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GEOSOLUTIONS

An Economic Assessment of Green Energy Park Concepts

An Roinn Fiontar, Trádála agus Fostaíochta
Department of Enterprise, Trade and Employment

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DISCLAIMER

EXECUTIVE SUMMARY

Published in March 2024, Powering Prosperity – Ireland's Offshore Wind Industrial Strategy, set out a number of key actions for Government and State Agencies, with a vision of building a successful, vibrant, and impactful new offshore wind sector in Ireland which creates value for the State.

Several actions in the strategy relate to Green Energy Parks (GEPs), and while not defining what a GEP is, the strategy notes the intention to consider how additional generation capacity from offshore renewable energy could be used to power Large Energy Users, in combination with the co-location of renewable energy supply and demand. The strategy also highlights the opportunity to establish new indigenous green businesses and attract new Foreign Direct Investment to Ireland, based on this competitively priced supply of abundant renewable energy and a strategic approach to co-location of renewable energy supply with demand.

With this in mind, Gavin and Doherty Geosolutions Ltd., working with Glic as economic consultants, was commissioned by the Department of Enterprise, Trade and Employment to carry out an assessment of GEP concepts, to identify learnings for Ireland.

This report reviews key policy drivers at a national and international level; completes case studies for relevant projects; reports on a comprehensive stakeholder engagement process undertaken to inform the assessment; carries out an analysis of the key criteria that may determine the location and development of future GEPs in Ireland; and performs economic analysis of potential GEP scenarios.

When defining what a GEP means for Ireland, this report has set out some key characteristics that concepts should have. These are sites that:

- Co-locate Large Energy Users, such as data centres or large industrial demand, with renewable energy generation
- Have some level of self-sustainability / security of supply and are not over- or fully-reliant on the grid
- Are primarily powered by renewable energy and are or can transition to be net-zero or below a certain emissions threshold

To maximise benefits, GEPs will need to become sites that naturally promote cross-industry and community collaboration for common benefits, and ultimately develop into centres of expertise in areas such as supply chain or RD&I related to the uses at the site. A prime example here is the potential seen for hubs to be established around harbour regions which are developed to support the installation or maintenance of offshore wind projects, which could then develop into supply chain bases, where other associated industries could become established. Similar collaborative examples for other industries can be envisaged.

Beyond this, it is not believed there is value to setting a strict definition or definite criteria for a GEP at this stage, as this would most likely hinder development. Plans and concepts for energy parks seen in Ireland and internationally vary greatly in design and development processes, so this needs to be accommodated to allow projects to develop in phased manners.

There is no standard approach to developing GEPs, but there are many characteristics which are common to most of the sites chosen in the plans reviewed, which include: having existing infrastructure in place and a legacy of industrial activity, proximity to the transmission system and available grid capacity, available land bank for development and expansion, availability of renewable sources of power (existing and proposed), and availability of thermal/dispatchable generation. In addition to site characteristics onshore, locations identified by the State for offshore wind development under the plan-led system will be a key driver for the future location of GEPs in Ireland.

The key power suppliers for GEPs in Ireland will be offshore wind, onshore wind, and solar, backed-up by battery storage, with some form of dispatchable generation or power from the grid. Dispatchable generation in the near-to-medium term can be expected to come from gas-fired power plants, although plans will need to be progressed for these sources to be decarbonised and replaced with other fuels such as green hydrogen or hydrogen-derived fuels. Relying solely on electricity storage as a backup to variable renewables for security of supply is not feasible given current storage technologies, nor those on the horizon, particularly considering the potential for Dunkelflaute conditions, where power yields from renewables can be reduced for prolonged periods.

This report has also considered what the key industrial demands or anchor tenants for future GEPs could be. Data centres are seen as a key potential demand and there are clear synergies here, as offshore wind will need the demand that data centres can provide as an important route to market (in addition to more widespread electrification and export opportunities, as discussed in the Future Framework policy statement), while data centres will desire large-scale, reliable sources of carbon-free power to continue to locate in Ireland given their need to decarbonise operations. There are challenges technically to be overcome for data centres to be powered by renewables, however, given their flat demand profiles and high levels of power consumption. Large scale storage will be required, but this will likely need to be supplemented with access to dispatchable thermal generation, to provide the required security of supply. Increased demand flexibility will also need to be provided by data centres to mitigate against negative system impacts. Nonetheless there are clear benefits to be realised if these challenges can be overcome.

This report has found other relevant sectors which should be viewed as potential tenants for GEPs, which include: Material / Chemical Production, Cement Manufacturers, Food and Nutrition, Distilleries, Pharmaceuticals, and Tech Manufacturing. Many of the companies active in these sectors have established footprints in Ireland and will not be able to re-locate, but where this is the case, strategic GEP locations near these developments could be considered.

There is also the potential for a data centre to operate as the anchor tenant at a GEP location, with other industrial demands with less intensive and more flexible power consumption also being located at the park as secondary tenants.

Outside of the demand specific challenges discussed above, there are development challenges more generally which will need to be overcome to facilitate GEP development. Some key challenges or points in need of clarification which have been identified through this work are:

- limited grid capacity nationally and uncertainty on grid and storage requirements for GEPs
- long and uncertain permitting timelines

- long (and uncertain) development timelines for offshore wind relative to demand tenants' requirements
- the high price of electricity
- policy uncertainty around private wire connections
- uncertain and challenging Large Energy User connection policies
- potential labour capacity constraints for construction
- what the State's role in site selection (onshore and offshore) and supporting GEP development will be

If challenges can be overcome, there are huge potential benefits to GEP development in Ireland. Economic analysis undertaken as part of this work has shown that the development of a hypothetical GEP scenario could add as much as €3,069M gross value added (GVA) and 3,400 full-time equivalent (FTE) jobs annually once operational, while mitigating up to 2,108,163 t CO_2 equivalent. An additional €1,190M GVA and 10,661 FTEs could be created over the development and construction period. The fully developed scenario assessed considered the development of a GEP comprising; a 1GW fixed offshore wind farm, an offshore substation, an onshore substation, battery storage, a 150MW onshore wind farm, a 150MW solar farm, a 500MW data centre, a 20MW green hydrogen production facility and a 100MW pharmaceutical manufacturing facility. It should be noted, however, that the GVA calculation does not include the costs of new grid capacity and dispatchable generation which may be required to support the system more widely due to the addition of large-scale GEPs that interact with the grid. Currently the cost of such development is socialised across the energy system.

But to achieve and maximise potential benefits, a high level of ambition will need to be shown by both the State in providing direction and a facilitative policy and development environment for GEPs, and industry in committing to and developing these large-scale, innovative projects. Key State Agencies, Line Departments and other stakeholders will need to be aligned on the importance of unlocking their elements of the critical enablers discussed in this report.

This report has sought to set out useful next steps to help support the development of GEPs in Ireland, as described in the table below. In addition, the report has identified a number of areas for future consideration and research. Primary areas identified relate to the points below and are discussed further in this report:

- Providing further detail on GEP criteria and definitions
- Grid infrastructure, network interaction, and the future role of private wires
- The requirement for back-up dispatchable generation and storage and the implications of this
- Market and regulatory barriers
- Further engagement with Large Energy Users and potential anchor tenants
- The role of the State in GEP development and points to consider in a National Strategy
- Further economic modelling

Table 0: Report recommendations on next steps to support GEP development in Ireland

Action	Description	Lead & supporting bodies	Date for completion
A1: Develop a National Energy Park Strategy	Prepare a National Energy Park Strategy, as discussed in the SC-DMAP. This should set out the State's plans and expectations for GEP development in Ireland, provide clarity to the market, and enable plans to be progressed with more certainty and in line with Government expectations in advance of key facilitating actions being taken. Any such Strategy must align with other policies and strategies within Government and avoid duplication or contradiction. Further detail on what this Strategy should consider is included in this report.	**LEAD:** DETE & DECC **SUPPORTS:** Regional and Local Authorities, Offshore Wind Delivery Taskforce, DHLGH	Q1 2026
A2: Complete a Spatial Mapping Assessment	As per Article 15(b) of the Renewable Energy Directive (RED III), by 21 May 2025 the State is required to carry out a national mapping assessment for the deployment of renewables and related infrastructure to identify the domestic potential and the available land and sea area that is necessary for development. As part of this work currently being undertaken under the ARET (Accelerating Renewable Energy Taskforce), identifying areas with high potential for the development of GEPs could be considered, taking account of the key characteristics discussed in this report, mapping undertaken and plans identified, including the location of DMAPs and IDA Ireland's work on industrial parks. Potential pre- and post-2030 should be considered, although GEP development post 2030 is most likely. This work should be brought forward to the ARET for consideration.	**LEAD:** DECC through the ARET **SUPPORTS:** DHLGH, DETE, Local and Regional Authorities, EirGrid, ESBN, GNI, MARA	Q2 2025
A3: Designate RAAs and Implement RED Timelines	As per Article 15(c) of RED III, by 21 Feb 2026, the State should designate at least one Renewables Acceleration Area (RAAs) suitable for the development of renewable energy projects and associated infrastructure. In setting these areas, consideration should be given to aligning RAAs with areas suitable for GEP development (informed by A2). The preferable planning provisions outlined in RED III should be applied to these areas, and best endeavours should be made to achieve the permitting timelines (including grid connection permits) set out in RED III. As part of this exercise, consideration could be given to the provisions in the Net-Zero Industry Act for the establishment of net-zero strategic projects, which receive priority status at national level, faster permitting, focused attention in the Net-Zero Europe Platform, and urgent treatment in judicial and dispute resolution procedures.	**LEAD:** DECC and DHLGH **SUPPORTS:** DETE	Q1 2026

Action	Description	Lead & supporting bodies	Date for completion
A4: Consider the Implications of Future Policy Decisions on GEP Development	There are several areas of policy broadly related to GEP development which are currently under consideration. These include: plans to develop a Private Wires Policy Framework, the CRU's proposed decision on LEU connections policy, the publication of a roadmap for future DMAPs and a decision on ORE deployment timelines and methodology for the SC-DMAP. It is important that consideration is given to GEPs in all future policy formation, and efforts are made to create a supportive and certain policy environment for GEP development. Key State Agencies, Line Departments and other stakeholders will need to be aligned on the importance of unlocking their element of the critical enablers discussed in this report.	**LEAD:** Policy makers **SUPPORTS:** Regulatory bodies, Local Authorities, State Agencies	Ongoing
A5: Plan and Invest in Grid	Low available grid capacity has been cited as a key barrier to GEP development in Ireland. When compared to a counterfactual of having supply and demand in different locations it is expected that GEPs will lead to more efficient use of grid and limit the need for grid upgrades to a degree. However, GEPs will still need to be grid connected for the foreseeable future, and significant grid upgrades will still be required. In Shaping Our Electricity Future, EirGrid has outlined plans for renewable hubs, an approach which could be considered as an enabler for GEPs. This concept should be progressed in addition to longer term planning for grid upgrades, which includes plans for upgrades to facilitate GEPs in strategic locations, informed by A2/A3. Investment in the wider grid is a key strategic action needed to support the wider rollout of renewables in Ireland, not just GEPs. This analysis should consider the value of interconnectors and potentially hybrid interconnectors.	**LEAD:** EirGrid **SUPPORTS:** The CRU, ESBN, DECC	Ongoing
A6: Undertake Engagement with Potential Anchor Tenants	Data centres have been identified as a key potential anchor tenant for GEP development, but other potential sectors have also been identified (Material/Chemical Production, Cement Manufacturers, Food and Nutrition, Distilleries, Pharmaceuticals, and Tech Manufacturing). Engagement by the State should be undertaken with key potential demand stakeholders to fully inform strategy and policy development to support GEPs. This exercise should also consider engaging further with representatives of the national and international case studies identified in this work.	**LEAD:** DETE **SUPPORTS:** IDA, and Enterprise Ireland	2025 and Ongoing

Action	Description	Lead & supporting bodies	Date for completion
A7: Establish a Working Group to Progress GEP Concepts	A working group should be formed to coordinate and monitor key actions for GEP development. This group could be formed under the Offshore Wind Delivery Taskforce, but will require input from both offshore- and onshore-focused stakeholders. In addition to key State bodies, the group should include representatives from industry, on both the supply and demand sides. Existing working groups within Government should be used to support this work where possible.	**LEAD:** Offshore Wind Delivery Taskforce **SUPPORTS:** Key Government Departments and State bodies, (Industry, Regional and Local Authorities	Q3 2025
A8: Lead a Public Awareness and Engagement Campaign	GEPs are a new concept to many people in the industry, as well as members of the public. In parallel with the development of GEPs in phases, a public engagement and awareness campaign could be beneficial to explain GEPs as a concept and highlight the benefits of GEPs and renewable energy to local and regional communities. While it may be too early for such a campaign at this stage, consideration should be given to this once work on GEPs and a National Strategy has progressed.	**LEAD:** DETE	2026

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AI	Artificial Intelligence
ARET	Accelerating Renewable Energy Taskforce
AWS	Amazon Web Services
bcm	Billion Cubic Metres
BoP	Balance of Plant
CAP	Climate Action Plan
CCS	Carbon Capture and Storage
CCUS	Carbon Capture, Utilisation and Storage
CEAP	Circular Economy Action Plan
CO2e	Carbon Dioxide Equivalent
CPPA	Corporate Power Purchase Agreement
CRU	Commission for Regulation of Utilities
CSO	Central Statistics Office
CO2e	Carbon Dioxide Equivalent
DECC	Department of the Environment, Climate and Communications
DETE	Department of Enterprise, Trade and Employment
DMAP	Designated Maritime Area Plan
EC	European Commission
EEZ	Exclusive Economic Zone
EIP	Eco-Industrial Park
EMR	Eastern and Midland Region
EMRA	Eastern and Midland Regional Assembly
EPA	Environmental Protection Agency
ETS	Emissions Trading System
EU	European Union
EV	Electric Vehicle
FDI	Foreign Direct Investment
FTE	Full-time Equivalents
GBP	Great Britain Pound / Pound Sterling
GCS	Generation Capacity Statement
GDG	Gavin and Doherty Geosolutions Limited
GEP	Green Energy Park
GH2	Galway Hydrogen Hub
GSHP	Ground-source Heat Pumps
GVA	Gross Value Added
H_2	Hydrogen
IBF	Irish Bioeconomy Foundation
ICT	Information and communications technology
IDA	Industrial Development Authority
ISIF	Irish Strategic Investment Fund
LEU	Large Energy User
LNG	Liquefied Natural Gas

MAC	Maritime Area Consent
MAP	Maritime Area Planning
MaREI	Marine Renewable Energy Ireland
MEC	Maximum Export Capacity
MIC	Maximum Import Capacity
MS	Member State
MSP	Maritime Spatial Plan / Planning
NEDS	National Energy Demand Strategy Decision
NEP	Northern Endurance Partnership
NISA	North Irish Sea Array
NMPF	National Marine Planning Framework
NPF	National Planning Framework
NPS	National Planning Statement
NTL	New Technology Load
NWRA	Northern and Western Regional Assembly
NWR	Northern and Western Region
NZIA	Net-Zero Industry Act
ONS	Office for National Statistics
ORE	Offshore Renewable Energy
OW	Offshore Wind
OWDT	Offshore Wind Delivery Taskforce
PtX	Power-to-X
RAA	Renewables Acceleration Area
RED	Renewable Energy Directive
RD&I	Research, Development and Innovation
RFNBO	Renewable Fuels of Non-Biological Origin
RSES	Regional Spatial and Economic Strategy
SAF	Sustainable Aviation Fuel
SC-DMAP	South Coast Designated Maritime Area Plan for Offshore Renewable Energy
SDZ	Strategic Development Zones
SME	Small and Medium Sized Enterprise
SMR	Small Modular Reactors
SO	System Operator
SOEF	Shaping Our Electricity Future
SR	Southern Region
TES	Tomorrow's Energy Scenarios
TPER	Total Primary Energy Requirement
TSO	Transmission System Operator
UCC	University College Cork
UNIDO	United Nations Industrial Development Organisation

1 INTRODUCTION

Gavin and Doherty Geosolutions Limited (GDG) were commissioned by the Department of Enterprise, Trade and Employment (An Rionn Fiontar, Trádála agus Fostaíochta) (DETE) to complete an Economic Assessment of Green Energy Park (GEP) Concepts. This work was completed in conjunction with Glic as economic consultants and lead for all economic analysis.

1.1 OVERVIEW OF SCOPE – POLICY BACKGROUND AND MOTIVATION

Powering Prosperity – Ireland's Offshore Wind Industrial Strategy, published in March 2024 [1], set out a number of key actions for Government and State Agencies, with a vision of building a successful, vibrant, and impactful new offshore wind sector in Ireland, and ensuring the sector creates value for the people of Ireland.

The actions were set to maximise the benefit to the Irish supply chain and the State from achieving Ireland's offshore wind ambitions of 5GW of grid-connected offshore wind installed by 2030 plus an additional 2GW for non-grid limited uses in development, 20GW of offshore renewable energy (ORE) by 2040, and 37GW by 2050.

This iteration of the strategy focused on actions to be completed in 2024 and 2025, with these actions anchored on four key pillars: Offshore Wind Supply Chains, Research, Development, & Innovation (RD&I), Future Demand and End Uses for Renewable Energy, and Balanced Regional Economic Development Opportunities.

Several of the actions in the strategy relate to GEPs, as set out below in Table 1-1 and discussed in section 8.1 of the strategy document. This report has been commissioned to address Action 37 - *Commission a sectoral assessment of energy park concepts to include an analysis of the economics of the capital investment required*.

While not defining what a GEP is, the strategy notes the intention to consider how additional generation capacity from ORE could be used to power Large Energy Users (LEUs) such as data centres in Ireland, in combination with the co-location of renewable energy supply and demand. The strategy also highlights the potential opportunity to establish new indigenous green businesses and attract new Foreign Direct Investment (FDI) to Ireland, based on the expected supply of abundant renewable energy and a strategic approach to co-location of renewable energy supply and demand.

Prior to this, the National Hydrogen Strategy [2], published in July 2023, committed under Action 6, to assess the role that integrated energy parks could play in our future energy system, including their potential benefits and the possible barriers (market, legal or other) that may exist. This action was then carried into the Industrial Strategy as Action 36 (Table 1-1).

Table 1-1: Actions set out in Power Prosperity relating to GEPs [1]

Number	Action	Deadline	Owners
36	Undertake further work to assess the role that integrated energy parks could play in our future energy system, including their potential benefits and the possible barriers (market, legal or other) that may exist.	Q4 2025	DECC
37	Commission a sectoral assessment of energy park concepts to include an analysis of the economics of the capital investment required.	Q3 2024	DETE
38	Lead fact-finding mission with key stakeholders to international locations where green energy industrial parks have been successfully established.	Q4 2024	DETE
39	Establish a pilot framework to enable aligned delivery of offshore generation, grid and routes to market to include consideration of LEUs.	Q4 2025	DECC

The Hydrogen Strategy goes into more detail on Integrated Energy Parks for LEUs, with a focus on how they can be of use to data centres. The Hydrogen strategy notes that integrated energy park developments which co-locate large demand users and renewable energy generation alongside energy storage or energy transport infrastructure may offer significant opportunities, without placing significant new capacity requirements on our electricity grid. As discussed later in this report, however, while GEPs can be expected to limit and make more efficient use of grid infrastructure and upgrades considering the capacity they can add to the system, they may still place significant new capacity requirements on the grid, depending on the scale and nature of the operations.

The National Hydrogen Strategy lists Integrated Energy Parks for LEUs as the third highest priority use for green hydrogen (H_2) in Ireland, envisaging green hydrogen as a backup to renewable/grid electricity to meet high reliability requirements. It is predicted that this use could require up to 13.3 TWh of H_2 or 19 TWh of electricity to meet this demand by 2050.

Table 1-2: Summary of H_2 end uses envisioned in the Hydrogen Strategy (top 3 extracted) [2]

End Uses	Priority Order	Role Envisioned	Alternative Technologies	Likely Market Entry
Existing hydrogen end users	1	Renewable H_2 to replace niche fossil fuel-based H_2 uses in Ireland	N/A	2025-2030
Flexible Power Generation and long duration energy storage	2	Zero carbon flexible backup generation and long duration energy, enabling high penetrations of variable renewables and system security	Bioenergy-based generation, CCS-enabled natural gas generation, system flexibilities (demand-side management, etc.)	2030-2035
Integrated Energy Parks for LEUs	3	As a backup to renewable / grid electricity to meet high reliability requirements	Bioenergy-based generation, battery storage	2025-2030

These policy developments and other commitments from Government have brought the potential for energy parks/hubs/multiuse sites etc. very much to the forefront when considering future planning for ORE and renewable energy in Ireland, as well as the location of LEUs and industrial demand.

1.2 STUDY OBJECTIVES

GEPs are seen to have many potential benefits, and are an important concept to explore. They can potentially:

- provide an important route to market for offshore wind and other renewables that can help Ireland to reach its ambitious long-term targets;
- be a key power source for LEUs in Ireland that otherwise may have difficulty in obtaining a grid connection or choose to locate elsewhere, while simultaneously helping LEUs to decarbonise;
- complement investments in the national grid needed to accommodate large volumes of renewables in Ireland;
- attract FDI into Ireland and enable the growth of new green industries;
- drive regional growth in areas outside of the capital.

There is no exact definition of what a GEP is, or what their key characteristics should be, and there are many different concepts and make ups to energy parks which have developed internationally to date. Added to that, there is no clear understanding of how these parks should be developed, or the potential economic benefits that they could bring to Ireland. This work seeks to begin to address these points, and provide an assessment of GEP concepts to include:

- A definition and key characteristics of GEP concepts.
- An assessment of GEP models in other jurisdictions.
- A geographical mapping of renewable energy supply and industrial energy demand co-location developments that are currently being planned in Ireland.
- Assessment of future demand for, and economics of developing GEPs in Ireland.
- Assessment of the key criteria for the location and development of GEPs.

