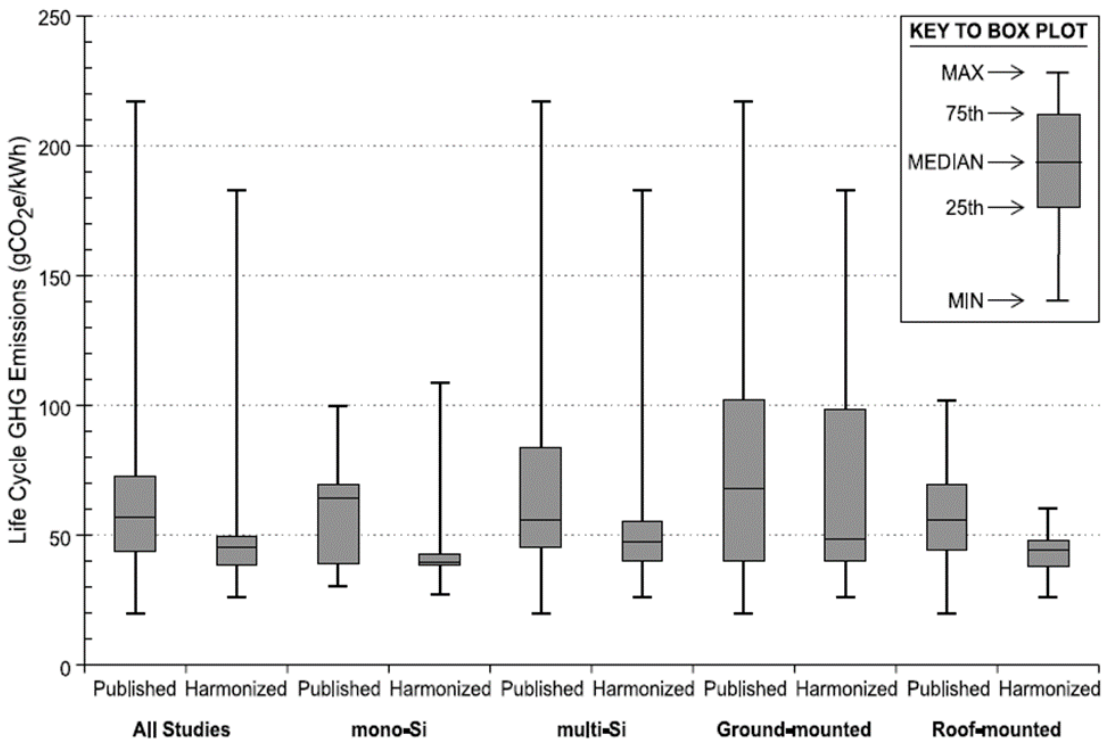
[2] Performance ratio refers to the difference in potential energy output (for a given module efficiency and annual solar insolation value), and actual energy output. The performance ratio is determined by BoS efficiency losses (namely inverter and cabling losses), cell mismatch, elevated PV module temperature, reflection from the module front surface, soiling, shading, and component failures.

Table 1-5: NREL harmonised input parameters

Solar insolation (kWh/m²/yr)	System lifetime (years)	c-Si module efficiency (%)		Performance ratio	
		Mono	Multi	Ground-Mounted	Rooftop
1,700	30	14	13.2	0.8	0.75

1.3.41 Based on the input parameters in Table 1-5, the NREL study generated a range of harmonised GHG impacts. These are displayed in Figure 1-2.

Figure 1-2: NREL lifecycle GHG emissions factors (NREL, 2012)



1.3.42 Based on Figure 1-2, it was decided that the range of emissions factors that would most closely represent the possible range of construction-stage GHG emissions for both possible technology types for the Project would be the lower quartile range (LQR) and upper quartile range (UQR) values for all LCAs considered in the meta-analysis. These have represented the upper and lower limits of the range presented in this assessment. Therefore, the initial range of values being considered were 39 to 49 gCO_2e/kWh (with a median value of 44 gCO_2e/kWh).

1.3.43 The lifetime GHG emissions factor – when expressed in terms of the system's lifetime energy output (i.e in terms of kWh) – is sensitive to the annual insolation value used in the calculation. The harmonized insolation value of 1,700 kWh/m²/yr used in the NREL study is representative of the meteorological conditions of southern Europe.