To summarise this work, the structure of this report is as follows:

- Section 2 defines GEPs and reviews relevant policy at a national, European Union (EU) and international level
- Section 3 sets out the stakeholder engagement undertaken to inform this work
- Section 4 reviews international energy park case studies
- Section 5 considers Irish plans and key opportunities
- Section 6 carries out a mapping exercise to identify areas in Ireland with high potential for GEPs
- Section 7 carries out economic analysis of GEP scenarios
- Section 8 sets out conclusions and recommendations.

2 DEFINING GREEN ENERGY PARKS

2.1 TERMINOLOGIES

Many countries have adopted concepts similar to GEPs, but different terminologies and definitions are often used to describe these concepts. Figure 2-1 presents some of the commonly used terms but is by no means an exhaustive list.

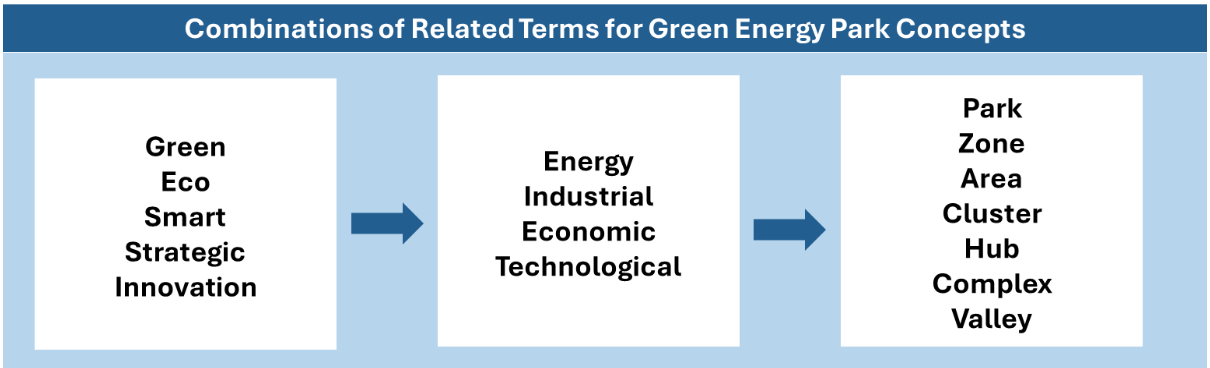


Figure 2-1: Different combinations of terms used for concepts similar to GEPs

Broadly speaking, these are concepts which co-locate LEUs with energy generation, often with additional focus on developing synergies between industries at the site, energy storage, RD&I facilities and the development of other energy transition technologies. Concepts vary greatly in scale, type of activities, levels of integration, degree of sustainability etc. This is discussed further in Section 4.

To inform understanding of GEPs and how these should be defined for Ireland, a policy review was undertaken at an international, EU and national level.

2.2 POLICY CONTEXT

There are several policies and frameworks at international, EU and national level which provide definitions and guidance for the development of GEP concepts, as summarised below.

2.2.1 INTERNATIONAL LEVEL

In 2021, the **United Nations Industrial Development Organisation (UNIDO)** provided a framework for developing **Eco-Industrial Parks (EIPs)** [3]**.** This framework defines basic requirements and performance criteria needed for an industrial park to qualify as an EIP, and provides a broad definition for an EIP as:

- A managed industrial area that promotes cross-industry and community collaboration for common benefits related to economic, social and environmental performance.

The document notes that these goals should be incorporated into the siting, planning, management, and operations of EIPs, and that aims for such areas include - resource efficiency; cleaner production; industrial symbiosis; pollution reduction; increased social standards; shared infrastructure; improved management of risks; and shared resources, including land and ecosystem services.

This broad definition means that many different concepts that integrate industries, energy production, and resource sharing to enhance economic, social, and environmental outcomes could qualify as EIPs. For decades, industries have clustered to efficiently link industrial activities with commercial and infrastructure services, boosting economic output. The UNIDO framework sees an opportunity to plan and manage industrial parks to not only meet economic targets but also social and environmental targets.

The document sets out some key requirements for EIPs, which include:

- **Increasing management performance** by investing in better infrastructure, applying national/international standards, organising and managing services, and marketing
- **Enhancing environmental performance** by minimizing park footprints, providing sustainable means of managing water, wastewater and resources and addressing climate change issues
- **Improving social performance** by addressing the needs of the community and employees in relation to labour rights, working conditions etc.
- **Increasing economic performance** by maximising returns for park managers and business owners, with these benefits including revenue and profit, job creation, increased competitiveness due to efficiencies in development and operations and investment for resident industries

While climate and sustainability are not key aims of EIPs, there are some key environmental drivers listed for EIPs which include: climate change commitments at national level, policy mechanisms, greening the supply chain through circular economy practices, and providing cost-effective infrastructure which can adapt to climate change.

There are also social drivers noted (better working conditions, local employment, gender equality, provision of vocational training etc.), as well as economic drivers (direct and indirect employment creation, skills-upgrading of the labour force, linkages between industrial park firms, small and medium sized enterprises (SMEs), and communities outside the industrial park, regional development approaches etc.). These drivers are similar to those for GEPs in Ireland.

Some barriers which are presented to the implementation of EIPs include: access to competitively priced water, energy, or raw materials for park resident firms, high short-term investment costs for longer term financial returns (relative to other international costs and less integrated / smaller scale approaches), challenges in transitioning to sustainability and integration of multiple complex processes.

Barriers in different areas and potential solutions are noted below in Table 2-1, summarised from the UNIDO's International Framework for Eco-Industrial Parks [3].

While EIPs do not have the same focus on renewable energy generation, and the co-location of this with demand, they do have a lot of commonalities with what is expected of GEPs, face similar challenges and share similar goals, which can help to inform Ireland's approach to the development of GEPs.

Table 2-1: Key Barriers for EIPs, and potential solutions, adapted from [3]

Key Barriers for EIPs and Potential Solutions	
Regulatory Barriers	
Barriers	**Potential Solutions**
• Lack of policies to encourage EIPs • Lack of policies to encourage clean technology development • Regulations not applied universally, leading to competitive disadvantages	**Policy makers can:** • Seek to understand the key national and local barriers to the adoption of environmental and social standards in industrial operations • Set hard and soft targets for the development of EIPs • Develop command and control, and fiscal incentives that encourage EIPs • Engage in national/regional/international dialogue to source best practices
Technological and socio-economic barriers	
Barriers	**Potential Solutions**
• Lack of finance to implement pollution prevention mechanisms • High upfront capital costs with longer term returns on investments limit implementation • Limited financial support for innovative processes and environmental measures to improve park infrastructure • Long lead times and disruptions when installing new technologies	**Policy makers can:** • Provide capital subsidies and support to implement new technologies • Encourage technological cooperation programs • Encourage standardisation • Promote socially responsible business practice **EIPs can:** • Engage in park-level dialogue and enterprise training to improve awareness of cost effective and advanced technology solutions and socially responsible business practices and associated benefits • Deploy outsourced, technically sound infrastructure and services through viable business models
Institutional and organisational capacity	
Barriers	**Potential Solutions**
• Lack of internal resources and technical workforce • Lack of motivation for continuous improvements in moving toward an EIP • Lack of experience in dealing with developers and authorities • Lack of capacity for energy conservation and pollution prevention, or awareness of their cost saving potential	**Policy makers can:** • Prepare national guidelines and standards for EIPs • Fund training programmes **EIPs can:** • Examine sector-specific international best practices and adhere to them • Develop internal training programs to build human resource capacities • Engage with national and regional stakeholders to build confidence in EIPs

2.2.2 EU LEVEL

Currently, the **European Commission (EC)** does not have a single, dedicated policy document for GEPs or similar concepts. However, policies which relate to or can inform the development of GEP concepts are contained within other policy documents.

The EC's 2020 **Circular Economy Action Plan (CEAP)**, [4] part of its European Green Deal, promotes climate neutrality at industry sites with the following circularity actions:

- The CEAP aims to promotes industrial symbiosis, an important element of GEP concepts, through an industry-led reporting and certification system
- The CEAP aims to promote circularity, another important element in many GEP concepts, through the integration of circular economy practises at industrial sites

We can also look to the **EU Energy Efficiency Directive** which aims to reduce overall energy consumption in EU Member State (MS) and is a key directive as the EU aims to reduce greenhouse gas emissions by at least 55% (compared to 1990) [5]. The revised Energy Efficiency Directive (EU/2023/1791) entered into force on 10 October 2023 [6] and establishes 'energy efficiency first' as a principle of EU energy policy, meaning that all MSs must consider efficiency in key policy and investment decisions. It notes energy efficiency as one of the cleanest and most cost-efficient measures by which to increase security of supply.

The directive discusses the increased need for this in the context of data centres and industrial demands possibly increasing their energy demands as they aim to decarbonise operations. Simply, the directive states that energy efficiency solutions should be considered as the first option in policy, planning and investment decisions by MSs when setting new rules for the supply side and other policy areas. While there is no specific mention of energy parks, the directive puts the onus on MSs to adopt 'a holistic approach, which takes into account the overall efficiency of the integrated energy system, security of supply and cost effectiveness and promotes the most efficient solutions for climate neutrality across the whole value chain.'

The 2023 revised directive set binding targets for EU countries to collectively ensure an additional 11.7% reduction in energy consumption by 2030, compared to the projections of the EU reference scenario 2020. The revised directive also introduces an obligation for the monitoring and reporting of the energy performance of data centres. The directive sets out the goal that EU countries must achieve, however, it is up to the Ireland to devise its own laws on how to reach these goals.

Another important directive is the **Renewable Energy Directive (RED)** [7]**.** The RED EU/2018/2001 was revised in 2023. The amending directive (RED III) entered into force in November 2023 [8], with MSs given 18 months to transpose most of its provisions into law, with a shorter deadline for some permitting provisions, as improvements to the permitting of renewables was seen as one of the most urgent changes needed to support the future roll-out of renewable projects.

RED III increases the EU's renewable energy target to 42.5% by 2030, with MSs encouraged to endeavour to reach 45%. Key motivations for this increase in ambition were Russia's invasion of Ukraine, and the effects of COVID-19, which exposed the EU's over reliance on imported energy and led to a surge in energy prices across the Union.

To address this, the EU aims to accelerate the deployment of renewables to increase generation within MSs, lower reliance on imports, increase security of supply and prevent or lessen the impact of future price spikes in fossil fuel markets. Some points of note from the directive are:

- Spatial planning is an essential tool with which to identify and steer synergies for land, inland water and sea uses. MSs shall favour multiple uses of the areas, and renewable energy projects shall be compatible with pre-existing uses of those areas.
- MSs should support the faster deployment of renewable energy projects by carrying out a coordinated mapping for the deployment of renewable energy and related infrastructure in their territory in coordination with local and regional authorities. By 21 May 2025, MS should carry out this exercise to identify the domestic potential and the available land surface, sub-surface, sea or inland water areas that are necessary for the installation of renewable energy plants and their related infrastructure, such as grid and storage facilities, including thermal storage
- MSs should designate as a sub-set of those areas as renewables acceleration areas (RAA)[1]. Those areas should be suitable for the purpose of developing renewable energy projects. By 21 February 2026, Member States shall ensure that competent authorities adopt one or more plans designating renewables acceleration areas for one or more types of renewable energy sources.
- Renewables projects in RAAs should benefit from a presumption of not having significant effects on the environment. Therefore, such projects in some cases could be exempt from the obligation to carry out a specific Environmental Impact Assessment at project level.
- MSs should be able to designate dedicated infrastructure areas, where the deployment of grid or storage projects that are necessary to integrate renewable energy is not expected to have a significant environmental impact, such an impact can be duly mitigated, or compensated for. Infrastructure projects in such areas may benefit from streamlined environmental assessments.
- MSs shall ensure that the permit-granting procedure shall not exceed 12 months for onshore renewable energy projects in RAAs, or 2 years for ORE projects.
- The permit-granting procedure for the repowering of renewable energy power plants, for new installations with an electrical capacity of less than 150 kW, for co-located energy storage, including power and thermal facilities, as well as for their grid connection, where located in RAAs, shall not exceed six months. However, in the case of offshore wind energy projects, the permit-granting procedure shall not exceed 12 months. Outside of RAAs, permitting granting procedures should not exceed 2 years for onshore projects, 3 years for offshore.

The **Net-Zero Industry Act** (NZIA) entered into force on the 28 May 2024. It aims to enhance European manufacturing capacity for net-zero technologies and their key components, and sets a goal for net-zero manufacturing capacity to meet at least 40% of the EU's annual deployment needs by 2030.

[1] "renewables acceleration area" means a specific location or area, whether on land, sea or inland waters, which a MS designated as particularly suitable for the installation of renewable energy plants

The Act allows for the establishment of net-zero strategic projects, essential for enhancing the resilience, strategic autonomy, and competitiveness of the EU's net-zero industry. Net-zero strategic projects receive additional advantages, including priority status at national level, faster permitting, focused attention in the Net-Zero Europe Platform[2], and urgent treatment in judicial and dispute resolution procedures, in line with national and EU laws. The Act also enforces the implementation of mandatory non-price criteria in procurement procedures for clean technologies and renewable energy auctions, and makes it possible for MSs to set up regulatory sandboxes to test innovative net-zero technologies and stimulate innovation, under flexible regulatory conditions [9].

These directives taken together show a clear support for a more coordinated, plan-led approach to the deployment of renewables and associated infrastructure, a favour towards multi use sites and more efficient use of infrastructure, while at the same time looking to speed up and streamline the permitting of projects, which will be crucial to reaching deployment targets.

2.2.3 NATIONAL LEVEL

Currently, Ireland also does not have a single, dedicated policy document for GEPs, however, several key national policies and strategies support or will inform their development, some of which are discussed below.

The **Department of the Environment, Climate and Communications'** (DECC) much anticipated **National Hydrogen Strategy** [2] from July 2023 set out the strategic vision for the role that H_2 will play in Ireland's future energy system, with a focus on how it can contribute to decarbonising our economy, enhancing our energy security, and developing industrial opportunities for Ireland. Points of note in relation to GEPs or similar contained in the document include:

- The use of H_2 as a primary energy source for LEUs, such as data centres, is considered a low priority end-use, as the direct supply of electricity from renewables will be more efficient.
- Renewable H_2 in combination with direct renewable sources and co-located with LEUs could be used to fuel on-site back-up generation, in particular through integrated energy park developments which co-locate LEUs and renewable energy generation alongside energy storage or transport infrastructure. A major benefit of this approach cited is the limited new capacity requirements placed on the electricity grid.
- Integrated Energy Parks for LEUs are noted as the third highest priority end use of renewable H_2 in Ireland, behind replacing existing H_2 end uses (Priority 1) and providing flexible power generation and long duration storage (Priority 2).

[2] The platform advises on financing for net-zero strategic projects and engages in international net-zero industrial partnerships.

DETE's 2024 policy document - **Powering Prosperity: Ireland's Offshore Wind Industrial Strategy** [1] outlines the following in relation to GEPs:

- There is potential for the co-location of LEUs with renewable energy generation.
- LEUs, including data centres, could use surplus ORE as part of their decarbonisation.
- Consultations with industry, carried out as part of the strategy development, identify the opportunities to establish new indigenous green businesses based on the expected supply of abundant renewable energy and a strategic approach to co-locating this supply with demand.
- GEPs can provide new industrial opportunities for appropriate geographical locations where complementary renewable energy can be sourced/developed.
- A number of key enabling actions including undertaking further assessment of GEPs, commissioning a sectoral assessment of energy park concepts, including an analysis of the economics of the capital investment required, and leading a fact-finding mission with key stakeholders to international locations where green energy industrial parks (actions 36 - 38).

DECC's Future Framework for Offshore Renewable Energy Policy Statement [10] from May 2024 lays down a roadmap for how Ireland's ambitions of 20GW ORE by 2040; and at least 37GW in total by 2050, will be achieved. The framework notes that multipurpose sites, which involve the co-location of ORE generation technologies, can optimise site efficiency by improving energy security through increased generation, streamlining the regulatory and consenting processes compared to individual projects, and limiting adverse effects on the environment by optimising spatial usage of a geographic area. While marine multipurpose site which involve ORE technology co-location are different to GEPs as discussed above, there are similarities and potential synergies.

Considering the potential for offshore wind to feed into GEPs, an important piece in the future development and location of offshore wind in Ireland is **Maritime Spatial Planning.** Ireland adopted its Maritime Spatial Plan (MSP), **the National Marine Planning Framework (NMPF)** in July 2021 [11]. The framework provides for spatial designations for specified areas or uses which will be known as **Designated Maritime Area Plans (DMAPs).** A DMAP will be a management plan for a specific area of our marine waters and can be used to develop multi-activity area plans; to promote use of specific activities; and/or for the purposes of the sustainable use and protection of particular marine environments. Through spatial designations and policy objectives, a DMAP will guide future developments in Ireland's seas and oceans, including in respect of ORE. An overview of how a DMAP can be established is given in the NMPF, with this process then set out in legislation in the **Maritime Area Planning (MAP) Act 2021** [12].

Ireland established its first DMAP – **The South Coast Designated Maritime Area Plan for Offshore Renewable Energy (SC-DMAP)** [13] – in October 2024. The Plan identifies four Maritime Areas in the Irish part of the Celtic Sea within which proposed future fixed-bottom ORE projects may be located and includes policies that will guide ORE deployments and competent authority decision-making. Rights to develop Maritime Area A (Tonn Nua) will be auctioned in ORESS Tonn Nua in 2025, for development as close to 2030 as feasible. Further ORE deployments will take place in Maritime Areas B-D according to the timing and methodology determined by the Minister for the Environment, Climate and Communications, in their role as DMAP Competent Authority.

The Tonn Nua project will be directly connected to the grid, with this offshore transmission infrastructure being developed by EirGrid. The offtake solution and routes to market in respect of ORE developments in Maritime Areas B-D is yet to be determined but will take place through an orderly, strategic and managed process of development (see site details in Table 2-2, Figure 2-2).

The SC-DMAP discusses the potential role for ORE in driving regional development, and the opportunity for the south coast to align the development of offshore wind energy with LEUs in the pharmaceutical, technology and data industries. The plan also highlights the role that Regional Assemblies, Local Authorities, and the ORE Taskforce can play in identifying areas suitable for the development of energy parks, with this to potentially form part of a **National Energy Park Strategy.** DECC, through its role in the Offshore Wind Delivery Taskforce (OWDT), is expected to publish a **roadmap for future DMAPs shortly** which should indicate plans for when and where future DMAPs in Ireland will be established. This will be important to informing future GEP planning.

Table 2-2: Summary of Maritime Areas A-D in the SC-DMAP [13]

Parameter	Tonn Nua (A)	Lí Ban (B)	Manannán (C)	Danu (D)
Area (km^2)	306	368	341	300
Distance to shore (km)	12.2	24	25	26
Min – Max & Mean water depth (m)	48 – 69, 57	65 – 76, 70	64 – 72, 69	48 – 94, 67
Average wind speed @ 150m (m/s)	10.4	10.4	10.4	10.4
Indicative capacity range (GW)	0.9	1.1 – 1.5	1 – 1.4	0.9 – 1.3

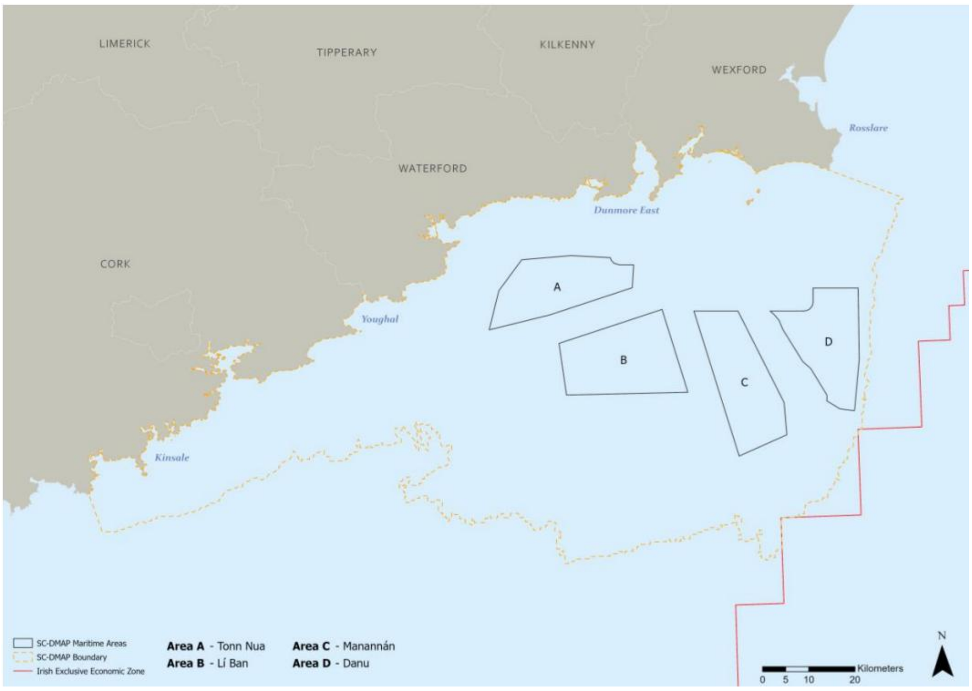


Figure 2-2: SC-DMAP overview showing Maritime Areas A-D [13]

Grid development will of course be another key part of Ireland's energy future, and important to where and when GEPs will be developed in Ireland.

In November 2021, EirGrid released **Shaping Our Electricity Future (SOEF) 1.0** [14], outlining a grid development roadmap towards at least 70% renewable electricity by 2030 while considering net zero targets for 2050. This outlined the key grid infrastructure development that would be required to reach the then target of 70% renewable electricity. In July 2023, this was updated with **SOEF 1.1** [15], to account for Ireland's updated target of 80% renewable electricity by 2030. The scenarios used by EirGrid for Ireland and Northern Ireland in SOEF 1.1 are shown below in Table 2-3. The capacity values in the table are the additional capacities compared to the year 2023.

Table 2-3: SOEF 1.1 assumed capacities to reach 80% renewable electricity by 2030 [15]

Category	Ireland	Northern Ireland
Demand	45.1 TWh (~Median GCS Scenario)	10.8 TWh (~Median GCS Scenario)
Offshore Wind	+5,000 MW +2,000 MW for H2 production	+500 MW
Onshore Wind	+4,500 MW	+1,000 MW
Solar PV	+8,000 MW (including 2,500 MW small scale)	+400 MW (including 100 MW small scale)
Short Duration Storage	+100 MW	+50 MW
Long Duration Storage	+2,400 MW	+350 MW
De-rated Gas Capacity	+2,000 MW	+900 MW

The SOEF reports also contain information for proposed upgrades to the transmission system to accommodate these capacities of renewables (Figure 2-3 & Figure 2-4). Figure 2-3 is taken from SOEF 1.0 and notes grid upgrades required to reach the then target of 70% renewable electricity by 2030, while Figure 2-4 is taken from SOEF1.1 which includes additional grid upgrades required to reach the 80% renewable electricity target.

The SOEF 1.1 roadmap also plans for several 'renewable hubs' in the midlands and southeast. Renewable hubs are envisaged by EirGrid to permit the gathering together of renewable projects in a geographic area into a new collector substation and injecting power onto the grid where there is realisable capacity, which could play an important role in GEPs. This approach avoids multiple smaller-scale connections to the 110 kV grid with associated planned outage implications, according to EirGrid. Generation, storage, network support devices, and demand could potentially all connect at these collector substations. EirGrid has identified four candidate large-scale renewable hubs in SOEF 1.1, three to accommodate new renewable generation in the midlands, and one to accommodate renewable generation in the southeast. Plans for the renewable hubs include:

- A 400 kV hub collector substation looped-in to the Oldstreet– Woodland 400 kV circuit and a 220 kV hub collector substation looped-in to the Maynooth – Shannonbridge 220 kV circuit (both in the eastern Midlands);
- A new 220 kV hub collector substation tailed into the Maynooth 220 kV substation (Kildare); and
- A new 220 kV renewable hub collector substation tailed into the Great Island 220 kV substation (Wexford).

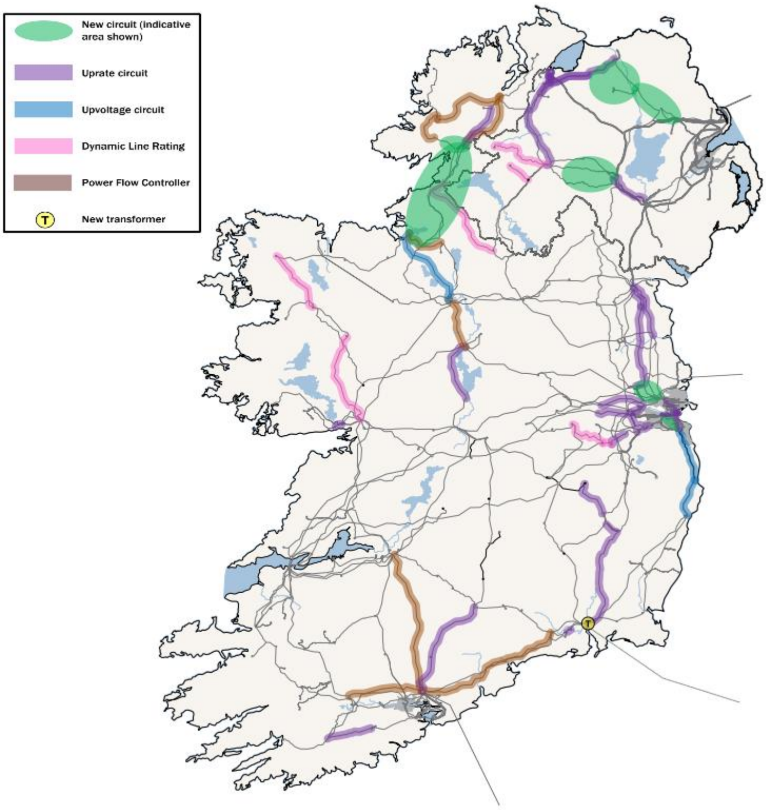


Figure 2-3: Map of Ireland and Northern Ireland (NI) detailing reinforcements [14]

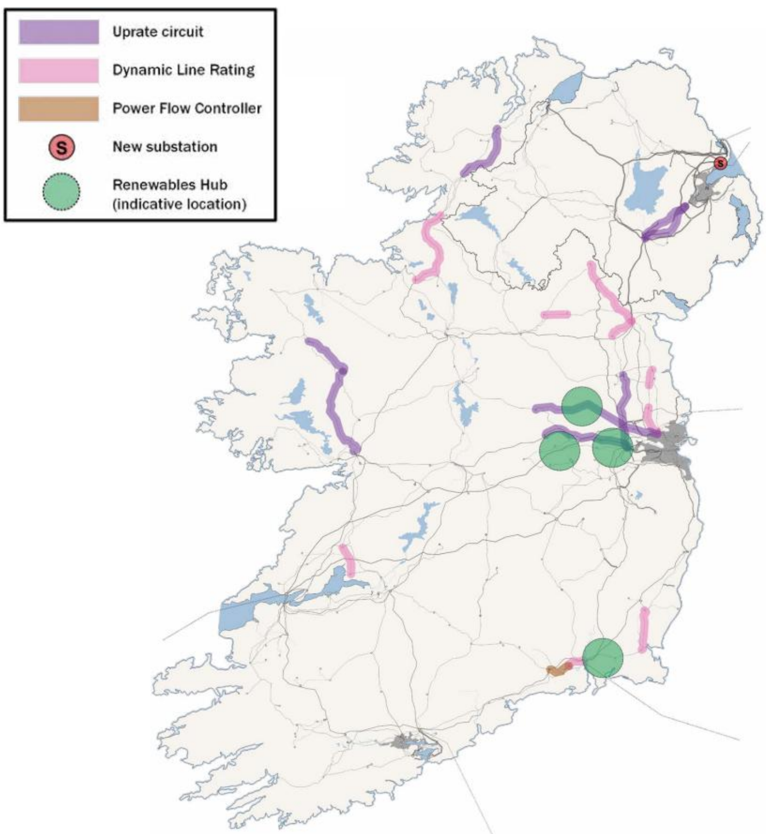


Figure 2-4: Map of Ireland and NI detailing reinforcements [15]

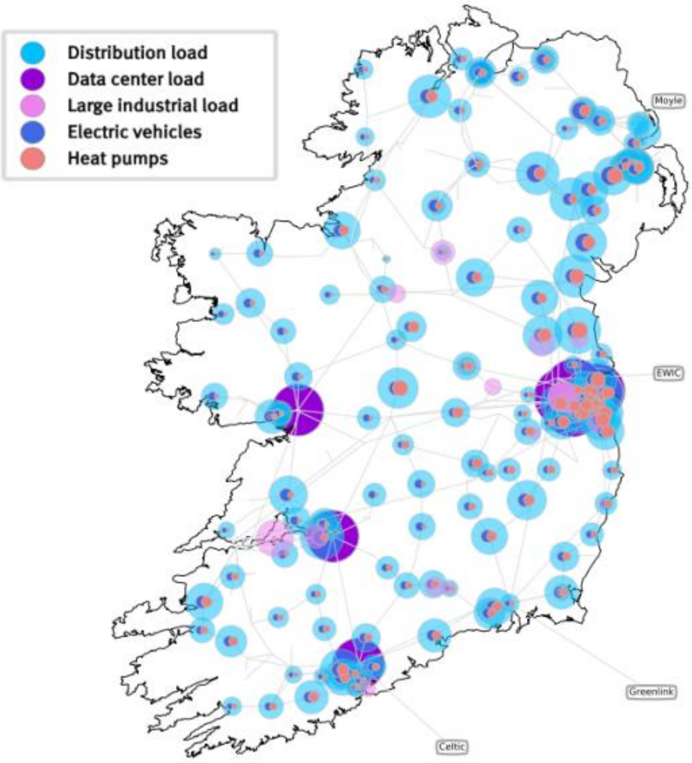


Figure 2-5: Map of Ireland and NI detailing demand spatial distribution in 2030 [15]

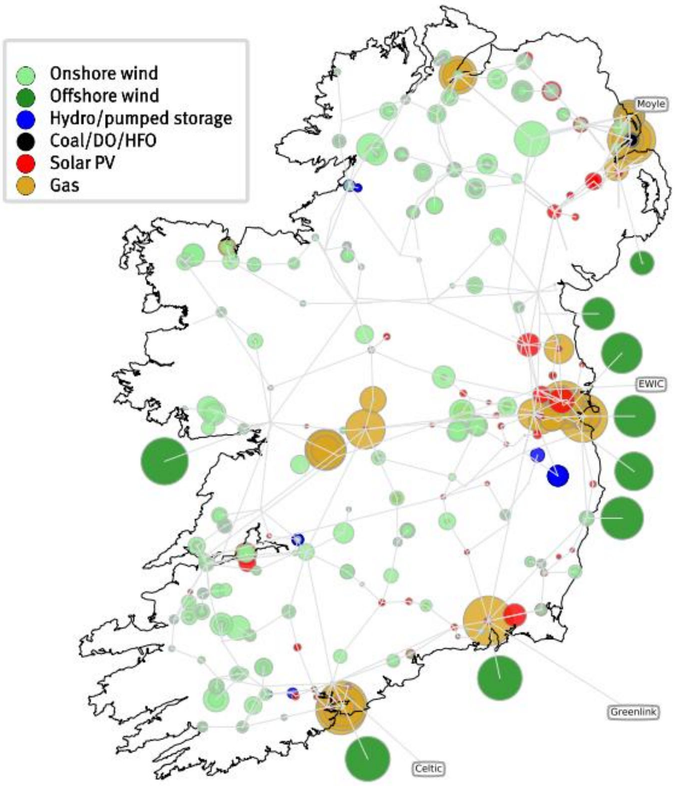


Figure 2-6: Map of Ireland and NI detailing generation spatial distribution in 2030 [15]

The SOEF reports also spatially map expected demand and generation in 2030, based on EirGrid modelling. Primary areas of demand can be seen in the Dublin, Cork, Waterford, Galway and Limerick areas (Figure 2-5).

Figure 2-6 shows modelled electricity generation. It can be seen that allowance has been made for all of the Phase 1 offshore wind projects (Oriel Wind Farm off the coast of Louth, North Irish Sea Array (NISA) off the coast of north county Dublin, Dublin Array off the coast of Dun Laoghaire and north Wicklow, Codling Wind Park off the coast of Wicklow, Arklow Bank off the coast of Arklow and Sceirde Rocks off the coast of Galway). In addition, the report modelled for 2 south coast offshore wind farms (this was prepared before the SC-DMAP).

Another important aspect in relation to grid and GEP development in Ireland is the future role of private wires, as discussed by DECC in the **Private Wire Guiding Principles for Policy Formulation** [16] from 2024. Private Wires refers to private individuals or undertakings running their own electricity cables in order to transfer electricity from one site to another. As of July 2024, the legal position in Ireland is that only the ESB can own an electricity distribution or transmission system[3], and as such the supply of electricity from generation site to demand user takes place on the ESB owned, National Electricity Grid. This is a barrier to the development of Energy Parks, as well as to Ireland's Corporate Power Purchase Agreement (CPPA) targets.

Private wires policy is required to expand the right of private undertakings to connect supply directly with demand, and the **Climate Action Plan (CAP) 2024** Annex of Actions [17] includes a commitment to develop a Private Wires Policy Framework by the end of 2024 which is eagerly anticipated. This will be an important development for the future of energy parks.

Key principles set out in the policy paper however note that:

- any change to private wire policy must complement other policy objectives around security of supply, offshore wind, climate ambitions etc;
- the National Electricity Grid will remain the primary way to connect generators and consumers to consumers of electricity, and where grid-based solutions are available, these will be preferred;
- those with a private wire must pay the full cost of the service they have sought from, or is provided to them by, the National Electricity Grid; and
- private wires will not be permitted to undermine the efficient development of the National Electricity Grid.

As discussed, data centres are seen as a key potential demand for GEPs in future. In July 2022, Government released its **Government Statement on the Role of Data Centres in Ireland's Enterprise**

[3] as per Part III of the Electricity Regulation Act 1999, although changes will be required to enable EirGrid to fulfil its future role as offshore Transmission Asset Owner. The only limited exceptions to this rule are where a developer builds their own connection from a new generator to the national grid, with ownership of transmissions assets ultimately transferring to the ESB (known as on a "contestable basis"), or where the CRU permits the construction of a 'direct line' between a generator and customers where an applicant has been refused a connection to the national grid due to a lack of capacity, or the CRU has otherwise determined a connection dispute. The CRU can also authorise others to own interconnector infrastructure, which is not automatically part of the transmission system, as per the Act.

Strategy [18]**.** It notes that data centres are core digital infrastructure and play an indispensable role in our economy and society, however, in the short term, there is only limited capacity for further data centre development, as the key state bodies, regulators and the electricity sector work to upgrade our infrastructure, connect more renewable energy and ensure security of supply. Overall, the statement notes that Government's preference is for data centres which are associated with strong economic activity and employment, make efficient use of our electricity grid, and help to fund renewable energy through CPPAs in Ireland. It also notes 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 CPPA, private wire or other arrangement. In relation to CPPAs, a 2030 target of having 15% of electricity demand supplied by renewable sources contracted under CPPAs was first included as a target in the CAP 2019 (although it has not been included in subsequent versions of the CAP). GEPs, combined with Private Wire Policy, could play a key role in meeting this target.

Additional load relating to data centres will only be permitted if it meets the requirements set out in the **CRU Direction to the System Operators (SOs) related to Data Centre grid connection processing (CRU Direction CRU/21/124)** [19]. In this Direction from the CRU from November 2021, they directed EirGrid and ESBN to implement measures to prioritise data centre connection offers based on the location of each data centre applicant; the ability of each data centre applicant to bring onsite dispatchable generation (and/or storage) equal to or greater than their demand; and the ability of each data centre applicant to provide flexibility in their demand by reducing consumption when requested to do so by the Transmission System Operator (TSO) in order to support security of supply. **The CRU's proposed decision paper on the LEU connection policy (CRU202504)** (February 2025) is also an important consideration in this regard [20]. The proposed decision paper sets out a potential pathway for connection applications for new data centre customers to the electricity grid. The primary points from this proposed decision include:

- Data centres connecting to the electricity network will be required to provide dispatchable generation or storage onsite or nearby with matches their Maximum Import Capacity (MIC) and will participate in the electricity market. There are no requirements for this generation to be from renewable sources
- The ramping up of a new data centre's demand will be linked to the delivery of the required generation. If the performance of the dispatchable generation falls below a certain threshold, the SOs may reduce the amount of electricity the data centre can import from the grid
- The SOs will consider the location of any data centre connection applications and associated generation capacity in respect of if it is in a constrained or unconstrained region
- Data centres will be required to report to the SOs annually on their use of renewable energy and their sites' emissions. A summary of these reports will be published
- The CRU notes that energy parks can allow the location of anchor client demand facilities on the same site as or proximate to renewable generation and storage, and reduce the need for the use of electricity network infrastructure, and that these types of arrangements may help facilitate new LEU connections while respecting security of supply and system constraints
- SOs can require demand flexibility from data centres on the local system as deemed necessary

This work takes place in the context of a large projected rise in electricity demand in Ireland. **EirGrid's Ten-Year Generation Capacity Statement (GCS) 2023–2032** [21], released in January 2024, states that it is likely that in the coming years we will experience system alerts and will need to work proactively to mitigate the risk of more serious impacts, due to an inadequacy of electricity generation to meet demand. The median demand scenario projects that Total Electricity Requirement in Ireland will increase from approximately 34TWh in 2024 to almost 45TWh in 2032.

Also notable is that by 2032, 30% of all electricity demand is expected to come from data centres and new technology loads (NTLs) (currently approximately 20%). The GCS states there is presently approximately 2000 MVA of demand capacity that is contracted to data centres and other new technology loads at the transmission level, and approximately a further 300 MVA contracted at the 110 kV distribution level. Almost all this extra load is contracted in the greater Dublin region and was contracted prior to the CRU Direction CRU/21/124. Policy going forward should ensure that data centre development takes place in a more regionally balanced manner, assuming all other requirements of data centres can be achieved e.g. access to national optical cable infrastructure and other necessary infrastructure, which also opens up the potential for the co-location of renewables and data centres in GEPs outside of the Dublin region.

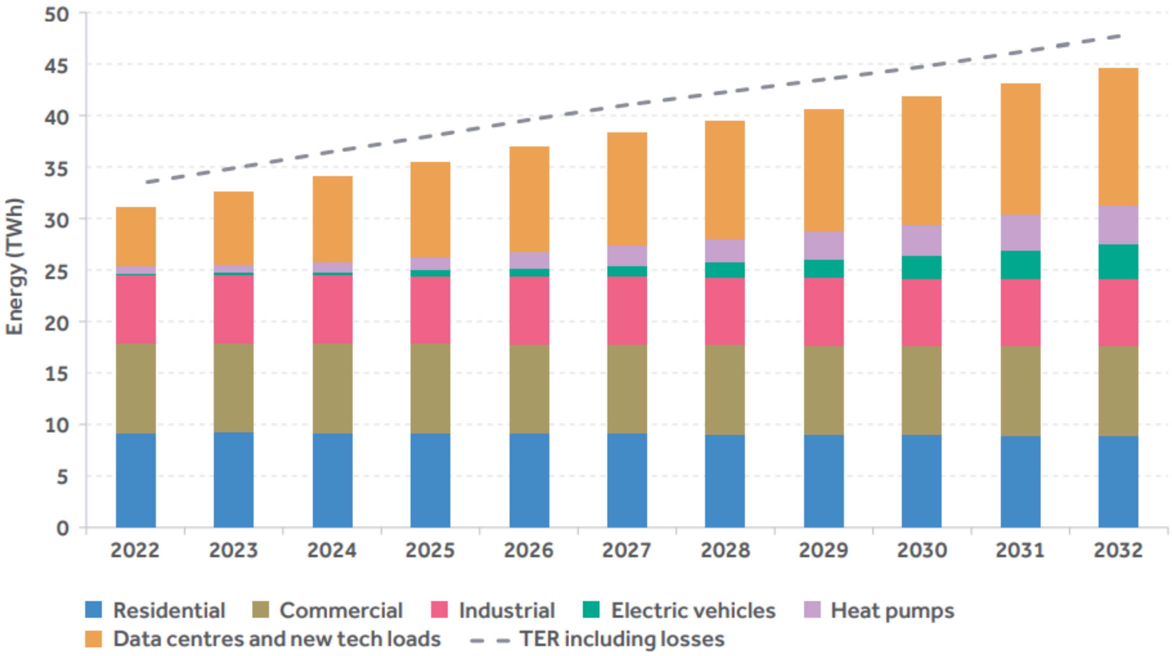


Figure 2-7: Ireland median demand scenario showing the approximate split into different sectors

A key point in this regard is infrastructure requirements to support these developments. European Commission analysis from 2022 found that infrastructure in the Irish Northern and Western region is at 34.7% of EU 27 average level, while the Southern region is at 50.7% of the average, and the Eastern and Midlands region is at 115.2% of the average [22]. The 'Infrastructure' pillar in this assessment describes dimensions of infrastructural quality such as connectivity and accessibility, and includes rail and road transport performance, and access to passenger flights [23]. Strong infrastructure in the Dublin region is a reason that development to date has centred here, which serves to further increase this disparity. To reverse this trend, infrastructure must be improved generally in these regions outside Dublin, which will attract more investment and further improve infrastructure.

Looking longer term, **EirGrid's Tomorrow's Energy Scenarios (TES) 2023** [24] analysis shows electricity demand more than doubling by 2050, with forecasts of a demand of up to 86TWh by 2050 (Figure 2-8), with a peak demand of around 13GW. The report recognises that the growth of technologies such as Artificial Intelligence (AI) and other emerging new technologies may lead to additional demands that are not possible to accurately forecast over extended time horizons, so this assumption may be seen as conservative.

The document notes that there will be an increased need for efficiency and demand flexibility to accommodate this increased demand. It notes that data centres have a flat demand profile and are not considered flexible.

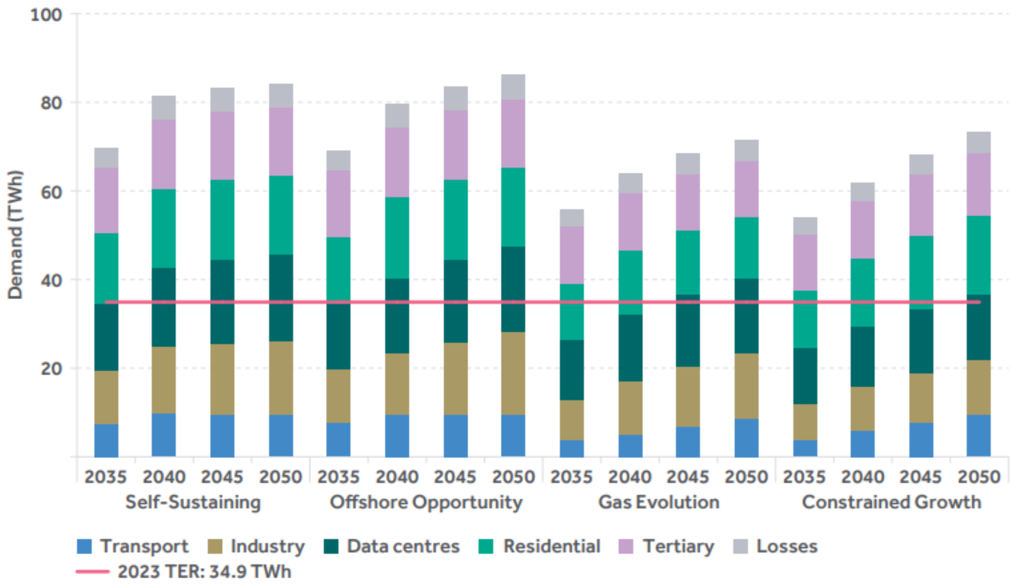


Figure 2-8: Modelled Annual Total Electricity Requirements from TES 2023 [24]

In July 2024, the CRU released the **National Energy Demand Strategy Decision (NEDS)** [25]**.** The report focuses on progressing initiatives that can contribute towards demand flexibility in the short term, in addition to defining the longer-term strategic plan. The strategy aims to set out measures to ensure electricity demand is consistent with Ireland's carbon budgets and sectoral emissions ceilings; deliver demand flexibility; and support the delivery of Ireland's transition to net zero by 2050. It lists key initiatives to:

- Incentivise and enable LEUs to participate in flexible demand initiatives
- Create a route to market for medium and long-duration storage facilities
- Identify smart energy pilot schemes and skills training that can enable the adoption of demand side flexibility behaviours in communities.