1.3.44 The IEA's 'Life Cycle Inventories and Life Cycle Assessments of Photovoltaic Systems' report (IEA, 2020a) contains country specific annual average solar energy yields, whereby average annual energy outputs from PV systems in various countries are expressed in terms of the peak capacity of the system. An average annual energy yield (in terms of annual kWh/kW_p[3]) for a solar array in southern Europe was obtained by averaging the same values for Spain, Portugal, Italy and Greece. This value was then used to factor out the annual energy output for the lifetime GHG

[3] 'W_p' refers to the nominal power of a solar array, i.e. its peak generation capacity.

emissions factor, so that the emissions factor could be expressed in terms of gCO_2e/MW (i.e. in terms of installed capacity rather than lifetime energy generation), and therefore representative of the likely range of construction-stage GHG effects of the Ireland-based Project. The lifetime GHG factors, expressed as gCO_2e/MW could then be multiplied by the 3.72 MW generating capacity of the PV to be installed at the Project (120 kWp per data centre to support the admin areas, 500 kWp per data centre to support remaining demand) in order to calculate the construction-stage GHG impacts in tCO_2e. Table 1-6 display these construction-stage GHG intensities and impacts of the Project, as well as the possible upper and lower limits.

Table 1-6: Construction stage GHG emissions factors and impacts of solar array

	Lower limit	Median	Upper limit
Literature Lifecycle GHG intensity (gCO_2e/kWh)	39	44	49
Literature Average annual energy yield[4] (kWh/kW_p)	1,419	1,419	1,419
Literature Operating lifetime (yrs)	30	30	30
Literature Total GHG (gCO_2e/kW_p)	1,659,645	1,914,975	2,085,198
Literature Total GHG (tCO_2e/MW_p)	1,660	1,915	2,085
Development annual energy yield (MW_p)	3.72	3.72	3.72
Total Development GHG (tCO_2e)	**6,174**	**7,124**	**7,757**

1.3.45 A potential limitation of this assessment is the age of the meta-analysis study that has used to inform the potential construction-stage GHG emissions. So as to provide further confidence in the results expressed in Table 1-6, a recent study by Milousi et al (2019) was also considered. This study calculated the lifecycle GHG implications of 3 kW PV systems of varying panel technology in Crete, which were therefore under similar irradiance conditions to the harmonized irradiance value expressed in the NREL study. The Milousi et al (2019) study concluded that mono-Si systems have a lifecycle GHG impact of 52.4 gCO_2e/kWh, whilst multi-Si systems have a lifecycle GHG impact of 44.3 gCO_2e/kWh. These results provide further confidence that the results expressed in Table 1-6 are in the correct order of magnitude.

1.4 Operational Effects

1.4.1 The use of the Project post-completion would result in indirect GHG emissions due to the use of electricity (sourced from natural gas) within the buildings. The operational energy demand has been split into regulated and unregulated energy.

1.4.2 Regulated energy consumption results from the specification of controlled fixed building services and fittings, such as space heating and cooling, hot water, ventilation, and lighting. It is these regulated loads that are able to be reduced through embedded design measures.

1.4.3 Unregulated energy consumption is associated with systems or processes that are not controlled and do not have regulations imposed on them. Unregulated energy consumption within the Project is largely resultant from the data hall demand, where any energy efficiency and carbon reduction measures will be within the control of the tenant.

1.4.4 The methodology undertaken to calculate emissions associated with each is detailed below.

Energy Sources

1.4.5 The energy demand associated with the Project is to be met by the onsite generation of electricity using gas turbines. This strategy is in line with recent EU and Irish Government direction on the use of gas for generation as a transition fuel, with gas being sourced from the Gas Networks

[4] For a solar array in southern Europe

Ireland (GNI) gas network. As such, all operational emissions associated with electricity consumption at the Project have been calculated by scaling relevant energy demands, by the SEAI current natural gas emissions factor of 204 gCO_2e/kWh.

1.4.6 The resultant calculated lifetime emissions are conservative, as they do not account for the planned decarbonisation of the gas network by GNI by 2050. Adoption of such a gas supply will greatly reduce the operational emissions associated with the power generated on site.