This document shows there will be a need for a strategic approach to the connection of new LEUs, and that LEUs will need to provide more flexibility than has been shown in the past.

Terrestrial planning for the parks and associated onshore infrastructure will of course be key to future GEP development. With regards planning for strategic developments, **the National Planning Framework** (NPF) is a policy document used to guide sustainable development and high-level strategic planning for the next 20 years in Ireland. An Updated Draft Revised NPF was published in November 2024 [26]. An overarching aim of the NPF is resource efficiency and transition to a climate neutral economy, which will be achieved through sustainable land management and resource efficiency and renewable energy helping us to reach a climate neutral economy. Relevant points and objectives from the NPF which will inform and support GEP development include:

- **National Policy Objective (NPO) 48:** Regional, metropolitan and local development plans will take account of and integrate relevant MSP issues.
- **NPO 67:** Support the circular and bio economy including through greater efficiency in land and materials management.
- **NPO 68:** Support the growth and development of efficient district heating, electrification of heating, and utilisation of geothermal energy.
- **NPO 71:** Support the development and upgrading of the national electricity grid infrastructure, including supporting the delivery of renewable electricity generating development.
- **NPO 73:** Support the co-location of renewable technologies with other supporting technologies and complementary land uses … at appropriate locations.
- **NPO 74:** Each Regional Assembly must plan, through their Regional Spatial and Economic Strategy (RSES), for the delivery of the regional renewable electricity capacity allocations indicated for onshore wind and solar reflected in Table 2-4 below, and identify allocations for each of the local authorities, based on the best available scientific evidence.
- **NPO 75**: Local Authorities shall plan for the delivery of Target Power Capacity allocations consistent with the relevant RSES, through their City and County Development Plans.
- **NPO 103:** Planning authorities will use compulsory purchase powers to facilitate the delivery of enabling infrastructure to prioritised zoned lands, to accommodate planned growth.
- **NPO 104:** Planning authorities and infrastructure delivery agencies will focus on the delivery of enabling infrastructure to priority zoned lands to deliver planned growth and development.

The NPF is important in setting the context for sectoral policy and policy in lower-level statutory plans, such as the RSESs and local authority development plans. A primary aim of the NPF is for a roughly 50:50 distribution of future growth between the Eastern and Midland region, and the Southern and Northern and Western regions combined (NPO 2), targeting our five cities for 50% of overall national growth between them, with Ireland's large and smaller towns, villages and rural areas accommodating the other 50% of growth (NPO 4). NPO 74 sets onshore renewables capacities per regions, shown in Table 2-4.

Ireland is divided into three **regional assemblies** which each have their own RSES. These assemblies work with local authorities and their subsequent County and City Development plans and this ensures that policy aligns with and reflects the needs of communities at a local, regional and national level.

The regional assemblies planning areas are set out as below, which will be used to inform the spatial assessment undertaken as part of this work (Figure 2-9 - Figure 2-12).

Table 2-4: Regional renewable electricity capacity allocations (extracted from Table 9.1 in [26])

Region	Energised Capacity 2023 (MW)	Additional Renewable Power Capacity Allocations (MW)	Total % of National Share in 2030	Energised Capacity 2023 (MW)	Additional Renewable Power Capacity Allocations (MW)	Total % of National Share in 2030
		Onshore Wind			Solar PV	
Eastern and Midlands	284	1966	25%	306	3294	45%
Northern and Western	1761	1389	35%	0.3	959	12%
Southern	2622	978	40%	138	3302	43%
Total	4667	4333		445	7555	

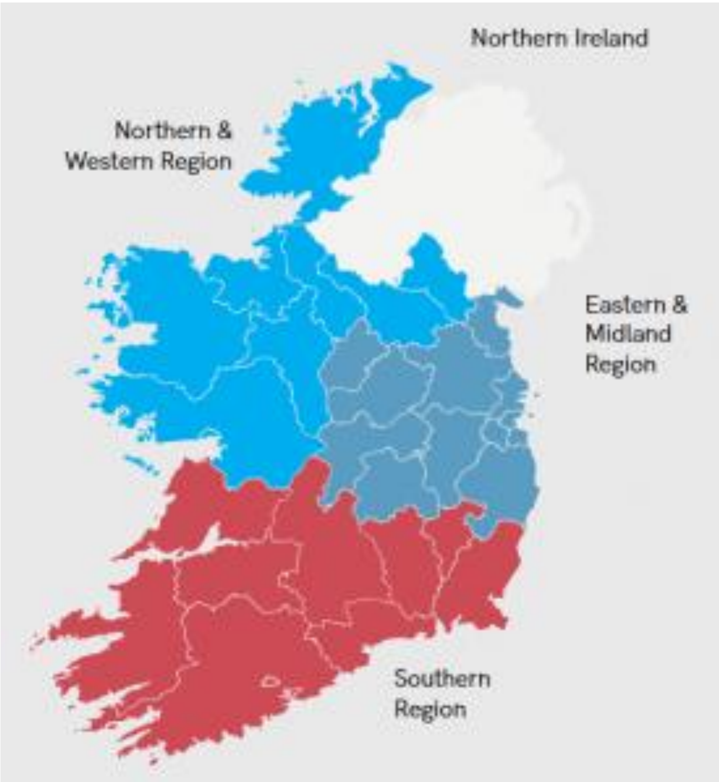


Figure 2-9: Overview of the three Regional Assembly areas [27]

Figure 2-10: Breakdown of the Northern and Western Region (NWR) [28]

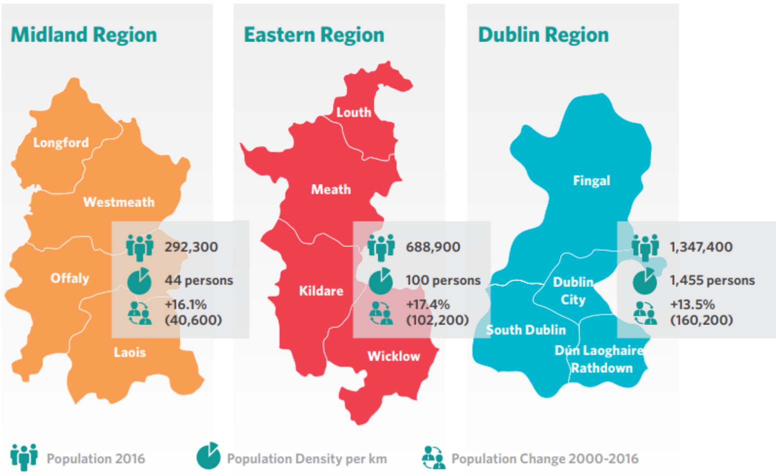


Figure 2-11: Breakdown of the Eastern and Midland Region (EMR) [29]

Figure 2-12: Breakdown of the Southern Region (SR) [30]

The RSESs provide the bridging point between the NPOs set out in the NPF, and local development plans. The RSESs must be consistent with the NPF, as well as the principles of proper planning and sustainable development, and can be used to establish strategic economic development priorities at a regional level, which will embed them in the planning system, and inform decision making at a local level.

At a local level, City and County development plans [31] must be consistent with the NPF, the CAP, and the relevant RSES. These plans form the basis of decision making on individual planning applications, and support economic and industrial development at the right locations through policy measures, zoning objectives and designations.

Going forward, the **Planning and Development Act 2024** [32] includes a specific requirement to include a strategy relating to the economic development of the functional area of the planning authority. The strategy must include objectives relating to: (a) the promotion of sustainable economic development, employment generation and retail provision; (b) the location of employment-related, industrial and commercial development…; and (e) identifying the attributes of particular places within the functional area that are essential to enhancing economic performance, including the quality of the environment, cities, towns and rural areas, the physical infrastructure, and the social, community and cultural facilities. The Act is due to be commenced on a phased basis in 2025 and 2026. When developing these plans, a planning authority will need to identify suitable locations for economic and industrial development, which may be key to identifying suitable locations for GEP development at a local level.

The Planning and Development Act 2000 (as amended) [33] includes a provision that allows the Government to designate lands for the establishment of a strategic development zone (SDZ) where a 'specified development' is of economic or social importance to the State. Once designated, a planning scheme that sets out detail of the nature and extent of development permissible in the SDZ must be submitted to the local authority for approval. Once approved, development proposals that are consistent with the approved scheme must be permitted. These provisions will be replaced in the 2024 Act with Urban Development Zones.

The Planning and Development Act 2024 empowers the Minister for Housing, Local Government and Heritage to issue National Planning Statements (NPS), subject to Government approval. A NPS can set out policy and guidance in relation to planning matters, including the promotion of particular types of development or a particular use of land. These provisions will all be important in designating areas on land for the development of GEPs.

Overall, this review has shown that while there is a lack of detail in Irish policy on what a GEP is defined as, what GEPs will comprise and how they will be developed, which this report will seek to address to a degree, policy pieces have and are being put in place which will support, guide and inform the future development of GEPs in Ireland.

2.3 REPORT DEFINITION

Considering the policy context, international examples, and the opportunities and plans for such concepts in Ireland, this report defines some key characteristics which can be expected of GEPs below.

- ***Sites that co-locate large energy users, such as data centres or large industrial demand, with renewable energy generation***. For many sites, balancing variable renewable energy supply with demand will require forms of energy storage and dispatchable generation. Typically, these sites will have an 'anchor tenant' which will provide the main demand at the park, and additional smaller demands and firms may then also locate at the park.
- ***Sites that have some level of self-sustainability / security of supply and are not over-reliant on the grid***. A key benefit required of GEPs is that they will limit demands on the grid, and minimise and make more efficient use of the infrastructure required (compared to less coordinated, individual developments). This can mitigate costs, enabling focused and aligned development, and ideally reducing permitting requirements. Partial grid connections can be expected however, and fully off-grid GEPs will not be the norm, given technological and policy constraints. Relying solely on electricity storage for security of supply is not feasible given current battery technologies, nor those on the horizon, particularly considering the potential for Dunkelflaute conditions. Any sites with grid connection will have an impact on electricity security of supply in Ireland which needs to be considered.
- ***Sites that are primarily powered by renewable energy, and are or can transition to be net-zero or below a certain emissions threshold***. GEPs in Ireland are seen as a key route to market for renewables, and particularly for offshore wind. While it may be difficult for sites to be 100% powered by renewables, GEPs will need to satisfy some sort of emissions-based criteria. Dispatchable generation in the near-to-medium term can most likely be expected to come from gas-fired power plants, although plans will need to be progressed for these sources to be decarbonised and replaced with other fuels such as green hydrogen or hydrogen-derived fuels.

In addition to the key criteria which define a GEP above, they will also be expected to be:

- ***Sites that promote cross-industry and community collaboration, where possible, for common benefits***. Example of this would be resource sharing between industrial users, or using industrial waste heat for community district heating. The opportunity for cross-industry collaboration will be highly specific to the location and industries present. To maximise benefits, GEPs will need to become sites that promote collaboration for common benefits, A prime example here is the potential seen for hubs to be established around harbours which are developed to support the installation or maintenance of offshore wind projects, which could then develop into supply chain bases, where other associated industries could establish. Similar collaborative examples for other industries can be envisaged. This collaboration is key to the wider motivation for GEPs.
- ***Site that, due to the co-location of renewable energy supply and industrial demand and activities, become centres of expertise***. This could make them ideal choices as supply chain or RD&I hubs for testing energy transition technologies, such as green hydrogen, e-fuels and energy storage. Sites potential as RD&I hubs will again be highly specific to their location and the industries present.

Overall, GEPs in Ireland should aim to improve the economic, social and environmental performance of industries located in the park. Through the co-location of renewable energy supply with industrial demand, and cross-industry collaboration, sites should aim to improve in areas such as resource efficiency; cleaner production; pollution reduction; increased social standards; shared infrastructure; improved management of risks; and shared resources, including land and ecosystem services.

While this definition has sought to set out the key criteria that a GEP should meet, it also raises some important points which may need to be clarified before a full understanding of GEPs can be reached. These considerations are also discussed in Section 8.1:

1. **What does 'co-located' mean and is there a specific distance threshold that needs to be set within which all park infrastructure must be located for it to be defined as co-located and within one GEP?** This threshold could also consider whether users should be required to connect into the same grid node, as this requirement could allow users to determine an acceptable distance threshold, based on the cost and practicality of the grid connection.
2. **What level of security of supply must the park have and how reliant on electricity from the grid can it be?** For example, a park which can support itself with generation from the park for 70% of the year and rely on the grid for the remaining 30% may be classed as a GEP, but one which is 70% grid reliant may not. There may be need for a range or threshold to be set in this regard. Another consideration here are the costs for grid development. GEPs with a reliance on the grid will necessitate the construction of grid reinforcements (and potentially additional conventional dispatchable generation). Under current rules, these costs for grid reinforcements would be charged to all grid users. A mechanism to charge GEP developers for these reinforcements may help to encourage them to lower reliance on the grid to as low a level as is practicable. Time reliance and demand flexibility are other considerations. If GEPs take power from the grid at times of excess generation and lower emissions intensity, and do not contribute to grid congestion, their reliance on the grid on a percentage basis is not as relevant. Potentially approaches to grid connection are discussed further in Section 7.2.2.
3. **What level of emissions is acceptable from the park?** It is clear that a park which is 100% run on fossil fuels would not be seen as a GEP, but it also cannot be expected that all parks will be 100% renewables powered/net-zero emissions, particularly from the outset. There may be a need to set a range or a threshold for carbon emissions/intensity levels from GEPs, or park operators may need to be able to show a roadmap to reaching net-zero or low levels of emissions.

GDG believes that at this stage of development, there is no great benefit to setting strict definitions around the criteria that GEPs need to satisfy. It will be seen in the case studies reviewed later in this report, that plans vary greatly in scale, development approach, phasing, uses etc. To set strict definitions at this stage (e.g. all GEP infrastructure needs to be all located within a specific radius, be self-sustaining and carbon neutral) would likely only serve to hinder development and prevent more innovative approaches.

What is important is that GEP concepts are progressed with the key characteristics set out above in mind, and can demonstrate benefits in terms of resource efficiency, security of supply, lowering demands on the grid, and lowering emissions, with longer term plans for further improvements.

3 STAKEHOLDER ENGAGEMENT

To inform different aspects of this study, GDG conducted a comprehensive stakeholder engagement exercise. This exercise primarily targeted 4 main groups, as set out below:

1. Developers of energy parks in other jurisdictions;
2. Developers with plans for Irish GEPs or similar concepts;
3. Irish Governmental Departments and key State bodies which will be relevant to the future roll-out of GEPs (this group also acted as a Steering Group for the work); and
4. Representatives of LEUs in Ireland.

Interviews were conducted over Teams with key discussion points used to guide the conversations with each stakeholder group. While discussion points were modified slightly depending on the particular interviewee and stakeholder group, generally the primary points discussed were:

- Different terms and definitions for GEPs;
- Key characteristics and drivers for location;
- Key stakeholders in establishing GEPs;
- Funding mechanisms for GEP development;
- Key policy levers;
- Primary barriers to development and potential solutions;
- The role of the State and State bodies in establishing GEPs;
- Discussion around the role for data centres and other LEUs in powering GEPs and how this might work practically.

In total, 15 interviews we completed to inform this work, as well as a meeting with Steering Group members at the mid-point of the project. Other stakeholders were contacted and interested in engaging, but due to time constraints or scheduling conflicts, interviews could not be arranged. Ideally, further interviews would have been conducted with representatives of LEUs in Ireland in particular, so this has been set as a key action to inform future GEP policy development.

Despite this, a comprehensive engagement process was undertaken, and important key learnings were taken from this exercise, as summarised in Table 3-1 below:

Table 3-1: Overview of key learnings from stakeholder engagement

Interviewee	Key Points
Developers of Irish GEPs (Bord na Móna, RWE, ESB, Simply Blue Group, Offaly CoCo, representative from former Shannon Estuary Economic Taskforce)	**Transmission Expansion:** Critical for long-term success of GEPs as fully off-grid solutions are not viable or will be very difficult technically. Planning for grid development needs to be longer term and think of ways to enable GW-scale generation, outside of what is planned in SOEF. There is potential for 'a partial grid connection' approach where the park would be connected to the grid but would be self-sufficient for a good portion of the year, and only use grid electricity when needed. **Policy Clarity:** Needed on private wire connections, auctions to support GEPs (if planned), LEU connection policies, hydrogen strategy, future DMAPs, and the State's role in site selection. **Potential for auctions / State support to encourage GEP development:** Interviewees agreed there was a role for the State needed to support GEP development and provide certainty to enable investment, with different potential roles suggested and no clear preference or view identified. Potential roles suggested included the State taking on some of the risk of the development in some sort of risk-sharing mechanism, the State holding auctions similar to ORESS where renewable energy generation paired with industrial demand could bid as a consortium for an identified site, the State having a role in site selection and making land available, investment tax credits etc. Overall, there was a view that a high level of ambition would need to be shown by the State to facilitate developments. **Planning Beyond 2035:** Thinking around GEPs should focus on long-term benefits. Look at things holistically for the business case, including benefits of additional offshore wind, security of supply etc. **Anchor Tenants & Regional Growth:** Ireland does not have an energy intensive industrial base. Hyperscale data centres are likely to be the key anchor tenant for GEPs in Ireland, but smaller demands offer regional opportunities. **Data centres' electricity requirements:** While seen as the key tenant group, it was noted that data centres require 100% up time and storage and are sensitive to risk, so will be challenging technically to supply with renewables. It was noted that other offtakers in the park would likely need to accept intermittent supply if co-located with a data centre, which could limit options (assuming the other user is not fully grid connected and its primary power source is coming from within the GEP, and renewable generation capacity for the GEP is not significantly oversized for demand within the GEP). The point being made here is that the data centre would

Interviewee	Key Points
	require priority on any renewable electricity generated within the park, storage for the data centre would be the second priority, and any remaining renewable electricity would be available for the other offtaker(s). It should be noted that secondary offtakers with flexible demand could add benefits by maximising the use of any renewable electricity generated and reducing impacts on security of supply by only requiring power at times of high/excess generation. **Permitting & Site Selection:** Permitting will be a key consideration which should inform site selection. Selection of site needs to consider legacy activities and existing infrastructure. Potential need for Strategic Development Zones (SDZs) or similar. If there is a site available and zoned, there is less risk and a greater chance of investment. For offshore wind, given the move to plan-led, a particular site may need to be chosen by the State and designated for a project to feed into a GEP. **GEP characteristics:** Many of the characteristics of a GEP are similar to a normal business park which the IDA will be planning for; they require water and power supply, land you can expand to, back-up power, a skilled workforce, schools, housing, 3rd level facilities, roads and public transport, other industrial activity etc. Aiming for zero-carbon energy parks from the outset could slow development.
Steering Group Members (DECC, EirGrid, DETE, Enterprise Ireland, the Industrial Development Authority (IDA), the Irish Strategic Investment Fund (ISIF))	**GEP characteristics:** Co-location of renewables with demand, close to energy independence, aiming for net-zero. However, details are needed on what these points mean. Large-scale clusters which could have up to 3-5GW offshore wind coming in at one point, which could then be used for H_2, electricity, sustainable aviation fuels (SAF) etc. Parks should initially focus on proven technology but also be used to promote innovation. **Grid Challenges:** Integrating this power into the grid is the key challenge. Our grid is not designed to cope with GW-scale demand. GEPs should limit grid upgrades but will still likely need a partial grid connection. If the park needs a partial grid connection which means all the same grid infrastructure is needed, the benefits in limiting grid upgrades are more limited. **Certainty:** Size, location, and timing of GEP development needs careful coordination so grid, renewable generation and demand can all be progressed, and signals need to be sent to the market. Clear lines of responsibility need to be drawn to note what role the public sector has and what is for the private sector. There is a ‘chicken and egg’ element to consider also in whether the demand comes first or the generation. The development timelines for offshore wind do not align well with corporates’ preferences to sign contracts with generation that will be available in the next 3-5 years.

Interviewee	Key Points
	Funding: it is important to distinguish between the funding of the GEP itself and the funding of the assets or businesses that are situated in the park. For example, the power producer and the energy user may be fully fundable on a commercial basis, but other key elements like site assembly, enabling infrastructure etc. may need to be targeted by the State. **Data centre demand and demand profile:** It is hard to supply a flat profile demand like a data centre with offshore wind. They will need to be flexible and large levels of storage and dispatchable generation will be required. When looking at data centre's demand for power in Ireland, the work should look beyond what is in the planning system and consider the demand that would be there if the grid was less constrained. **Primary barriers:** The price of electricity, planning and consent, lack of land with correct zoning, Policy (private wires, H_2 development, clarity on targets and phasing of these, MSP), grid, different development timelines for offshore wind and GEPs and demands.
Developers with plans for energy parks in other jurisdictions (Ventspils Industrial Park, Latvia, Haraholmen Industrial Park, Sweden)	**Employee Shortages:** Energy parks provide an opportunity for regional development, but more remote regions can struggle to find or attract workers to the areas where energy parks are planned for, which can limit growth. Facilities and infrastructure to house and support workers are a key requirement. **Take advantage of the location and legacy infrastructure/activities:** While there are key drivers to location selection which are common for most energy parks, there is no one-size-fits-all, and each park is planned and designed to take advantage of the location-specific advantages in a flexible manner. Energy parks should look at how to re-purpose existing infrastructure that might have been used previously for fossil-fuel related activities for example, which also enables skill transfer and a just transition. **Long-term policy certainty and funding:** Long term certainty on policy and support from Government and municipalities/local authorities is needed to give confidence for plans to be progressed. Funding should also be made available to progress plans, as well as to provide benefits to the local communities hosting the park. **Grid Infrastructure:** If parks are located in remote regions, a key consideration needs to be how excess power which is sent to the grid can be exported to where it is needed, particularly when large power demands are located far from the generation.