1.4.7 The following measures have been proposed by GNI to enable decarbonisation of gas networks:

- Introduction of bio-methane from agricultural sources;
- Introduction of hydrogen in lieu of methane by up to 20% by volume. This will gradually increase over time; and
- Use of carbon capture and storage to reduce carbon emissions. Although this technique is unlikely to be applied directly to this site, it will allow GNI to capture the CO_2 produced by power generation.

1.4.8 Further, to support Net Zero strategy, the Applicant will be a strong supporter of Biomethane production from offsite Anaerobic Digestion (AD) facilities. GNI forecasts in biomethane production show significant growth in AD facilities forecasted between now and 2030. These fuels will likely provide the renewable form of feedstock for operating onsite generation. Additional information with regards to the Project's energy supply strategy is provided within Volume II, Appendix 1.3.

Regulated Energy Consumption

1.4.9 Emissions associated with the regulated energy consumption have been informed by consumption figures reported within the Energy Efficiency and Climate Change Adaptation Design Statement (HDR, 2024) prepared in support of this application. This Statement reports energy intensities for energy consumption associated with the offices, reception, WC, circulation areas, and security rooms. The energy consumption associated with the heating, ventilation and air conditioning (HVAC) used to condition the data storage halls and switchroom areas, and the server energy demand, were not taken into account.

1.4.10 Operational energy reductions have been embedded within the building design through the integration of energy efficiency measures (as detailed within paragraph 1.2.7). The statement details a reduction of 22% from 96.1 kWh/m^2 per annum to 75.1 kWh/m^2 per annum. When the as built energy intensity (75.1 kWh/m^2 per annum) is scaled by the total GIA for the Project, an annual energy consumption of 12,374,039 kWh per annum is estimated. This offers an annual reduction of 3,460,118 kWh due to the embedded efficient design.

Solar PV

1.4.11 The annual energy output of the proposed solar PV array has been calculated assuming a load factor of 10.77%, as calculated from the Digest of UK Energy Statistics (DUKES) 6.3 data set, using the average load factors for solar PV generation from 2011/12 to 2020/21 (BEIS, 2022). The annual load factor of solar PV associated with the admin areas relates to the total number of hours at which the array is generating electricity at its rated capacity (i.e. 120 kW per data centre, total of 720 kW) over the total number of hours in a year. A PV array's load factor is determined by irradiance conditions, performance ratio and orientation and tilt of the panels. Total annual energy output from the proposed solar PV array has been estimated at 679 MWh in the first year of operation. A degradation factor of 0.7% (IEA, 2021) has been applied to all subsequent years, with the lifetime energy output from the solar PV array totalling 28,741 MWh.

1.4.12 It has been assumed that electricity generated by the solar PV array displaces electricity that would otherwise have been generated by the onsite gas generators. As such, avoided emissions have been calculated by scaling the electricity generated by the solar PV by the current natural gas emissions intensity factor (204 kgCO_2e/kWh).

CPPA

1.4.13 As detailed within the Energy Efficiency and Climate Change Adaptation Design Statement (HDR, 2024), 30% of the energy demand remaining following energy efficiency reduction measures will be met by renewable sources. Approximately 5% of such energy demand has been calculated to be met by the onsite generation by solar PV in the first year of operation, the remainder will be met by purchased electricity via Commercial Power Purchase Agreements (CPPA).

1.4.14 Annual energy output from the solar PV (accounting for annual degradation of the panels) was subtracted from 30% of the annual estimated regulated energy demand (following energy efficiency reductions) to give the remainder of the regulated energy consumption to be met by CPPA. In the first year of operation this totals 3,033 MWh, and 156,869 MWh over the Project's lifetime.

1.4.15 The commitment to a CPPA enables the Project to avoid 1,007 tCO_2e per annum, or 52,081 tCO_2e over the Project lifetime. This has been calculated by scaling the above energy consumption to be met by CPPA by the current electricity intensity factor (332 gCO_2e/kWh) and does not account for targeted decarbonisation of the electricity network.

Summary

1.4.16 Energy demand and emissions associated with the regulated energy demand have been summarised within Table 1-7, below, detailing the reductions enabled by the designed-in energy efficiency and renewable energy measures. In combination, such measures (including the use of gas generators in place of total energy demand sourced solely from grid electricity) results in an emissions reduction of 66%.

Table 1-7: Regulated energy demand mitigation measures.

	Annual Energy Demand (kWh)	Annual Emissions (tCO_2e)
No mitigation		
Total	**15,834,157**	**5,257**[2]
Embedded emissions reduction measures		
Energy Efficiency measures	-3,460,118	
Solar PV[1]	-679,285	
CPPA[1]	-3,032,926	
Total	**8,661,827**	**1,767**[3]
Total percentage reduction	**-45%**	**-66%**

[1]Accounting for the first year of operation only. Over the lifetime of the solar PV array panel degradation will result in reduced output. Given 30% of energy demand must be met by renewable sources, this will result in an uplift throughout the Project's lifetime in the energy demand to be met within the CPPA.

[2]Emissions have been scaled by SEAI emissions factors for electricity (332 gCO_2e/kWh)

[3]Emissions accounting for embedded emissions reduction measures have been scaled by SEAI emissions factors for natural gas (204 gCO_2e/kWh) to account for the use of gas generators in the onsite provision of electricity.

Unregulated Energy Consumption

1.4.17 Emissions associated with the unregulated energy consumption has been informed by the project design – 6 no. data centre buildings, each comprising of eight data halls with an electrical capacity to support up to 30 MW of IT equipment load in each building. In addition, further demand arises from building services and regulated energy demand (as detailed above) adding a total of 10 MW additional energy demand per data centre building, resulting in total building consumption of 40 MW, and a total Project demand of 240 MW, or 2,103,840 MWh per annum.

1.4.18 Total unregulated energy consumption has been calculated by subtracting the calculated regulated demand (as detailed above) from the total Project energy demand. To provide a conservative emissions estimate, it was assumed that the data centres would run 24 hours a day, 365.25 days a year, resulting in the consumption of 2,091,466 MWh per year.

Solar PV

1.4.19 The annual energy output of the proposed solar PV array has been calculated assuming a load factor of 10.77%, as calculated from the Digest of UK Energy Statistics (DUKES) 6.3 data set, using the average load factors for solar PV generation from 2011/12 to 2020/21 (BEIS, 2022). The annual load factor of solar PV associated with the data halls relates to the total number of hours at which the array is generating electricity at its rated capacity (i.e. 500 kW per data centre, total of 3,000 kW) over the total number of hours in a year. A PV array's load factor is determined by irradiance conditions, performance ratio and orientation and tilt of the panels. Total annual energy output from the proposed solar PV array has been estimated at 2,830 MWh in the first year of operation. A degradation factor of 0.7% (IEA, 2021) has been applied to all subsequent years, with the lifetime energy output from the solar PV array totalling 119,756 MWh.

1.4.20 It has been assumed that electricity generated by the solar PV array displaces electricity that would otherwise have been generated by the onsite gas generators. As such, avoided emissions have been calculated by scaling the electricity generated by the solar PV by the current natural gas emissions intensity factor (204 kgCO_2e/kWh).

CPPA

1.4.21 As detailed within the Energy Efficiency and Climate Change Adaptation Design Statement (HDR, 2024), 30% of the energy demand of the data centres will be met by renewable sources. Less than 1% of such energy demand has been calculated to be met by the onsite generation by solar PV in the first year of operation, the remainder will be met by purchased electricity via CPPAs.

1.4.22 Annual energy output from the solar PV (accounting for annual degradation of the panels) was subtracted from 30% of the annual estimated regulated energy demand (following energy efficiency reductions) to give the remainder of the regulated energy consumption to be met by CPPA. In the first year of operation this totals 624,609 MWh, and 31,252,234 MWh over the Project's lifetime.

1.4.23 The commitment to a CPPA enables the Project to avoid 207,370 tCO_2e per annum, or 10,375,742 tCO_2e over the Project lifetime. This has been calculated by scaling the above energy consumption to be met by CPPA by the current electricity intensity factor (332 gCO_2e/kWh) and does not account for targeted decarbonisation of the electricity network.