Interviewee	Key Points
	Funding and incentives: Direct funding from government and/or tax incentives/deductions e.g., Special Economic Zones can be beneficial. Competition for these facilities is international, not just national.
Representatives of LEUs in Ireland (Data centre representative)	**Planning:** Planning is a key barrier that needs to be resolved. This includes getting new offshore wind projects through the system, but also speeding up planning for onshore renewables and storage. **Data Centres' interest in Ireland lessening:** We are seeing investment move from Ireland and go elsewhere due to more favorable planning, costs etc. Data centres will also contract with nuclear in other markets. **Grid and Interconnectors:** Grid infrastructure enhancements are needed and are a good long-term investment. GEPs will need some form of grid connection and won't be fully offline. Investment in the grid includes investment in more interconnectors. **Policy Certainty and pro-active planning and infrastructure upgrades:** Changing policy causes uncertainty and prevents investment. A more planned approach which provides certainty is needed, and pro-active investments in grid and infrastructure. **GEPs do provide a strong opportunity:** If barriers can be overcome, offshore wind-powered GEPs are a great solution which can work. They can provide an ecosystem for data centres, RD&I, Universities living etc. **Long duration energy storage needed:** There is a technical challenge to powering data centres with variable renewables, so long duration storage will be key. **Similar concepts being progressed elsewhere:** GEP concepts are being progressed by data centre developers in other jurisdictions including Asia where old shipyards are being converted to data centre campuses due to a lack of land availability, but current concepts can be improved upon to full ecosystems. **Building sustainability into planning for GEPs and data centres can bring long-term benefits and build relationships:** Looking at GEPs and sustainable investments will add costs in the short term in many cases, which causes difficulties in building a business case. These concepts need to be viewed with a long-term lens considering the wider benefits they can bring and the relationships they can forge.

4 INTERNATIONAL GREEN ENERGY PARKS REVIEW AND RESEARCH

4.1 OVERVIEW

While GEPs and related concepts such as energy hubs, enterprise zones, innovation valleys, energy clusters etc. take many shapes and sizes they are relatively new concepts for Ireland, which have not materialised at any great scale here to date.

Some contributing reasons include: Ireland does not have a large industrial or manufacturing base historically where these hubs could organically materialise; we rely on imports to meet most of our energy needs; we don't have offshore wind or hydrogen industries established in the country; significant electricity demand from data centres and LEUs is a relatively newer development here; and private wire connections have not been permitted here to date.

International examples of energy parks or similar can be found, however, which can provide learnings for Ireland. This section of the report provides a review of these examples as part of an assessment of Energy Park models in other jurisdictions.

4.2 OBJECTIVES

This section will provide a review of GEP concepts (or similar) in other jurisdictions. It should be noted that GEPs of scale as ultimately envisaged by the state (large scale industrial demand, powered directly by offshore wind at scale and co-located with onshore renewables, storage, and/or other industrial activities) have not been developed to date as this is an evolving concept. But there are examples of industrial/energy parks that involve some degree of co-location with energy production and/or renewables and other uses. Example of these, from a broad range of countries and jurisdictions, have been chosen and a short summary provided for each in Appendix A – International Case Studies. Four examples have been chosen for more detailed case studies included in Section 4.3.

Priority has been given, where possible, to case studies with large off-takers of renewable energy. For each case study, the following is established:

- What exactly is the energy park/hub/cluster defined as and what are its key characteristics
- How did the park evolve to its current form, and what were the key drivers for the location
- Who were the key stakeholders in establishing the park
- How was the park funded and what governance models are in place
- What policy levers, if any, were used to facilitate and support development of the park

This case studies are informed by the interviews undertaken as part of the stakeholder engagement process (See Section 3). The key findings are synthesised, and an overview of how they can apply to Ireland is provided.

4.3 INTERNATIONAL CASE STUDIES

The different international concepts that have been considered in this report are presented in Table 4-1, with a short summary provided for each in Appendix A. Four of the energy park concepts outlined have been chosen as case studies to give a deeper understanding of how the concepts evolved, the key drivers for location, the key stakeholders and the funding mechanisms and policy levers for developing the park. This will better inform understanding of the potential in Ireland. The sites selected for case studies are shown in ***Bold*** in Table 4-1 and discussed below.

Table 4-1: GEP Concepts in different jurisdictions

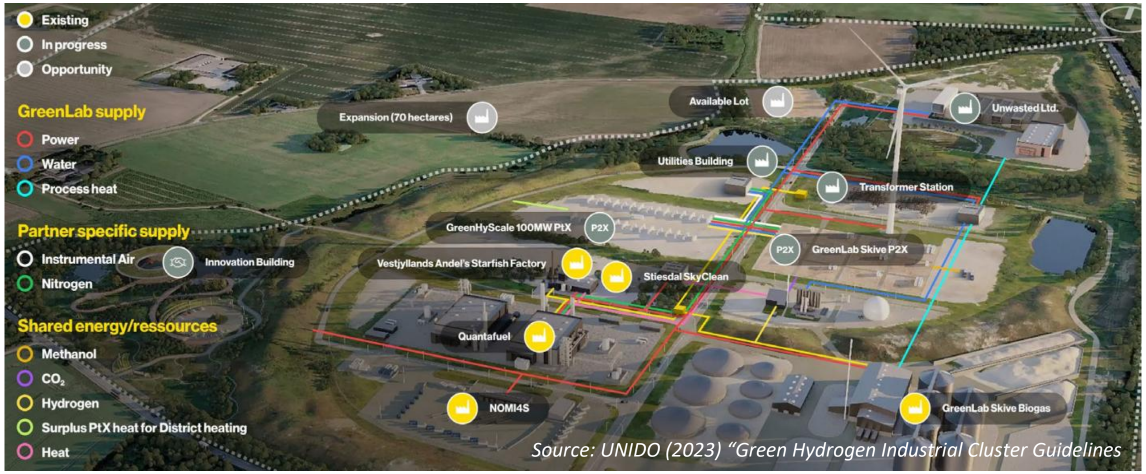
Location	GEP Concept
Denmark	Kalundborg Eco-Industrial Park
Sweden	Barsebäck Clean Energy Park
Norway	CCB Energy Park
Norway	Akershus Energy Park
Australia	Oakajee Strategic Industrial Area
Denmark	***GreenLab***
South Korea	The Smart Green Industrial Complex at Saemangeum
Latvia	***Ventspils Industrial Park***
Sweden	Haraholmen Green Industrial Park
Denmark	***Megaton Energy Park***
UK	***Chelveston Renewable Energy Park***
UK	Net Zero Teeside
Belgium	Green Energy Park Zellik

CASE STUDY 1: GREENLAB, DENMARK

References: [1] Mortensen et al, "Middle-out evolution of greenfield eco-industrial parks - The journey of GreenLab, Denmark" Journal of Industrial Ecology 2024, 1-14
[2] Svendsen et al, "Guide: How can municipalities support the development of industrial symbiosis", European Regional Development Fund, 2021

Energy Park Overview	
Location	Skive, Denmark
Owner(s)	Skive Kommune; SPAR VEST FONDEN; Norlys; Klimafonden
Ownership Model	Non-profit public – private partnership
Stakeholders in Park Establishment	Skive municipality initiated the establishment of the park to position Skive as a hub for sustainable energy.
Park Funding	• Skive Municipality major financial supporter • Private investment – SPAR VAST FONDEN provided 1st financial support. Continued investment from shareholders. • EU Horizon funding for several projects at site
Location Drivers	• Outside of major urban areas. • Close to 150kV power grid & 40-bar gas pipeline. • Ambition to create a location "ideal for transforming how energy & resources are produced, stored, and shared".

Key Characteristics	
Renewable Energy Production	• 54 MW directly connected onshore wind farm. • 26 MW directly connected solar energy site
Industries Present	• **Unwasted**: Sustainable construction boards • **NOMI4S:** Sustainable waste management • **Quanafuel:** Low carbon synthetic oil production • **GreenLab Biogas:** Biogas plant (21 million m^3 biogas/ year capacity) • **GreenLab P2X:** 10 MW methanol plant & 12 MW electrolysis plant (*planned*) • **Vestjylland Andel:** Sustainable protein production plant • **Stiesdal:** Green fuel production • **GreenHyScale:** 100 MW electrolysis plant (*planned*)
Industry Symbiosis	Site uses **SymbiosisNet** – intelligent energy network for exchange of surplus energy and resources at site. GreenLab businesses can generate income from by-product sales of i.e., excess heat, water, biomass etc, giving businesses located in GreenLab a competitive edge



Source: UNIDO (2023) "Green Hydrogen Industrial Cluster Guidelines

Background

GreenLab is a green and circular industrial park located in Skive, central Denmark. The main aims of the site are the integration of renewable energy supply and energy demand from sustainable industries, and on achieving industry symbiosis through its innovative SymbiosisNet.

Site Evolution

GreenLab's evolution can be characterised into 3 phases. From the 1970s until the 2010s, it was an idea nurtured by local government & industrial stakeholders, with academic support. In 2012 & 2014, formal planning strategies were developed. By 2020s, GreenLab has evolved as a nationally significant site, it has begun to formulise its industrial park and to adopt characteristics of an eco-industrial park by having a collaborative industrial network at the site.

Policy & Regulation

Skive Municipality played a key role in overcoming legislative barriers for GreenLab's development. Normally restricted from industrial use, the rural site was approved through collaboration with the Danish Ministry of Industry. Skive owns the park's land and leases it to GreenLab Skive A/S, which subleases to participating industries, allowing energy to flow freely between companies via private grids and avoiding public grid taxation. A dedicated municipal department was also established to drive projects like GreenLab, aiming for Skive to achieve carbon neutrality and energy self-sufficiency by 2029.

CASE STUDY 2: VENTSPILS INDUSTRIAL PARK, LATVIA

References: *[1] Invest in Ventspils, "Ventspils Industrial Park - Place for Green Investment", 2024, https://www.investinventspils.eu/industrial-parks.html [Accessed 03/12/2024]*
[2] Port of Ventspils, "About the Port", 2024, https://www.portofventspils.lv/en/port-in-general/ [Accessed 03/12/2024]

Energy Park Overview	
Location	Ventspils, Latvia
Owner(s)	Freeport of Ventspils Authority
Ownership Model	State-owned
Stakeholders in Park Establishment	Freeport of Ventspils Authority, Ventspils Municipality
Park Funding	• €80 million in national funding from the Latvian Government for manufacturing development outside the capital. • €10 million awarded from a national tender for park development.
Location Drivers	• Ventspils freeport is in the busy Baltic Sea region, close to several planned offshore wind farms, including ELWind. • The 2450 ha port is Latvia's Ro-Ro cargo centre and aims to be a manufacturing and installation base for offshore wind. • The port is in the EU's Trans-European Transport Network (TEN-T) network, is 180 km from Riga Airport, has strong rail links and an optical cable network.

Key Characteristics	
Renewable Energy Supply	• Offshore wind (in development) - ELWind is an Estonian-Latvian offshore wind farm, with 1GW capacity each side of the border. • Solar Energy (in development) – Over 100 ha area marked for solar energy production.
Existing Industries Present	There are 130 companies currently located near the port, including: • Utility vehicle manufacturer. • Metalworking producer for automotive industry. • Electronic system development and manufacturer. • Bio-fuel producer.
Future Industries	The park aims to host future green industries, including: • PtX & hydrogen production • Bioeconomy • Biomedicine and medical technologies • Pharmaceuticals • Photonics and smart materials

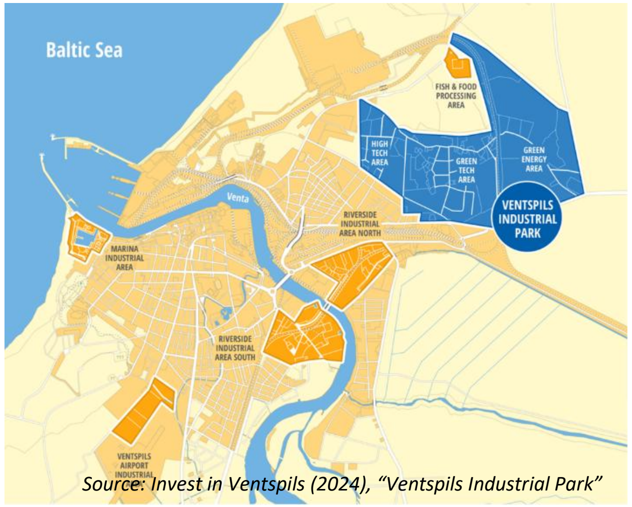
Background

Venstpils Industrial Park is located at Ventspils Port, Latvia. It is a national level project aiming to boost the green economy in the region. With the development of nearby renewable energy (offshore wind, solar), the park aims to become a leading green energy production area in Northern Europe. The ports e-fuel handling capacity (2 ammonia tanks at site) & experience in handling fossil fuels means that hydrogen & e-fuel production are considered high priority options for the site.

Site Evolution

Since 2002, the park has expanded from a port-based economy with few industries to a multi-sectoral economy with over 130 companies located near the park today. The next steps are to develop the park into a green industrial park with green infrastructure, leveraging its existing logistics infrastructure (port, railways) and emerging wind sector To this end, three areas have earmarked for the following industries:

1. **Green Tech Area** - electricity, hydrogen and e-fuels.
2. **Green Energy Area** – green energy production (including solar)
3. **High Tech Area** - smart materials, technologies & engineering systems, as well as information and communication technologies.



Source: Invest in Ventspils (2024), "Ventspils Industrial Park"

Policy & Regulation

Important policy & regulation for the port include the 1994 *Law on ports* (operations & procedures), the 1997 *Ventspils Freeport Law* (for businesses within the port), and the 2002 *Law on Tax Application in Free Ports and Special Economic Zones (*regulates tax incentives for businesses within the port).

In 2002, the municipality adopted an industrialization policy aimed to support the transition from a port-based economy to a multi-sectoral economy. Now, 130 companies and 18 new factories operate in Ventspils, and 50,000 m^2 of production buildings have been constructed in Ventspils special economic zone.

The municipalities next industrial policy aims for Ventspils to become a centre for green and digital technologies.

CASE STUDY 3: MEGATON ENERGY PARK

References: *[1] GreenGo Energy (2023), "GreenGo Energy develops 4GW, 8 billion EUR green energy park in Ringkøbing-Skjern municipality" [Accessed 04/12/2024]*
[2] State of Green (2024), "4 GW Energy Park with integrated co-benefits and local ownership" [Accessed 04/12/2024]

Energy Park Overview	
Location	Tarm, Denmark
Owner(s)	GreenGo Energy
Ownership Model	Privately owned by GreenGo with investment from its clients and partners.
Stakeholders in Park Establishment	GreenGo Energy, Ringkøbing-Skjern Municipality, COWI, Arkitema, New Power Partners
Park Funding	• Required total investment expected to be DKK 60 billion (€8bn). • Investment will come from GreenGo Energy's clients and partners, inc. large-scale renewable energy and infrastructure investors. • Intention that project shares will be offered locally
Location Drivers	• Site's location in Ringkøbing-Skjern municipality benefits from complementary solar and wind production profiles. • Proximity to North Sea offshore wind sites. • Adjacent to the future Stovstrup 400kV substation east of Tarm.

Key Characteristics	
Renewable Energy Supply	GreenGo Energy plans for 4 GW total of hybrid solar and wind energy to power the park – to be operational by 2030. Planned production: • 4,000 hectares of onshore solar and wind projects in the municipality, totalling 2 GW renewable energy supply. • 2 GW of directly connected offshore wind, taken from GreenGo Energy's offshore wind development portfolio in Denmark. • Grid connection as an alternative electricity supply.
Green Fuel Production	GreenGo Energy planning to produce 1 million tons of green fuels annually by 2030, via: • 2 GW electrolysis facility. • Carbon captured from a local biogas producer. • Use of 7MT of purified wastewater in the electrolysis process.
Other Industries Present	• Surplus heat planned to be provided to local district heating. • Surplus heat & power intended to be used for new industries such as greenhouses and vertical farming on an industrial scale.

Source: GreenGo Energy (2023), "Megaton"

Background

Megaton Energy Park, located in Tarm, Denmark, is an ambitious large-scale project aiming to develop a 4 GW renewable energy supply, €8billion, GEP by 2030. It is being developed by GreenGo Energy, with the main focus for the park being the production of 1 million tons of hydrogen-derived green fuel annually, for hard-to-electrify sectors.

Site Evolution

Greengo Energy is a Danish company, founded in 2011, with its core business being developing state-of-the-art renewable energy solutions. They now have a 27 GW global pipeline of renewable energy projects in development or in construction. Phases of development for the Megaton Energy Park are:

- Phase 1: 200 MW onshore wind and 200 MW solar with up to 200 MW electrolysis.
- Phase 2: 1,800 MW offshore wind from the North Sea Tender Wind Farms to be matched with around 1,800 MW solar with and up to 1,800 electrolysis.

Green Fuel Production

Large-scale green fuel production is the main goal of Megaton Energy Park. The park developer's business case for green fuel production at the park centres on the following:

- Competitive advantage: Denmark's world leading wind sector and the significant scale of the Megaton's offshore wind capacity is seen as crucial for green fuel production.
- Complementary Sector: Megaton's hybrid wind and solar energy supply will ensure a more constant energy supply, achieve high electrolyser utilisation.
- A location at a large substation is seen as important for balancing energy production.

Policy & Regulation

Denmark's PtX strategy promotes large-scale hydrogen and green fuel production, which Megaton aligns with. Policy levers of this strategy include substantial investments in PtX, establishment of a funding scheme, regulation of the Danish hydrogen market. Currently, Megaton has received no funding under the strategy.

CASE STUDY 4: CHELVESTON ENERGY PARK

References: [1] Chelveston, "Chelveston Renewable Energy Park - About", 2023, https://chelveston.com/about.html [Accessed 04/12/2024]
[2] Carbon Copy, "Chelveston Renewable Energy & Innovation Park", 2024, https://carboncopy.eco/initiatives/chelveston-renewable-energy-innovation-park [Accessed 04/12/2024]

Energy Park Overview	
Location	Chelveston, Northamptonshire, England
Owner(s)	Wykes Engineering, Prop-Search
Ownership Model	Privately Owned
Stakeholders in Park Establishment	Wykes Engineering, Prop-Search
Park Funding	• The park owners initially invested £80m in developing around 80 MW of renewable energy, including wind and solar. • The next development phase, including battery storage, more solar energy production & a hydrogen plant has commenced with further investment by the owners. • Park generates money by exporting renewable energy to the grid. • A separate business within the park, Innovate Recycle, has been awarded £2.35m to develop a carpet recycling factory, by the Southeast Midlands 'Getting Building' Fund.
Location Drivers	• Located on a repurposed former airbase with flat land, ideal for renewable energy infrastructure and refurbished military buildings.

Key Characteristics	
Renewable Energy Supply	• 25 MW installed onshore wind capacity (9x125m wind turbines). • 60 MW installed solar (250,000 solar panels). • 60 MW additional solar in development for hydrogen production. • 80 MWh export grid connections / 26 MWh import grid connection. • 47 MW gas peaking plant.
Energy Storage	• 20 MW Lithium-ion battery for load shifting & frequency response.
Offtake	The park currently supplies renewable electricity to the grid but plans to develop an Innovation Park for energy-intensive businesses that will use renewable energy from Chelveston at a lower price than the national grid. Targeted businesses include: • 10MW hydrogen production plant in development to fuel a fleet of converted HGVs. The plant is owned by the park owners – Wykes. • 1.3 MW fuel cell testing facility (Intelligent Energy) • Carpet recycling factory (Innovate Recycle)

Source: BBC (2021), "Chelveston energy park aims to power 100 lorries a day with hydrogen"

Background

Chelveston Energy Park is in Northamptonshire, England. It is the UK's largest combined renewable energy facility. Since the site was purchased in 2005, the owners have focussed on developing renewable energy production, and the site now has over 85 MW installed capacity. The park owners are developing the park further to include battery storage and hydrogen production & develop an innovation park that will be a home to independent businesses powered by cheap renewable energy from Chelveston via a private wire.

Site Evolution

The former airbase was purchased in 2005 by Wykes Engineering and Prop-Search (a property specialist). The first phase of development included development of an onshore wind farm (operational 2014) and solar farm (operational 2015). Next phase of development included the construction of on-site energy storage (operational 2023), additional solar farms for hydrogen production (in development), and a hybrid hydrogen/gas-fuelled peaking plant. The park is currently focussed on developing its innovation park, offering 32,900m^2 of space for green industries, with a direct wire to renewable energy generated on-site. The target sectors for the innovation park include 'food industry, manufacturing, vertical farming, frozen / cold storage, Hi-Tech / R&D, medicine, defence, healthcare and life sciences, data processing & storage and specialist recycling.'

Policy & Regulation

The site developers highlighted the importance of good relationship with the local planning authority to achieve some of the unusual planning permissions require for site development. For example, an appeal against an initial refusal for the construction of a wind farm secured planning for the sites 9 wind turbines. Also, planning permission was secured for the solar array through careful design of a new hedgerow to prevent the potential loss of amenity.

4.4 SUMMARY AND KEY LEARNINGS FROM INTERNATIONAL REVIEW

A summary of some key learnings from the international review is given below:

Key Characteristics: All four case studies co-locate renewable energy supply with demand, though generation capacity ranges from medium to large-scale. Megaton is particularly relevant to Ireland, as it plans for large-scale offshore wind production, electrolysis, and the development of local infrastructure. With the park slated for full operational status by 2030, it represents a project worth monitoring. Additional features of each park vary: GreenLab focuses on industrial symbiosis, Chelveston includes energy storage for load-shifting, and Megaton will use surplus heat for district heating and industry. Opportunities differ based on the industries involved and developers' goals. Each park plans to develop PtX: GreenLab and Chelveston are planning electrolysis plants; Ventspils is prioritising e-fuel production; whilst Megaton's central focus is hydrogen and e-fuels. Key location drivers include proximity to renewables, grid and existing infrastructure.

Park Evolution: The parks are at different stages of development: GreenLab is fully operational but expanding, Ventspils has industries but is developing renewable connections, Chelveston has renewables but is developing demand, whilst Megaton is in early development, progressing renewables and PtX in phases. This show that whether to develop supply or demand first, or both together, depends on site-specific opportunities. GreenLab highlights the benefits of developing both together, Ventspils connects existing industries with renewables, Chelveston prioritises renewables to attract industry, and Megaton uses phased development. For Ireland, the approach will depend on location, existing supply and demand, and infrastructure.

Key Stakeholders: Ownership and stakeholders vary by park: Ventspils is state-owned (via the Freeport Authority), GreenLab is a public-private partnership between the municipality and private partners, while Chelveston and Megaton are privately owned. Local municipalities, such as Skive and Ventspils, play significant roles, with Skive initiating the park's development and providing financial support and Ventspils industrial policy focusing on green tech development. Whilst privately owned, Chelveston's developers have emphasised the importance of good relations with the local municipality. For Ireland, public and private (or mixed) ownership models can effectively support GEP development. State support, especially at the local level, is crucial for park success. Engaging local authorities and communities early in the process can secure local backing.

Park Funding: Park funding varies across case studies: Ventspils received government funding, GreenLab has a mix from Skive municipality and private stakeholders, while Chelveston and Megaton are both privately funded. Each developer owns different renewable infrastructure: GreenLab secures its electricity via a PPA, Chelveston owns its supply, Ventspils plans to connect to the ELWind offshore wind farm, and Megaton's supply comes from its renewable energy portfolio. All parks own the land, with some developers also owning industries on-site, such as GreenLab's biogas and PtX plants, and Chelveston's hydrogen plant. For Megaton, the developers own the large offtaker on-site—the planned 2 GW electrolysis facility. Developers also own much of the supporting infrastructure, including transport facilities and hydrogen transport infrastructure (e.g., GreenLab's hydrogen pipeline). Ireland could benefit from exploring diverse funding models for GEPs, and local government support could be key in securing and providing funding.

5 IRISH CONTEXT

5.1 IRISH CASE STUDIES

While Ireland does not have GEPs developed to date, several developers/organisations have announced interesting plans for the development of energy park or co-location concepts in Ireland. Some of these plans shown in Table 5-1 are reviewed below for learnings, but this list is not exhaustive. In addition to these case studies, Ireland has done extensive work in developing economic clusters and business sectors in many areas across the county, as shown by the IDA [34]. Learnings can be taken from these cases also, to inform future GEP plans.

Table 5-1: Overview of Irish developer-led plans for energy park concepts

Location	GEP Concept
Wicklow	Echelon Data Centre and Arklow Bank Wind Park 2
Drogheda	Gyrogy – Core Project
Clare/Kerry	ESB – Green Atlantic at Moneypoint
Offaly/Meath/Westmeath	Bord na Móna Eco Energy Park
Offaly	Offaly County Council GEP at Rhode Business Park
Galway	Sh2amrock project
Tipperary	Lisheen Bioeconomy campus
Cork	Simply Blue Energy Renewable Energy Park in Whitegate
Cork	Cork County Council GEP in Cork Harbour
Meath	Drogheda Port Company and Ronan Group Real Estate - Bremore Ireland Port

5.1.1 ECHELON DATA CENTRE AND ARKLOW BANK WIND PARK 2

Data centre operator Echelon was approved by EirGrid for a grid connection for its €500 million data centre campus in Wicklow, reportedly the first data centre development to be approved for a grid connection since the CRU issued Direction CRU/21/124. The Dub20 campus is located on a former Irish Fertiliser Industries (IFI) site. Echelon also plans to invest in battery storage and renewable energy to offset the fossil fuels consumed by the data centre. Primary power to the data centre will be from the national grid.

The project developers state the project will show 'what is possible when we co-locate critical infrastructure like data centres and renewable energy resources' [35]. It is also stated that the campus in Arklow, Co Wicklow, will eventually lead to the creation of 200 permanent jobs, as well as 1,100 jobs during construction. Echelon has a joint venture with SSE renewables to co-develop grid infrastructure to enable the delivery of c. 800MW of offshore wind from the Arklow Bank 2 project onto the Irish electricity grid, noting that the data centre development 'significantly accelerates and de-risks the delivery of the 800MW SSE renewables delivery'. Echelon and SSE Renewables will develop a joint 220kV substation at the Avoca River Business Park in Arklow that will provide direct energy to the data centre and also send the offshore wind power to the Irish national grid. Total planned investment in the project is said to be in the region of €3.5 billion. A detailed breakdown on this investment is not available, but it is thought this includes investment in the data centre, grid infrastructure and associated renewables [36].

The development provides a good example of a data centre helping to facilitate the delivery of an offshore wind project, in Arklow Bank 2. Recent analysis of the project by BiGGAR Economics for SSE states the project could bring a total investment to Ireland of €1.4 billion over its lifetime (of €4.88 billion total). See Figure 5-1 from [37].

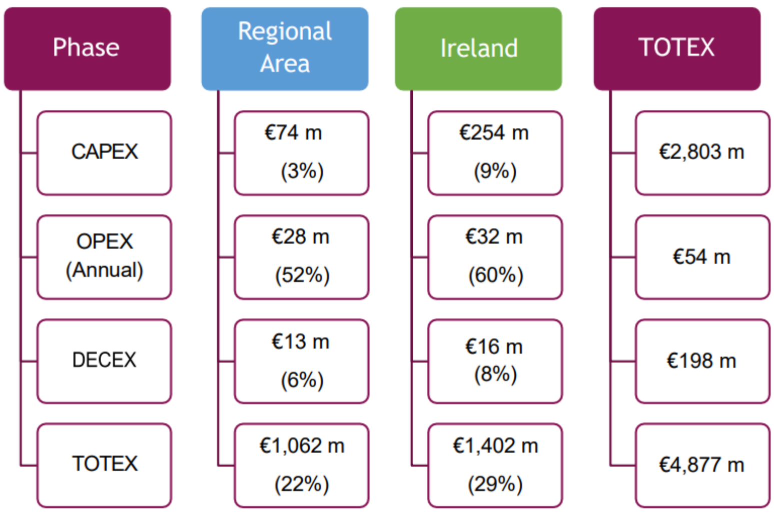


Figure 5-1: Assumed contract values and shares by project stage for Arklow Bank 2 [37]

5.1.2 THE CORE PROJECT

The Core project plans to redevelop the old Premier Periclase Limited site which dates back to 1938 and was initially used for cement production before transitioning to magnesia and magnesium hydroxide products in 1977. Gyrogy (an Irish energy-tech firm), in partnership with Meridiam (an asset manager and investment benefit corporation), plans to redevelop the old industrial site adjacent to Drogheda Port into a modern, mixed-use industrial campus which will include low carbon energy solutions to support the government's renewable energy objectives.

Premier Periclase submitted its planning application in November 2024 [38] and the project will involve an investment of between €600 million and €1 billion over the next ten years. The redevelopment plan includes demolition and site remediation works, substantial upgrades to the Premier Periclase site infrastructure, and the integration of renewable energy sources, flexible generation and advanced energy storage systems on the new Core campus. Subject to planning, the first phase of development will focus on installing sustainable energy infrastructure and a 32MW data centre.

The site will be grid-connected at the existing 38kV substation adjacent to the site to charge batteries at optimum times but aims to have the capacity to supply its own energy to the users on the campus through on-site renewable energy generation, battery storage, gas engines and rotary power conditioning. The project also aims to be able to export power to the grid, and hopes to grow to accommodate other high-tech industries including bio-pharma, food, and sustainable manufacturing [39] (Figure 5-2).

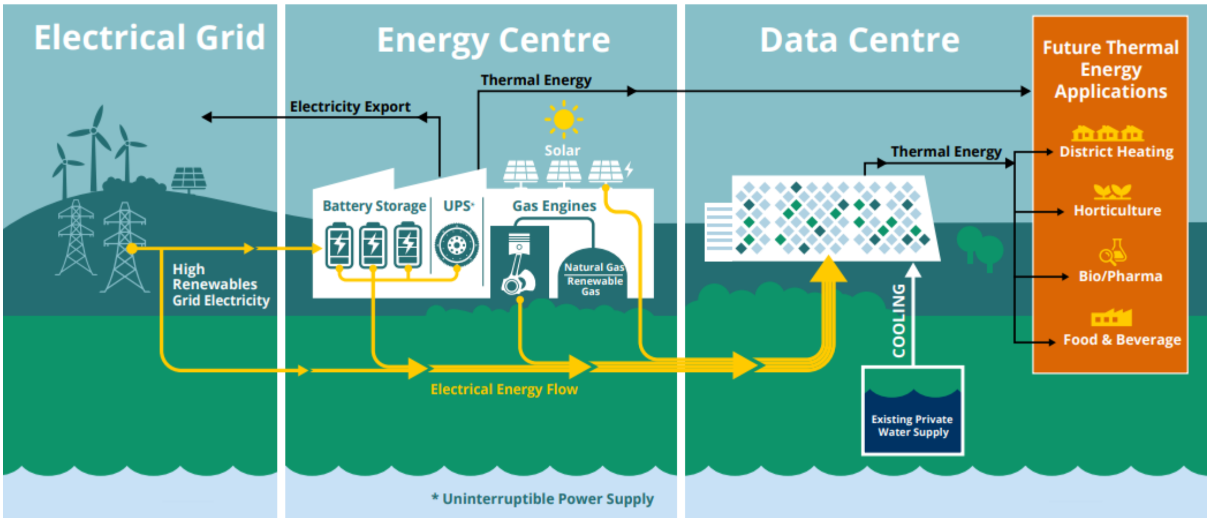


Figure 5-2: Overview of the energy technology to be employed at the proposed Core development [40]

5.1.3 ESB GREEN ATLANTIC AT MONEYPOINT

Moneypoint Power Station in west-Clare was constructed in the late 1980s and is Ireland's largest power plant at 900MW [41]. While plans are in place to close the station, in October 2024, An Bord Pleanála permitted the ESB to convert the coal-burning power station to Heavy Fuel Oil, due primarily to its operational parameters as a generator of last resort over a defined period up to the end of 2029, and the need for back-up generators in time of high demand on the Irish electricity system to avoid the risk of black-outs [42]. To facilitate Ireland's energy transition, the plant is now set to be closed by the end of 2029.

The ESB (with its development partner Ørsted) intends to re-develop and upgrade the site of the power station to the Green Atlantic energy park, in plans first announced in 2021. Green Atlantic will be a multi-use site containing a green energy hub including a €50m Sustainable System Support facility (a Synchronous Compensator which was installed in 2022), a 1400MW floating offshore windfarm, a wind turbine construction hub and an investment in a green hydrogen production, storage and generation facility [43] (Figure 5-3). While initial plans for development of the Green Atlantic project envisaged development in the early 2030s, policy uncertainty around the development of floating wind in Ireland and a lack of a DMAP for offshore wind on the west coast, and later delays to the closure of the Moneypoint plant discussed above, mean timelines are now more uncertain.

The Green Atlantic project provides an interesting example of what an Irish, large-scale GEP concept incorporating offshore wind could include. The location has been chosen based on a few key drivers which include: the existing 400kV grid connection at Moneypoint, the deep-water quay, the potential for floating offshore wind in relative proximity, land availability and the potential to re-purpose existing infrastructure from the power plant. It is a great example of how legacy infrastructure used for fossil-fuels can be re-purposed to drive sustainable growth.

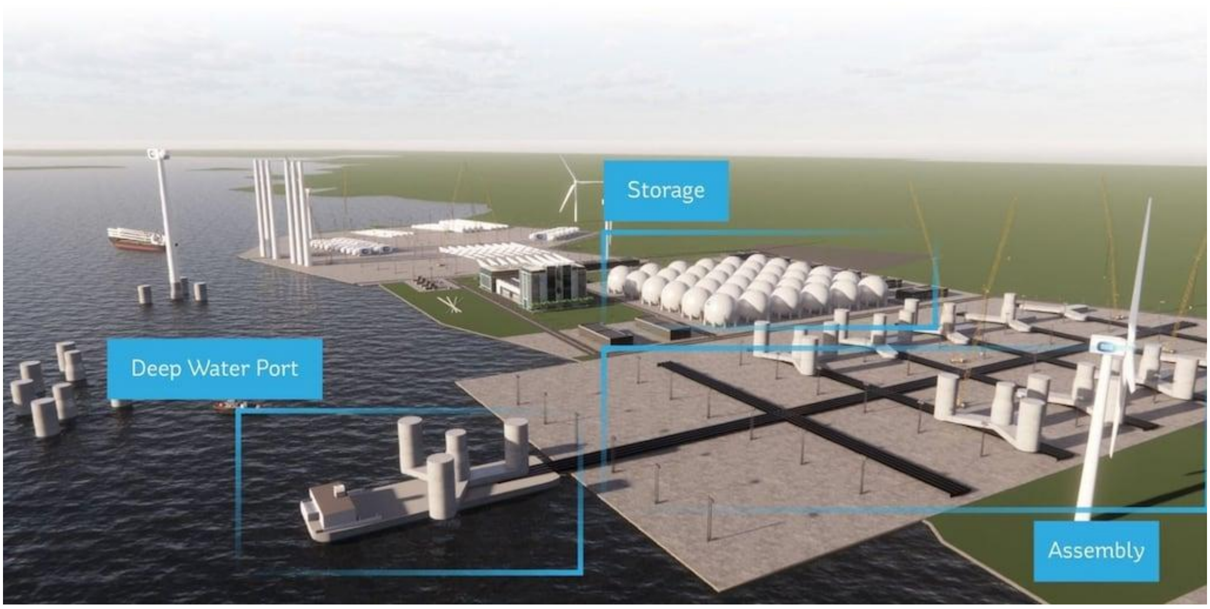


Figure 5-3: Green Atlantic at Moneypoint overview [43]

5.1.4 BORD NA MÓNA ECO ENERGY PARK

Bord na Móna Eco Energy Park will be located on the company's peatland landbank of approximately 3000 ha [44]. The Park will be built across four bogs in the Derrygreenagh Group, in counties Offaly, Westmeath and Meath, and Bord na Móna intend to use an array of renewable energy sources to power the park including wind and solar, with generation capacity expected to be approximately 200 MW. Energy storage facilities are also planned for the site (Figure 5-4).

In April 2024, the Park announced a strategic partnership with Amazon Web Services (AWS) that will see AWS become the anchor tenant for the park. This is seen as an important step in the policy to move data centre development from the East, so progression of the project(s) will be closely monitored. The park also plans to engage with other sectors to co-locate at the park including Manufacturing, Pharmaceutical, Agrifood, Information and Communications Technology (ICT), Transport, Green Hydrogen derived E-Fuels and Logistics.

The Bord na Móna energy park example does not incorporate offshore wind, but provides another strong case study of how existing infrastructure and facilities can be leveraged to provide new opportunities for energy park development. Its focus on more developed onshore renewables also gives greater certainty to development. Key drivers for the choice of this location include: an easily accessible grid and gas network nearby, motorway access, fibre infrastructure networks, and a power generation legacy in the area.

The company also plans to build a 710MW thermal power plant in the area to fill short term gaps in renewable generation as well as covering longer periods of low generation from renewable sources (Derrygreenagh Power). A major advantage which Bord na Móna also has as a result of its State functions, which most other developers will not, is the amount of interconnected land that it owns in the area, which can give flexibility to development and allow the concepts to be developed organically.

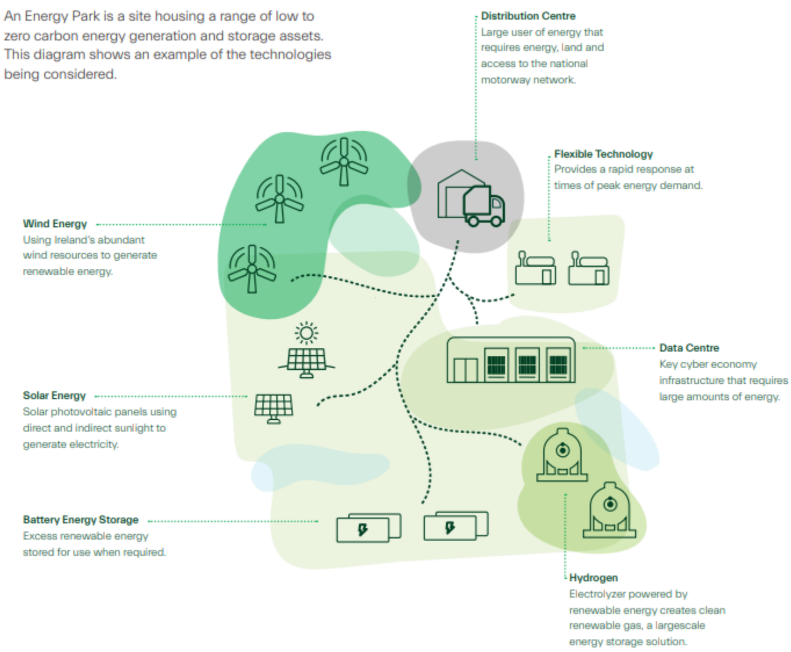


Figure 5-4: Bord na Móna Eco Energy Park overview [45]

5.1.5 RHODE GREEN ENERGY PARK

The Rhode GEP site was originally the site of Rhode power station, a peat-fired power station which commenced operations in 1960 and was demolished in 2004 and replaced by a peaking power station. In 2020, after completing a strategic analysis of the opportunities for Offaly arising from the closure of peat-fired stations in the area, Offaly County Council and North Offaly Development Fund commissioned an Opportunity Assessment Report for Rhode, to assess the potential for the development of a GEP at the location [46]. The Rhode GEP will aim to demonstrate the benefit of a planned approach to energy and industry co-location, following the closure of peat powered generation stations in the region. The council sees three 'strands' of benefits from its proposal:

- Strand 1: Energy decarbonisation/innovation hub built around renewable energy, hydrogen and electricity system integration.
- Strand 2: Eco-Industrial Park model whereby large-scale energy intensive employment (data centres, agri-food, horticulture, bio-economy) develops around the electricity and heat resources available.
- Strand 3: Educational/ Innovation/ Centre of Learning for renewables and electricity grid: to improve awareness within the community of how the energy transition is happening, for collaboration with stakeholders across the Midlands Region and to create partnerships with Third Level Institutions.

Reports have also been commissioned to assess the potential for renewable hydrogen production at the site [47], and for data centre integration [48] which highlight the potential of the location. This project provides a great example of how the legacy of energy production in an area and the associated infrastructure (grid, gas, broadband, motorways, water) could be used to drive a just transition from fossil fuel generation. The project aligns well with other plans in the area including Bord na Móna's Eco Energy Park, and Offaly County Council is taking a leading role in consulting with the public and attracting businesses to the location. These different plans together show the potential for energy park development in the midlands should not be ignored.

5.1.6 SH2AMROCK HYDROGEN VALLEY

The Sh2amrock concept aims to deploy green hydrogen to decarbonise public transport and trucking across Ireland, including key infrastructure to enable production, distribution and use of green hydrogen. The project aims to develop Ireland's first hydrogen valley and multi-modal hydrogen hub in Galway. The consortium consists of 28 members, including National University of Galway, the Port of Galway, CIÉ Group, Aer Arann Islands, the ESRI and Bord na Móna. The 5-year project will involve a total investment of €80 million. The concept of the Hydrogen Valley involves having hydrogen research, production, distribution and transportation co-located in order to encourage indigenous production and pipeline of green hydrogen fuel for public and private vehicles [49]. The project received €7.5 million in funding from the EU Clean Hydrogen Partnership in January 2023 [50] [51].

5.1.7 LISHEEN BIOECONOMY CAMPUS

Located on a former zinc mining site, Lisheen Bioeconomy Campus will be the National Bioeconomy Campus for the Irish Bioeconomy Foundation (IBF), and it aims to position itself as 'the centre of advancements for the circular economy' [52]. In late 2017, the IBF secured significant funding from Enterprise Ireland to build the National Bioeconomy Innovation and Piloting Facility on the Lisheen site. The project has since received a €5 million grant from the EU's Just Transition Fund and was touted as one of the top six European locations for bio-economy investments following the closure of the Lisheen zinc and lead mine in 2015. The bio-economy uses renewable resources from agriculture, forestry and the marine to produce food, feed, materials and energy, while reducing waste, in support of achieving a sustainable and climate neutral society [53]. The site comprises of 455 hectares (Figure 5-5) and its development is bolstered by the Irish Bioeconomy Policy [54]. Relevant infrastructure at the site includes roads, electrical substation, wind turbines, weighbridges, water, and buildings. The project is in collaboration with University College Cork (UCC), who will demonstrate six emerging technologies at Lisheen Bioeconomy Campus [55], and dairy and forestry bioprocessing industries.

Figure 5-5: National Bioeconomy Campus site at Lisheen, Co. Tipperary [53]

5.1.8 SIMPLY BLUE GROUP RENEWABLE ENERGY PARK IN WHITEGATE

In June 2024, it was announced that Simply Blue Group has acquired land in Whitegate, adjacent to the oil refinery, as part of its plans to develop a renewable energy park in Cork focused on producing sustainable fuels. This announcement followed the signing of a memorandum of understanding between Simply Blue and Irving Oil in 2022 [56]. The location is seen as an area with high potential for energy park development primarily due to the scale and quality of offshore wind potential off the south coast, the existing infrastructure at the Whitegate refinery with a legacy of energy production, the existing and future potential for the Cork harbour area, and the availability of land in the area which is already zoned for industrial use. The location is also near the high voltage transmission system, the gas grid, and has access to the shore, which allows for the potential for a south coast offshore wind farm to feed into the park to provide the power for sustainable fuel production [57].