Summary

1.4.24 Emissions associated with the unregulated energy demand have been summarised within Table 1-8, below, detailing the reductions enabled by the designed-in renewable energy measures. In combination, such measures (including the use of gas generators in place of total energy demand sourced solely from grid electricity) results in an emissions reduction of 57%.

Table 1-8: Unregulated energy demand mitigation measures.

	Annual Energy Demand (MWh)	Annual Emissions (tCO_2e)
No mitigation		

	Annual Energy Demand (MWh)	Annual Emissions (tCO_2e)
Total	**2,091,466**	**694,367**[2]
Embedded emissions reduction measures		
Solar PV[1]	-2,830	
CPPA[1]	-624,609	
Total	**1,464,026**	**298,661**[3]
Total percentage reduction	**-30%**	**-57%**

[1]Accounting for the first year of operation only. Over the lifetime of the solar PV array panel degradation will result in reduced output. Given 30% of energy demand must be met by renewable sources, this will result in an uplift throughout the Project's lifetime in the energy demand to be met within the CPPA.

[2]Emissions have been scaled by SEAI emissions factors for electricity (332 gCO_2e/kWh)

[3]Emissions have been scaled by SEAI emissions factors for natural gas (204 gCO_2e/kWh) to account for the use of gas generators in the onsite provision of electricity.

BESS

1.4.25 For the purpose of providing uninterrupted and conditioned power, each data centre building will have a dedicated BESS system. The storage capacity provides a back-up energy source to the data centres, in addition the BESS adds resilience to the wider electricity network as it will have the capacity to provide immediate export of energy to the grid, or the capacity to store excess electricity generated externally, if required.

1.4.26 The role of the BESS in providing a back-up energy source to the data centres has not been assessed, given it is unknown to what extent the BESS will provide support over the Project's lifetime. Further, emissions associated with the energy consumption from the data centres has already been calculated (see sections above), and as such, any energy consumption and resultant emissions arising from discharge from the BESS to the data centres has already been accounted for. This assessment of the operational effects of the BESS therefore focuses on their role in exporting electricity to the grid.

1.4.27 The magnitude of impact of the BESS on the Project's operational GHG impact is determined by the quantity of electricity sourced to charge the BESS, the quantity of peaking plant generation it displaces, and the associated GHG impacts of each.

1.4.28 The BESS may be charged from a number of sources: the grid, or surplus energy generated by the on-site gas turbines.

1.4.29 When charged by the grid, it is assumed that as the penetration of non-dispatchable renewable energy resources in the Irish grid increases, energy market price mechanisms will be in place to ensure that, insofar as is possible, stationary grid-scale batteries only charge using surplus renewable energy. However, as it is not certain that this would be the case in all market conditions, an analysis of the sensitivity of the GHG impacts of the BESS to the carbon intensity of an alternative source has been undertaken.

1.4.30 When charged by the on-site gas turbines, the BESS will not be avoiding the use of gas peaking plants (given the electricity will be generated from gas turbines, in place of renewable or lower carbon alternatives), emissions associated with electricity provision to the grid by the BESS has been calculated by scaling the annual energy input (consistent with that listed in Table 1-9) with Ireland's natural gas emissions factor (204 gCO_2e/MWh) (SEAI, 2023).

1.4.31 Table 1-9 displays the annual energy input and output values for the BESS associated with a single data centre, and the parameters by which they are determined by.

Table 1-9: BESS energy flows (per data centre)

Parameter	Value	Unit	Source
Input Parameters			
Rated power	40	MW	Project design parameters
Discharge time	0.33	hrs	Project design parameters
Storage capacity	13.2	MWh	Project design parameters
Round trip efficiency (RTE)[5]	0.85		Cole & Frazier, 2019
Depth of discharge	0.8		IEA, 2020
Annual cycles	365		Project design parameters
Output Parameters			
Annual energy input	3,854	MWh	
Annual energy output	3,276	MWh	

1.4.32 Wind energy generation accounted for 17.4% of electricity generated in 2021 (including both renewables and non-renewables) (SEAI, 2021). In Ireland and Northern Ireland, renewable energy is predominantly sourced from onshore wind. In 2022, the total wind energy generated in Ireland and Northern Ireland was 13,676 GWh, while 1,280 GWh of wind energy was dispatched down[6]. This represented 8.5% of the total available wind energy in 2022 (EirGrid, 2023). In the future, a higher percentage of this energy mix will come from offshore wind, as the Government have committed an additional resource for 7,000 MW of offshore wind generation by 2030 (SEAI, 2022a).

1.4.33 As such, it is expected that wind energy is the source of renewable energy that is most likely to be curtailed during periods of low demand. Therefore, for the purposes of this assessment, the indirect GHG emissions associated with charging the battery are assumed to be equal to those associated with the operation of wind generation.

1.4.34 The current literature surrounding LCAs for wind turbines is characterised by a high degree of variability in the published GHG figures and, therefore, a high degree of uncertainty occurs in selecting any one of these figures as a means of analysing the operational emissions resultant from wind generation. As a means of dealing with this uncertainty, the primary source of emissions factors was a study by the National Renewable Energy Laboratory (NREL, 2013) Life Cycle Assessment Harmonization Project, and Dolan and Heath (2012).

1.4.35 The NREL (2013) study was based on the output of the Dolan and Heath (2012) paper, and as such the Dolan and Heath paper has been referenced hereafter. This study (Dolan and Heath, 2012) conducted an exhaustive literature search, extracting normalized life cycle GHG emission estimates from published LCA literature. Data was screened to select only those references that met stringent quality and relevant criteria.

1.4.36 The median estimates of GHG emissions intensity figures were identified for both onshore and offshore wind across the whole life-cycle (Dolan and Heath, 2012). The NREL (2013) study further broke down and detailed the separation of intensity across each life cycle stage, attributing 9% of life-cycle emissions to operation and maintenance activities. This estimated percentage has been

[5] The RTE of a battery refers to the ratio of energy required to charge a battery compared to the available energy during discharge. The source used in this assessment for determining RTE has considered a range of recent and relevant published RTE values and selected a mid-point value. The RTE includes losses associated with cooling systems and battery control equipment; as such, this assessment takes into account the implications of the operational energy use of onsite electrical equipment.

[6] Dispatch-down of renewable energy refers to the amount of renewable energy that is available but cannot be used by the system. This is because of broad power system limitations, known as curtailments, or local network limitations, known as constraints.

applied to the Dolan and Heath intensity (11 gCO_2e/kWh), to give an operational emissions intensity of 0.99 gCO_2e/kWh.

1.4.37 To account for scenarios where market conditions may not favour renewable energy supply, the grid electricity carbon intensity (332 gCO_2e/kWh) (SEAI, 2023) has been applied to the estimated electricity input requried to charge the BESS.

1.4.38 The magnitude of the GHG impact of displacing peaking plant generation depends on its carbon intensity. Representative project examples have been used to establish the carbon intensity of peaking plants (RPS, 2020; and VPI Immingham, 2019), which has been assumed to be 0.504 tCO_2e/MWh.

1.4.39 Table 1-10 and Graph 1-1 display the total additional emissions (positive values) and avoided emissions (negative values) associated with all BESS to be installed across the Project. This accounts for their phased introduction, in line with the construction phasing associated with the data centre construction. The magnitude of GHG impact varies according to the energy source assumed for battery charging (i.e. applying the carbon intensity of offshore wind and the SEAI (2023) grid-average and natural gas carbon intensities). It is likely that emissions associated with the BESS will fall within this range.