5.1.9 CORK HARBOUR GREEN ENERGY PARK

Cork County Council has designated a large area in Aghada adjacent to the Whitegate Refinery for use for major energy related developments, and is planning to establish a GEP in Cork Harbour to capitalise on government plans for offshore wind in the area. The plan is for the harbour to be used as a marshalling and servicing base for offshore wind project on the south coast of Ireland, and to provide other aids to the renewables sector, while at the same time creating jobs in the region. Energy Cork has termed the area around Cork Harbour as 'Ireland's Energy Hub', which includes many of Ireland's energy companies and supplies over 25% of Ireland's energy demands. The wider area includes [58] [59]:

- A zoned Special Policy Area of 388 Ha (960 Acres) at Whitegate, prioritised for major, large-scale energy and renewable energy related development and an additional site of just over 30 Ha zoned for small to medium scale energy related development such as RD&I, transport and maintenance
- Whitegate oil refinery, Whitegate power station, Aghada power station, the onshore terminal for the Kinsale Area Gas Fields and associated infrastructure (decommissioned), onshore wind farms, the Marine Renewable Energy Ireland Centre (MaREI) at Ringaskiddy, UCC and Cork Institute of Technology.

While details on how this development will be progressed in the coming years are not available, the area around Cork harbour can be seen as an important strategic location for the development of a GEP, given the potential for offshore wind in the area, and the available port and energy infrastructure.

5.1.10 BREMORE IRELAND PORT

With ports and wider harbour areas seen to have high potential for future GEP development, Bremore provides an interesting case study [60].

The development of Bremore Ireland Port, through a partnership between Drogheda Port Company and Ronan Group Real Estate, is in response to the anticipated future deficit in port capacity on Ireland's east coast. Bremore is planned to provide additional options for Ireland's importers and exporters.

The project will also address Ireland's current lack of deepwater port facilities to service offshore wind. The primary goal of the first phase of Bremore's development is to establish a staging, installation, and storage facility, to provide construction and O&M services to planned offshore wind projects off the east coast of Ireland and in the Irish Sea, while also driving local and regional economic growth. The port facilities will include a 300m wide access channel, a 11m quay and access channel draft, a 1300m quay berth length and 600m quay berth width, jack-up capabilities, and access to motorway and rail [61].

Essential to the project proposal is a complementary energy hub with capacity to generate green hydrogen and its potential green fuel derivatives [61].

Figure 5-6 below gives an overview of plans for the development. While there currently do not appear to be plans for on-site generation of renewable electricity, the plans include offshore wind services, general cargo services, industrial areas, an innovation district, green fuel production, cruise ship areas etc. It is expected that educational opportunities will also arise as third-level institutions collaborate with the industry to ensure that the necessary skills are developed locally. The project states that constructing a new port, rather than retrofitting an existing one, paves the way for innovation in design, operations, and harmonising with the local environment. This all very much aligns with what is expected of a GEP.

The project aims to submit a planning application by 2026/2027, and the initial berths are anticipated to be operational between 2028 and 2030, subject to planning outcomes. Project materials state that Bremore aims to create thousands of direct jobs by deploying capital investment exceeding €1 billion in the coming decade, and could generate €6 billion in revenue across the first 30 years of its operations.

Figure 5-6: Bremore Ireland Port overview [58]

5.1.11 SUMMARY AND KEY LEARNINGS FROM IRISH REVIEW

Similarly to the international review, proposed energy park / co-location projects vary greatly in scope and scale in Ireland. This is not surprising given there has been no real policy to guide the development of GEPs in Ireland to date, and any plans are very much developer-led concepts. Most plans are also only at an early stage, but we can still take learnings from plans to date to inform next steps.

Taking advantage of existing infrastructure and legacy industries: All of the plans reviewed have been devised to make use of existing infrastructure in place, and legacies of energy production or industrial activity. Whether it is the ESB's plans at the port location around Moneypoint, Bord na Móna and Offaly County Council's plans in the Offaly region around existing projects and old thermal generation, Simply Blue Group and Cork County Council's announcements for the Cork area around the Whitegate refinery etc., many plans to date have been developed to make use of existing infrastructure, and to redevelop, rebuild, repurpose, and expand on this. The development of a GEP at a completely greenfield site (i.e. a site in an area with no infrastructure of note and no industrial or power generation activities) would likely pose a more significant challenge in terms of permitting and site selection, and providing all the required infrastructure starting from scratch would also delay developments and increase costs. When considering strategic locations for the development of GEPs in Ireland, existing infrastructure that can be repurposed, and existing activities in the area should be a key consideration. That is not to say that a GEP at a greenfield site is not possible, and even greenfield sites would have proximity to some level of infrastructure. Development of a new site would also bring advantages in that there would be no constraints from the old development to work within (see Bremore example), but any development of a GEP at a greenfield site would likely need to be considered as a longer-term, more strategic and forward-planned project.

Key Characteristics: In addition to the above, there are some key characteristics common to most sites, which include: proximity to the transmission system and available grid capacity (which could potentially include interconnectors to support security of supply), available land bank for development or to expand into (with this land ideally zoned for industrial uses), availability of renewable sources of power (existing onshore, proposed offshore), strong infrastructure generally with projects targeting areas specific to their planned use, water supply, and availability of thermal/dispatchable generation. A strong location for GEP development will have a combination of these factors, but the importance of each will vary depending on the needs of the GEP. Port locations usually have many of these characteristics which makes them popular choices for development plans. A lot of these key characteristics are common to general industrial parks in Ireland. A useful exercise could be undertaken to assess current (and planned) industry parks for the infrastructural requirements to enable them to transition to GEPs in the future, where possible.

Midlands a high potential area as well as the coast: The motivation for this work is the Offshore Wind Industrial Strategy, and a lot of consideration has been given to how GEPs could incorporate offshore wind, which leads to coastal locations being seen as priority areas for development. There are other advantages to the coastal locations, particularly those close to ports where industry and infrastructure naturally evolve (e.g. Cork Harbour, Bremore), and it can be expected that future GEPs of the largest scale in Ireland will be in coastal locations. However, significant work has been done in the midlands by Bord na Móna and Offaly County Council to progress their plans, and these will be important to monitor. Given the strategic landholding by Bord na Móna in the region, the availability of renewables and thermal generation in the area, the interest shown by AWS, and the more certain timelines for development onshore, Bord na Móna's project could provide key learnings for future offshore wind-powered GEP development in Ireland in the nearer-term, while itself becoming a GEP or Eco-park of significant scale.

Supply or Demand first: Whether to develop supply or demand first, or both together, depends on site-specific opportunities. Core will attempt to develop supply and demand at the same time. Bord na Móna's plans have evolved around supply, and they now plan to expand on this and attract industrial demands. The ESB and Simply Blue Group's plans are centred around the development of offshore wind, but demands have also been identified which can be progressed in tandem.

Given the long lead time for renewables projects, however, it is advantageous if these can be in progress first to provide more certainty to demand customers. Arklow Bank 2 had been in development for a number of years and been designated a Relevant Project[4] when it reached an agreement with Echelon. For Ireland under a plan-led model and with the aim for GEPs of large scale, a particular offshore wind site/project could be identified to support a GEP development at a suitable location onshore. Plans could then be progressed holistically bringing together all the various elements across both the supply and demand sides involving the key parties from an early stage.

Funding: While limited detail is available on investments, most plans reviewed have had no significant State involvement, either directly or through funding mechanisms, with the majority of plans being progressed by the individual developers at this stage, and most at an early stage where significant capital investment has not yet been required. However, the IBF secured funding from Enterprise Ireland (€4.6m under the Regional Enterprise Development Fund in December 2017) and the EU's Just Transition Fund (€5m) to develop the National Bioeconomy Innovation and Piloting Facility on the Lisheen site. In addition, the Sh2amrock project received €7.5m funding from the EU Clean Hydrogen Partnership in January 2023. The low level of State involvement is not surprising considering most plans reviewed are at a relatively early stage and significant investments have not yet been made. It is not clear how future developments will be funded and State support in some form can be expected to be required, whether this is to support GEP development directly, or provide supporting infrastructure. Many of the plans have located close to existing infrastructure that will have been funded by the State e.g. motorways, gas networks, broadband etc.

[4] In May 2020, the Irish government granted seven Irish ORE projects which were in development priority status as 'Relevant Projects', to enable them to progress through the consenting and development process in Ireland.

5.2 THE OPPORTUNITY FOR HYDROGEN IN IRISH GREEN ENERGY PARKS

Many GEP concepts include renewable hydrogen production within the site, as well as related technologies, such as e-fuel production, hydrogen storage and fuel cells. Many of these concepts have offtakers for renewable hydrogen located within the site. An example is GreenLab, Denmark, which has a 6MW electrolysis plant. The first offtaker at the site for the produced hydrogen is a factory producing a marine-based protein supplement from dehydrated starfish, with the hydrogen being piped a short distance from the electrolysis plant to the factory.

Currently in Ireland, few large industrial energy users are likely to use hydrogen directly as a fuel. Hydrogen may have a role in high-temperature industrial heat, and the pharmaceutical industry and the cement industry are two industrial examples where renewable hydrogen may displace some fossil fuel usage. However, current direct demand for renewable hydrogen remains low among LEUs that might establish operations in GEP parks. Instead, energy demand from existing LEUs in Ireland is primarily for electricity—particularly for data centres and other high-power applications.

As pointed out in the National Hydrogen Strategy [2], data centres have a requirement for a high degree of reliability and typically require on-site back up generation should their electricity fail. In an energy park with a variable supply of renewable energy, this security of supply could come from on-site energy storage or from a grid connection. Minimising impacts on the electricity grid is a priority for GEPs, and so the Hydrogen Strategy identifies that there may be some role for hydrogen as an energy storage medium, to ensure security of supply for data centres. For short- to medium-term variations in electricity supply, batteries may be the most efficient storage solution due to the energy losses involved in converting electricity to hydrogen, storing it, and then reconverting it. However, during prolonged shortages of renewable energy, additional storage beyond flexible batteries will be necessary.

Hydrogen is well-suited for long-term energy storage, as it enables large amounts of energy to be stored for weeks or months. Given its cost-effectiveness and storage capacity potential, geological hydrogen storage offers the most viable solution for ensuring reliable electricity supply during long periods of low wind and solar generation. As identified in the Hydrogen Strategy, several sites in Ireland are being explored for geological hydrogen storage. Long term storage of hydrogen could therefore support LEUs, such as data centres in GEPs, either through direct storage onsite, or via a connection to an electricity grid, that uses large scale storage of hydrogen to provide electricity generation during low wind and solar events.

There is a significant opportunity for GEPs to become hubs for future industries that have a renewable hydrogen demand. Due to its vast renewable resource, there is a significant opportunity for the development of hydrogen derived e-fuels in Ireland. This is reflected in several Irish energy park concepts developing e-fuels, including Simply Blue's renewable energy park concept in Whitegate [57]. GEPs could be ideal locations for e-fuel production for the following reasons:

- **Renewable energy supply:** GEPs will be located close to abundant renewable energy supply, such as offshore and onshore wind, and solar power, which are required to produce hydrogen for e-fuel production. This proximity minimises energy transmission losses and reduces overall costs.

- **Utilising potential curtailed electricity:** There may be potential to make use of cheap renewable energy that would otherwise be curtailed to produce hydrogen for e-fuel production. However, this will be highly dependent on the rate and quality of curtailment, as it is unlikely to be economic to run an electrolyser at an extremely low utilisation factor. This could be explored for different sites; however, larger scale e-fuel production is unlikely to be possible on curtailed energy alone.
- **Existing infrastructure:** E-fuel production can take advantage of existing infrastructure at GEPs. This could include access to existing port facilities for export, transportation networks, grid connection, industrial equipment (storage tanks, pipelines, processing units) and utilities.
- **Existing expertise:** E-fuel production can take advantage of existing expertise at GEPs in areas like renewable energy, fuel production and sustainable industrial processes. For example, Simply Blue's energy park concept at Whitegate can utilise existing expertise in the area from the refinery located adjacent to the renewable energy park site.
- **Grid stability:** Large scale e-fuel production can act as a vast demand side response. In Ireland, this will help stabilise an electricity grid with an increasing amount of variable renewable energy. For example, in the future, a portion of renewable electricity from a wind farm can be put to the grid with the remainder going to hydrogen and e-fuels production, assuming flexibility in electrolyser demand can be accommodated.

There are several notable e-fuels which could be produced in GEPs in Ireland, which can be used as "drop in" fuels in hard to abate sectors like aviation and marine transport. The main hydrogen derived e-fuels that could be produced at GEPs are presented in Table 5-2.

The EU's RED provides targets and regulations for the production of e-fuels, which fall under the term "Renewable Fuels of Non-Biological Origin (RFNBOs)". The EU has set a target of at least 5.5% advanced biofuels and RFNBOs in transport by 2030 (combined target of which at least 1% should be RFNBOs), with additional incentives for RFNBOs use in aviation and maritime transport. This highlights a growing market for e-fuels within the EU, offering a valuable opportunity for Ireland to capitalise on.

The EU provides rules which e-fuel manufacturers must comply with to ensure their fuels qualify as RFNBOs. The main rules are as follows [62]:

- RFNBOs must reduce emissions by at least 70% compared to gasoline and diesel.
- All RFNBOs must be produced with additional renewable electricity (except for some early movers, who start producing before 2028). Producers will need to conclude PPAs for e.g. new and unsubsidised wind and photovoltaic farms.
- The electrolysers will need to use renewable electricity when and where the sun shines and the wind blows. From 2030, electrolysers will need to adjust their consumption on an hourly basis. Carbon-based RFNBOs like e-methanol or e-kerosene can use fossil carbon from installations covered by the EU Emissions Trading System (ETS) until 2041. After that deadline, only carbon captured from the air and from sustainable biomass (as defined by the RED) can be used.

Table 5-2: Overview of hydrogen derived fuels and their potential uses for Ireland

E-Fuel	End Uses	Production Process	Feedstocks	Opportunity in Ireland
Green Ammonia	Shipping; Dispatchable power; Fertiliser production	Haber-Bosch process	Renewable Hydrogen, Nitrogen from air	Green ammonia could be a fuel for Ireland's maritime sector and can be more readily stored and transported for power production or export than pure hydrogen. A potential non-fuel application is the manufacture of sustainable fertilisers.
E-Methanol	Fuel for shipping, chemicals (plastics, pharma)	Hydrogenation	Renewable Hydrogen, Carbon dioxide (captured from industry or air)	E-methanol can be a versatile fuel for Ireland's maritime sector and can be readily store and exported. Production will require a CO_2 source, therefore production could be co-located with carbon capture. There are non-fuel applications in the chemical sector.
Synthetic aviation fuel (E-Kerosene)	Aviation	Fischer-Tropsch process	Renewable Hydrogen Carbon dioxide (captured from industry or air)	Developing e-kerosene production at GEPs could position Ireland as a SAF producer, leveraging existing aviation infrastructure. There is export potential to global markets.
E-Diesel / E - Gasoline	HGVs	Fischer-Tropsch process	Renewable Hydrogen Carbon dioxide (captured from industry or air)	Depending how heavy road transport is decarbonised, there may be a market for e-diesel and e-gasoline which could be produced at GEPs.

Locating e-fuel production in GEPs will have several advantages, considering these rules. GEPs can host new renewable energy farms alongside e-fuel manufacturing. Co-location of renewable energy supply and e-fuel manufacturing demand should make optimizing hourly consumption easier and GEPs can facilitate the co-location of carbon capture technologies with e-fuel facilities, ensuring compliance with carbon sourcing rules.

5.3 THE OPPORTUNITY FOR GEOTHERMAL AND DISTRICT HEATING IN IRISH GREEN ENERGY PARKS

Geothermal technologies harnesses energy from the subsurface, where temperatures increase with depth due to the natural geothermal gradient. This energy originates from several different sources depending on the depth. The upper layers typically store thermal energy from the sun, and at increased depths the decay of radioactive isotopes and residual thermal energy from the Earth's formation are the main drivers of the thermal gradient.

To access higher temperatures, wells or boreholes are drilled into the subsurface strata, often targeting hot water, steam, or heated rock. This thermal energy can be utilised directly for heating applications or converted into electricity using turbines.

Shallow geothermal energy, on the other hand, is extracted from the upper layers of the Earth's crust, typically the initial 400 m below the earth’s surface, where temperatures remain stable year-round. Ground-source heat pumps (GSHPs) are the most common technology for extracting shallow geothermal heat. These systems circulate a fluid, such as water or a glycol solution, through a closed-loop network of pipes buried in the ground either horizontally or vertically. The fluid absorbs heat from the ground during colder months and can also transfer excess heat back into the ground during warmer periods, making it a versatile and sustainable solution for heating and cooling.

For cooling, geothermal systems take advantage of the Earth's stable subsurface temperatures, typically between 8°C and 14°C at shallow depths in Ireland. These constant temperatures provide an efficient heat sink for dissipating excess heat generated by buildings or industrial processes. These geothermal cooling systems work by transferring heat from a facility into the ground, where it is absorbed and dispersed. Cooling systems also commonly use GSHPs, which can be particularly effective at managing the significant waste heat produced by IT infrastructure, reducing reliance on energy-intensive air conditioning and chiller systems.

For larger-scale cooling needs, geothermal systems can be combined with district energy system solutions. These systems can balance the thermal requirements of multiple facilities, offering a sustainable and scalable option for urban and industrial areas.

A range of technologies can be employed to address the potential heating and cooling needs of GEPs:

- **GSHPs**: Best suited for small- to medium-scale applications, these systems can provide efficient cooling and heating for facilities such as data centres.
- **Deep Geothermal Systems:** Ideal for large-scale projects, these systems supply high-capacity heating through district energy networks.
- **Absorption Chillers:** Using geothermal heat to drive a cooling cycle, absorption chillers offer an innovative solution for converting geothermal energy into cooling for industrial installations and GEPs.

Considering data centres in particular, these facilities generate substantial amounts of waste heat, creating a need for efficient heat load management. Geothermal energy can provide a sustainable solution by acting as both a heat sink for cooling and a heat source for heating and can dissipate large amounts of heat generated by servers and IT infrastructure. This reduces dependence on conventional cooling systems, lowering both energy consumption and potential carbon emissions.

District energy systems can also support cascading heat use, where waste heat from one primary facility is captured and redistributed for secondary applications, such as heating nearby offices, residential areas, or industrial facilities. This waste heat can be integrated into a district heating system, where it is distributed through a network of insulated pipes to provide centralised heating to multiple buildings and facilities. By utilising waste heat in district heating systems, geothermal technology can help to maximise resource efficiency, reduce energy waste and emissions, and support circular energy principles. This integration also enhances the sustainability and economic viability of the district heating network by leveraging otherwise discarded thermal energy.

Geothermal energy, with its ability to deliver base-load, renewable, thermal energy regardless of weather conditions, is exceptionally well-suited to providing stable and long-term heat supply. This reliability makes it particularly valuable during periods of "dunkelflaute", when solar and wind energy production drops due to low sunlight and wind conditions.

In GEPs, geothermal systems could effectively address diverse heating demands, including those of industrial processes, residential areas, and commercial spaces. By integrating geothermal energy into district heating networks, the need for individual heating systems is eliminated, reducing upfront infrastructure costs, enhancing energy efficiency, and lowering greenhouse gas emissions.

DECC is currently in the process of developing a national geothermal framework to unlock the country’s geothermal potential for sustainable energy solutions. The framework aims to provide regulatory certainty, encourage investment, and facilitate the integration of geothermal energy into Ireland's broader energy strategy. The framework supports innovative applications such as geothermal cooling for data centres and the establishment of district heating networks. As data centres become increasingly prevalent in Ireland, driven by the growth of the technology sector, geothermal and district energy solutions offer a pathway to address waste heat challenges while meeting sustainability goals.

Geothermal energy presents a strong opportunity to address the cooling and heating challenges of GEPs. By leveraging district energy technologies, waste heat from data centres could be efficiently managed and repurposed for cascading applications, optimising energy use and reducing environmental impact.

5.4 THE POTENTIAL ROLE FOR DATA CENTRES IN IRISH GREEN ENERGY PARKS

Ireland does not historically have a lot of electricity-intensive industrial activity which would be well suited to energy parks. As discussed however, the country has become a preferred location for data centres to become established. In Europe, the so -called 'FLAP-D markets' (Frankfurt, London, Amsterdam, Paris and Dublin) emerged during the early 2000s, with these markets chosen as the favoured countries for the establishment of data centres by the operators.

The four largest or 'Hyperscale' data centre operators in Ireland are AWS, Microsoft, Meta and Google. There are also a host of smaller scale operators including K2 Data Centres, EdgeConneX, Echelon Data Centres, Equinix, Digital Realty, Keppel DC REIT, CyrusOne, Pure DC, and Vantage Data Centers.

While requirements can differ between data centre types, when seeking ideal locations to establish, data centres are influenced by the availability of several things [48] [63]:

- Strong telecommunications, water and energy utilities, and back-up power
- Proximity to existing data centre market and suppliers, and skilled workforce
- The availability of significant parcels of suitable land for development and future expansion
- Favourable local planning and enterprise regimes and investment and policy stability
- Availability of renewable or carbon free power generation and opportunities for CPPAs
- Favourable climate conditions (mild and low risk of extreme events)
- Low cost of energy and construction
- Investment incentives

Ireland has emerged as a preferred area for data centre development due to having a strong combination of these factors, including access to primary subsea intercontinental fibre nodes, competitively priced energy utilities and a large technology sector. Preferred locations emerged where the best network infrastructure was available, which was also typically near academic centres, financial centres and subsea fibre nodes. This has led to the vast majority of data centres in Ireland being located in the Dublin area, with clusters in Grange Castle, Ballycoolin, Tallaght, and Clonshaugh. Similarly to the concept of energy parks, the aggregation and clustering of data centres can have a cumulative effect by attracting complementary investment in infrastructure and development of local skilled jobs, although this concentration has also caused issues, and future data centre development in Ireland is expected to be located outside of the capital as discussed earlier in this report. Figure 5-7 below taken from Data Centre Map [64] shows 72 data centres listed in Ireland, with 69 of these in the Dublin area. While it is not clear how up to date this map is, it gives an indication of the concentration of data centres in the Dublin region.