Table 1-10: Avoided GHG Impacts from BESS

Year of operation	Year	Input (MWh)	Output (MWh)	Cumulative GHG Impacts 100% Gas	Cumulative avoided GHG impacts (tCO2e)		
					100% Wind Scenario	100% Grid Average Scenario	50% Wind, 50% Grid Average Scenario
1	2026	3,854	3,276	786	-1,767	-491	-847
2	2027	7,709	6,552	2,359	-5,300	-1,472	-1,129
3	2028	11,563	9,829	4,718	-10,600	-2,945	-3,386
4	2029	15,418	13,105	7,863	-17,667	-4,908	-6,773
5	2030	15,418	13,105	11,008	-24,733	-6,872	-11,288
6	2031	19,272	16,381	14,940	-33,567	-9,326	-15,803
7	2032	19,272	16,381	18,871	-42,400	-11,780	-21,446
8	2033	23,126	19,657	23,589	-53,000	-14,725	-27,090
9	2034	23,126	19,657	28,307	-63,600	-17,670	-33,863
10	2035	23,126	19,657	33,024	-74,200	-20,615	-40,635
11	2036	23,126	19,657	37,742	-84,800	-23,560	-47,408
12	2037	23,126	19,657	42,460	-95,400	-26,505	-54,180
13	2038	23,126	19,657	47,178	-106,000	-29,450	-60,953
14	2039	23,126	19,657	51,896	-116,600	-32,395	-67,725
15	2040	23,126	19,657	56,613	-127,201	-35,340	-74,498
16	2041	23,126	19,657	61,331	-137,801	-38,285	-81,270
17	2042	23,126	19,657	66,049	-148,401	-41,230	-88,043
18	2043	23,126	19,657	70,767	-159,001	-44,175	-94,815
19	2044	23,126	19,657	75,485	-169,601	-47,120	-101,588
20	2045	23,126	19,657	80,202	-180,201	-50,065	-108,360
21	2046	23,126	19,657	84,920	-190,801	-53,010	-115,133
22	2047	23,126	19,657	89,638	-201,401	-55,954	-121,905
23	2048	23,126	19,657	94,356	-212,001	-58,899	-128,678
24	2049	23,126	19,657	99,073	-222,601	-61,844	-135,450
25	2050	23,126	19,657	103,791	-233,201	-64,789	-142,223
26	2051	23,126	19,657	108,509	-243,801	-67,734	-148,995

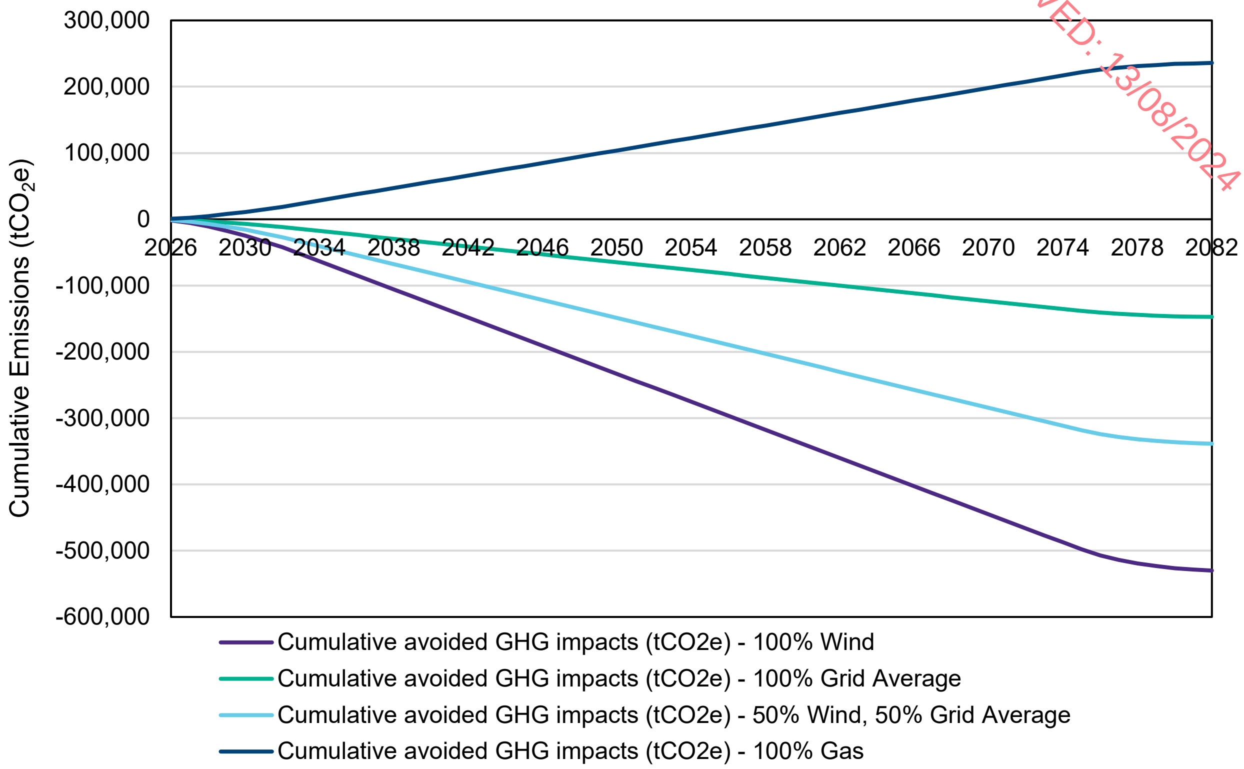
Year of operation	Year	Input (MWh)	Output (MWh)	Cumulative GHG Impacts 100% Gas	Cumulative avoided GHG impacts (tCO2e)		
					100% Wind Scenario	100% Grid Average Scenario	50% Wind, 50% Grid Average Scenario
27	2052	23,126	19,657	113,227	-254,401	-70,679	-155,768
28	2053	23,126	19,657	117,945	-265,001	-73,624	-162,540
29	2054	23,126	19,657	122,662	-275,601	-76,569	-169,313
30	2055	23,126	19,657	127,380	-286,201	-79,514	-176,085
31	2056	23,126	19,657	132,098	-296,801	-82,459	-182,858
32	2057	23,126	19,657	136,816	-307,401	-85,404	-189,630
33	2058	23,126	19,657	141,534	-318,001	-88,349	-196,403
34	2059	23,126	19,657	146,251	-328,601	-91,294	-203,175
35	2060	23,126	19,657	150,969	-339,201	-94,239	-209,948
36	2061	23,126	19,657	155,687	-349,801	-97,184	-216,720
37	2062	23,126	19,657	160,405	-360,401	-100,129	-223,493
38	2063	23,126	19,657	165,122	-371,002	-103,074	-230,265
39	2064	23,126	19,657	169,840	-381,602	-106,019	-237,038
40	2065	23,126	19,657	174,558	-392,202	-108,964	-243,810
41	2066	23,126	19,657	179,276	-402,802	-111,909	-250,583
42	2067	23,126	19,657	183,994	-413,402	-114,854	-257,355
43	2068	23,126	19,657	188,711	-424,002	-117,799	-264,128
44	2069	23,126	19,657	193,429	-434,602	-120,744	-270,900
45	2070	23,126	19,657	198,147	-445,202	-123,689	-277,673
46	2071	23,126	19,657	202,865	-455,802	-126,634	-284,445
47	2072	23,126	19,657	207,583	-466,402	-129,579	-291,218
48	2073	23,126	19,657	212,300	-477,002	-132,524	-297,990
49	2074	23,126	19,657	217,018	-487,602	-135,469	-304,763
50	2075	23,126	19,657	221,736	-498,202	-138,414	-311,535
51	2076	19,272	16,381	225,667	-507,035	-140,868	-318,308
52	2077	15,418	13,105	228,813	-514,102	-142,831	-323,952
53	2078	11,563	9,829	231,171	-519,402	-144,304	-328,467
54	2079	7,709	6,552	232,744	-522,935	-145,285	-331,853
55	2080	7,709	6,552	234,317	-526,469	-146,267	-334,110
56	2081	3,854	3,276	235,103	-528,235	-146,758	-336,368
57	2082	3,854	3,276	235,889	-530,002	-147,249	-337,497

1.4.40 Table 1-11 and Graph 1-2 summarises total emissions resultant from the operational phase of the BESS to be installed at the project. The magnitude of GHG impact varies according to the energy source assumed for battery charging. Negative values signify avoided emissions, while positive values are additional emissions. It is likely that avoided emissions will fall within this range.

Table 1-11: Avoided GHG Emissions from BESS - Summary

Test	Cumulative avoided GHG impacts (tCO_2e)	Unit
100% gas	235,889	tCO_2e
100% onshore wind	-530,002	tCO_2e
100% grid-average	-147,249	tCO_2e
50% onshore wind, 50% grid-average	-338,625	tCO_2e

Graph 1-1: Avoided GHG Emissions from BESS



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