With data centre electricity use projected to rise to 30% of the national demand by 2032 [21], their consumption and development has become a much-discussed issue in Ireland. Recent research for Friends of the Earth by UCC released in December 2024 states that electricity demand from data centres has grown at an annual rate of almost 23% since 2015, compared to less than 0.5% for other sectors [65]. The author of the report states that 'The current trajectory of data centre demand is incompatible with Ireland's climate commitments' [66], although it could be said that this is a potential issue due to a lack of renewable energy supply and grid capacity, rather than due to data centre demand. The report also discusses the potential use of biomethane by data centres as a mitigation strategy to address the gas demand from data centres to ensure security of supply. However, it notes that the scale of biomethane production and targets in Ireland would not be sufficient to meet this demand and that the use of biomethane in this capacity could divert it from displacing fossil fuels in the national electricity mix or for heating.

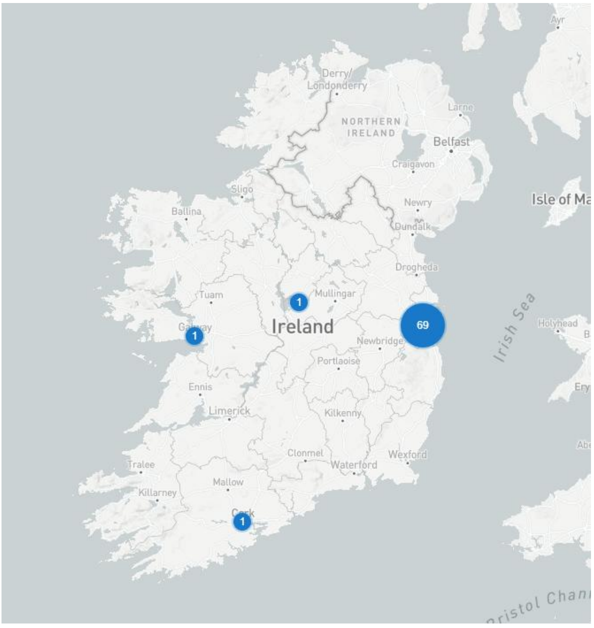


Figure 5-7: Irish data centre location overview [64]

From a GEP perspective however, if managed and planned correctly, data centres can provide a key power demand in future that can provide a route to market for onshore and offshore renewables, facilitate the development of GEPs at a large scale in Ireland, and continue to provide a strong basis for the technology sector in Ireland. This demand could be key to providing sufficient demand for Ireland's longer term offshore wind targets, as noted in Baringa's report for Cloud Infrastructure Ireland: Key to unlocking Ireland's offshore wind potential [63].

According to bitpower [67], the total design capacity of operational data centres in Ireland as of Q4 2024 is 1400 MW, which equals a total annual power consumption of around 6 TWh in 2024. This capacity is made up of 64 Large data centres, 9 Standalone data centres, and 19 small data centres, spread across 23 Campuses, with individual data centres ranging in size from 500 kW to 50 MW. New data centres are generally constructed in a 10 MW to 200 MW range, with the lower end considered a mid-tier and the upper end often referred to as 'hyperscale'.

Investments in Gigawatt campuses are becoming more normal globally, although there have been no announcements of AI-style campuses in Ireland as yet, most likely due to the current uncertainty in the market. Future data centre developments for AI workloads are expected to be of larger scale, requiring higher computational power. Some of these are expected to require 99.995% uptime, which equates to a maximum of just 26.3 minutes downtime in a year [68].

CPPAs have and will form a significant portion of data centre power procurement going forward in Ireland. There are different forms of CPPAs including Virtual CPPAs and Physical CPPAs, but Private Wire CPPAs, whereby the offtaker is directly connected to the generator, are not yet permitted in Ireland. This means that while CPPAs to date in Ireland have been useful as a route to market for renewables, data centre offtakers have not directly received the power from the generator which they are contracted with, and instead they have received their power directly from the grid (Figure 5-8).

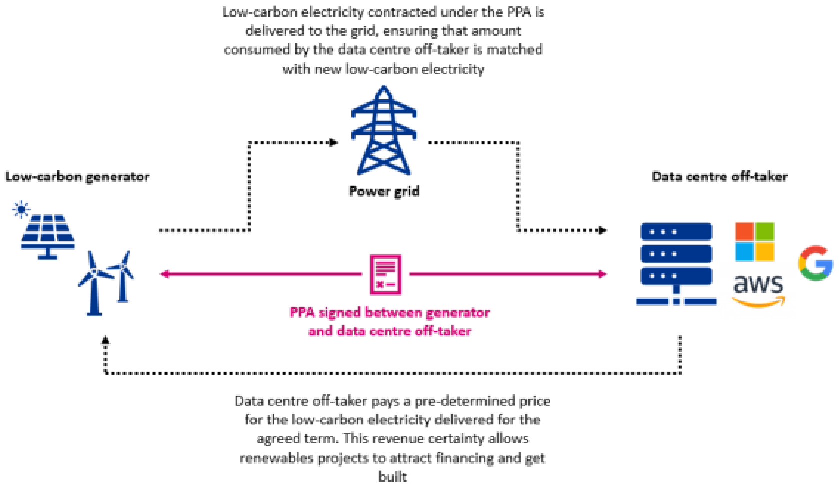


Figure 5-8: High level illustration of a CPPA structure [63]

We have seen CPPA announcements in recent years from many data centre operators in Ireland, including: **Microsoft:** (930MW of onshore wind and solar [69] [70]), **Meta**: (276MWp solar energy in Ireland [71]), **AWS**: (over 200MW of onshore wind and announced a strategic partnership with Bord na Móna to join the Bord na Móna Eco Energy Park [72]), and **Google**: (58MW of new-to-the grid capacity from the Tullabeg Solar Farm [73]). This just includes the hyperscaler operators, but demonstrates that data centres can play a key role in supporting the development of renewables in Ireland, and in helping Ireland to reach its target for CPPAs in electricity production.

According to bitpower [67], €15 Billion has been invested in building data centre facilities in Ireland. Around 15 other projects across the country are paused due to either lack of power or planning approval, representing an investment pipeline of €8 - €10 Billion. In 2018, Grant Thornton (in a study for the IDA) reported that between 2010 and 2018 the total economic impact of data centres was €7.13 billion with an average annual 5,700 roles created or supported annually both in the construction phase and on an on-going basis across various operational roles including Technicians, Engineers, Managers, Security Personnel, Software Developers and Health and Safety Personnel [74].

This report also notes that a large number of ancillary services and roles not directly related to data centre operation have been attracted following initial data centre investments, including finance, operations, sales, customer support and software engineers, and that many Irish based data centre operators see the physical location of their data centre operations as strategically linked to their overall activity and operations in Ireland i.e. the presence of data centres opens up the opportunity, and in some instances necessity, to locate other ancillary services in Ireland. A Central Bank of Ireland study from 2023 notes that 164,600 people were employed in the ICT Sector in Ireland in Q4 2022 [75].

It should be noted that Ireland is competing globally with other markets for data centre business, and recent issues around planning and grid connections here have caused concern for the market. In September 2024, AWS announced €35bn in investment in Europe but did not include any Irish projects [76]. We have also seen some of these operators buying into nuclear power and Small Modular Reactors (SMRs) [77] in other markets. This suggests that the data centre market demand and investment is by no means assured going forward, but if issues around grid connections, planning consent and private wires can be solved and if positive steps can be taken towards the development of GEPs which can reliably power larger data centres, this trend could be reversed. The CRU decision on LEU connection policy for electricity and gas will also be a key decision for the industry. Figure 5-9 and Figure 5-10 below based on CSO and SEAI data show how data centre electricity consumption has increased since 2015, and how this is projected to increase out to 2050.

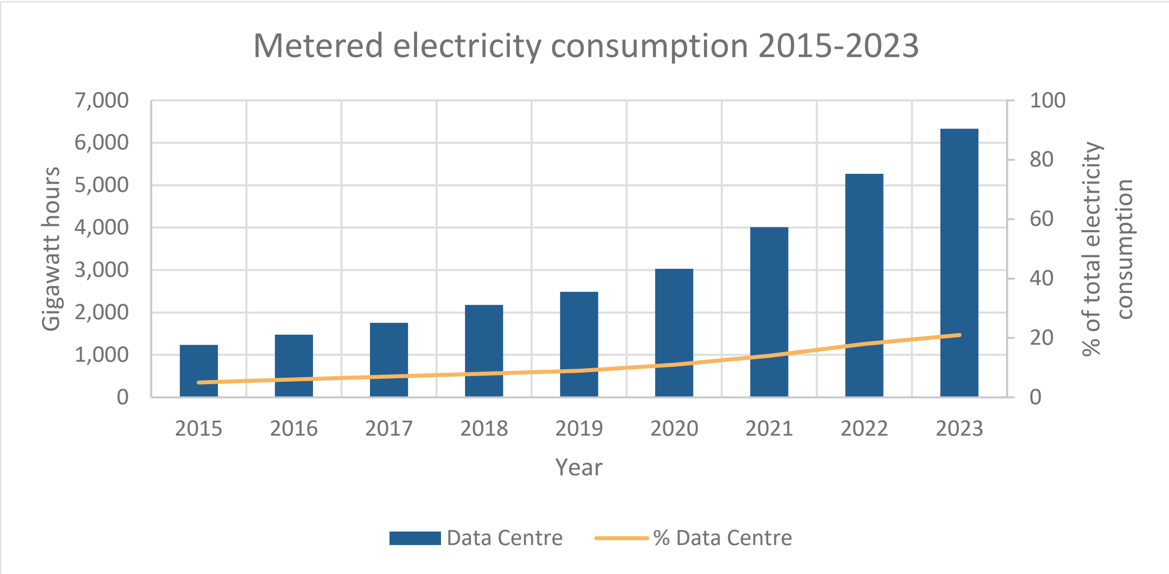


Figure 5-9: Metered electricity consumption (CSO, 2023)

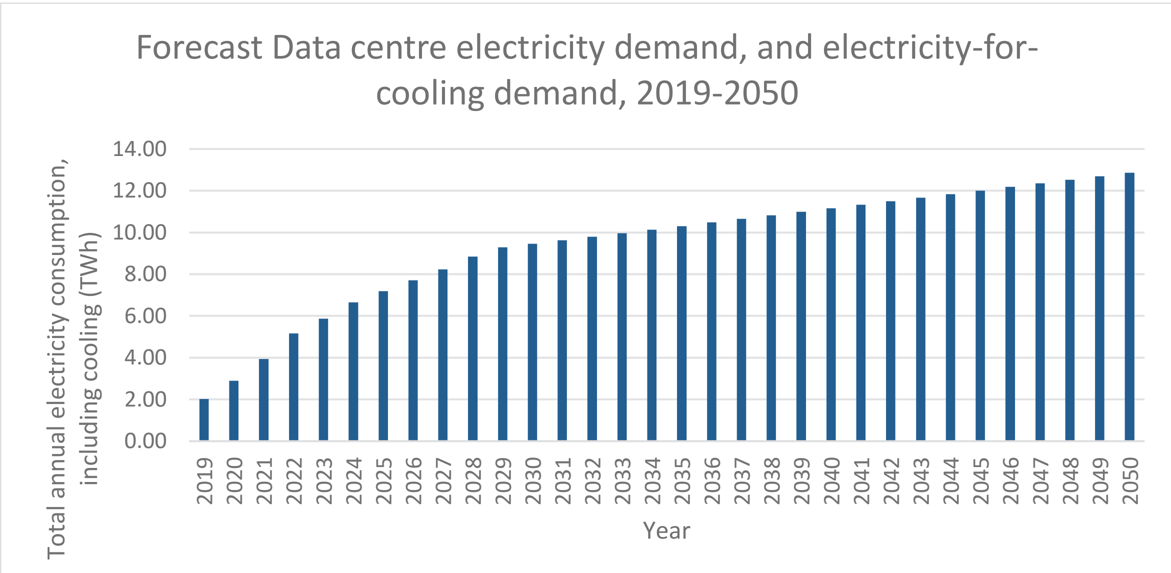


Figure 5-10: Total data centre electricity demand, including electricity for cooling, forecast to 2050 (SEAI, 2022)

5.5 OTHER INDUSTRIAL DEMANDS FOR GREEN ENERGY PARKS

Data centres have come to the fore as a key potential demand and anchor tenant for GEPs in Ireland, but from both consultation and research for this report, they should not be seen as the only demand.

For a proxy to energy demand, and to identify high potential customers for GEPs, we can look to the EU ETS. The EU ETS is a 'cap and trade' scheme where a cap is placed on the right to emit specified pollutants over a geographic area and companies can trade emission rights within that area. The ETS applies to emissions from the electricity and heat generation, industrial manufacturing and aviation sectors. The ETS applies to power stations and larger industrial plants like factories that produce cement, lime and chemicals. It also applies to airlines operating within the European Economic Area [78]. The Environmental Protection Agency (EPA) administers the EU ETS in Ireland. As part of the reporting for the ETS, emissions for the relevant companies/sites are verified for each country, for each year, the most recent being 2023.

ETS data for Irish-based activities can be downloaded from the European Environment Agency's EU ETS database [79]. As part of this analysis, this data has been reviewed, with aviation-related emissions removed as well as thermal power generation stations (neither seen as relevant demand customers for GEPs directly), and installations with zero verified emissions in 2023. Data centres were also removed from this list as they have been discussed in detail, and results were sorted from highest verified emissions in 2023 to lowest. This resulting database is displayed in Appendix B.

Key demands that can be identified from this review include:

- **Material / Chemical Production:** including Aughinish Alumina, Clogrennane Lime Limited.
- **Cement manufacturers:** including CRH, Mannok Cement Ltd., Breedon Cement Ireland Ltd.,
- **Oil Refining:** Irving Oil Whitegate Refinery
- **Food and Nutrition:** including Tirlán, Kerry Group, Lakeland Dairies, Dairygold, Carbery Food Ingredients Limited, Arrabawn etc.
- **Distilleries:** Irish Distilleries Limited, Diageo.
- **Pharmaceuticals:** Pfizer, Lilly Kinsale, Abbott Ireland, Allergan Pharmaceuticals, Janssen Sciences Ireland etc.
- **Tech Manufacturing:** e.g. Intel

While GEPs can be key to attracting new demands which can be 'green' they can also be used to decarbonise existing energy demands in Ireland, which is a key future need given Ireland's emissions reduction targets and carbon budgets. In many cases however, these installations will have established footprints and will not be able to re-locate to new GEP areas. For example, a cement plant may be located close to a quarry that is required to support its operations, and it would not be practical for these to be moved. A strategic GEP location in proximity to one or several of the key demands identified above could be considered, with these demands potentially incorporated into new GEPs. Their locations are reviewed in Section 6. Figure 5-11 below based on SEAI data shows electricity use by some of these industries in 2022.

It should be noted that different offtakers will have different requirements from a GEP. Due to time constraints, these LEUs have not been engaged as part of this work. While efforts were made to engage with this cohort as part of the work, unfortunately interviews could not be arranged. As such, engagement with LEUs has been set as a key next step in relation to GEP development.

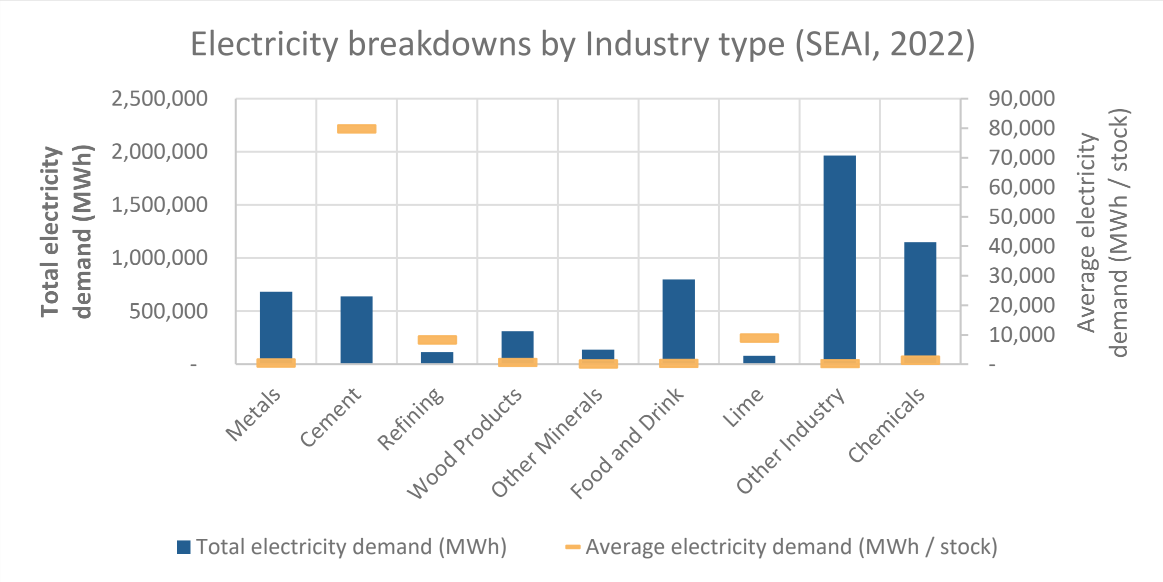


Figure 5-11 Electricity demand by building type (SEAI, 2022)

6 MAPPING OF HIGH POTENTIAL DEVELOPMENT AREAS IN IRELAND

6.1 BACKGROUND TO MAPPING EXERCISE

To inform understanding of what areas of Ireland show high potential for GEP development, a mapping exercise was undertaken by GDG. This exercise considered many of the criteria that have been identified as drivers for the location of GEPs, based on interviews, research and case studies. These criteria were mapped, and an assessment was made at a regional level to identify areas which show high potential for development, and which could be considered further at a more detailed level to determine specific development locations across Ireland. This assessment was undertaken on a regional basis, considering the key pillar in the Offshore Wind Industrial Strategy of balanced regional economic development opportunities, although it is anticipated these would be developments of large scale and national significance. For the avoidance of doubt, this mapping exercise has not considered interactions with the terrestrial planning system, including from a statutory land use zoning or designation perspective.

6.2 ASSESSMENT METHODOLOGY

From the international case studies outlined in Section 4 and the Irish examples discussed in section 5.1, we have identified the geospatial factors that are key considerations for the development of a GEP. In undertaking this geospatial analysis, data has been collated on these key criteria and a database of relevant Irish data has been developed.

Criteria considered include:

- Grid (including existing and planned interconnectors)
- Roads, railways, ports
- Population density (only showing areas > 500 people per km2)
- Existing energy demand
- Offshore and onshore wind farms
- Solar farms
- Plans for energy parks / co-location concepts in Ireland

We have assessed these criteria spatially on a regional basis following the three regional assemblies as outlined in “S.I. No. 573/2014 - Local Government Act 1991 (Regional Assemblies) (Establishment) Order 2014” [80] and discussed in Section 2.2.3. In order to determine preferred areas for GEP development we have assessed the above criteria in each of the regions. Additional infrastructure should be considered at a project level depending on the make-up of the proposed GEP. Additional criteria may include fibre optic broadband connectivity, water resource supply, land bank and zoning, gas network, housing, and consented renewables projects.

6.3 SPATIAL ASSESSMENT

The potential requirement for a grid connection should be considered during the early-stage development of a GEP. The development aim should be that the primary energy source for a GEP is renewable technologies; however, due to the intermittent nature of Ireland's major renewable energy sources, such as wind and solar, connection to the electrical grid will likely be required to meet the baseload requirements of co-located industries during periods of low generation or high demand within the GEP. Maintaining a balance between electricity demand and supply is a critical factor in the development of GEPs. While off-grid GEPs may be feasible in rare cases with energy storage systems such as battery storage to address baseload needs, developments are likely to require a grid connection. Consequently, proximity to major grid infrastructure has been a key consideration in this assessment. The EirGrid Network map below (Figure 6-1) illustrates the spatial distribution of 110, 220, 275 and 400kV power lines and substations across Ireland.

Transport infrastructure also plays a crucial role in the development and success of a GEP influencing both the construction and operational phases. During the construction phase consideration needs to be given to equipment delivery. The components required for many industries can be heavy and require specialise heavy transport vehicles and therefore the transport infrastructure may be a constraining factor on development location. The transport system supports not only the construction and operation of the park but also the supply chains and logistical needs of the industries there within.

Depending on the make-up of the GEP a large workforce may be required. Reliable transport infrastructure ensures that workers can reach the site efficiently during construction as well as long term operation of the GEP. This is considered in Figure 6-2.

The spatial distribution of energy demand is a critical consideration in the location assessment of a GEP (Figure 6-3, Figure 6-7). The load profile of the energy consumption spatially should be considered to determine patterns of nearby demand centres to ensure the GEP supply aligns with peak and baseload requirements. EirGrid's Generation Capacity Statement 2023–2032 shows that the energy demand forecast currently predicts that the large population dense cities and towns will continue to grow, and energy demand density will be situated around these major populations. There is potential to flatten the curve of energy demand across the country with the development of GEPs in areas which currently have a low energy demand but have generation potential in the future.

Other factors which could be important considerations for GEP development are the location of existing LEUs in Ireland, as discussed in Section 5.5. Many of these demands have well established footprints in Ireland and will not be able to easily re-locate, but a strategic GEP in proximity to one or more of these demands could be considered. The LEUs identified in Section 5.5 are shown in Figure 6-4. In addition to these LEUs, plans for Irish GEPs or co-location developments in Ireland which have been reviewed in Section 5.1 are also shown in Figure 6-4. This shows a good spread of plans across the country, including on the south, east, and west coasts, as well as in the midlands.

The other primary consideration for GEP development is of course the availability of renewable and non-renewable power sources. Figure 6-5 below shows energy generation in Ireland, including planned offshore wind, onshore wind and solar. A key consideration here will be the SC-DMAP sites (excluding Tonn Nua) as it is currently expected that all other offshore wind farms in the pipeline will be grid connected. The remaining SC-DMAP sites could potential feed into a GEP directly powered by offshore wind. The map also shows a high level of onshore wind across the country, and in the south west, north west, midlands and south east in particular. The map also shows a strong pipeline of solar projects across the country.

Telecoms will be an important consideration for some industries, in particular data centres. Figure 6-6 gives an overview of the National Broadband Plan Rollout areas, where commercial areas can be seen as areas with stronger telecoms infrastructure, and intervention areas seen as less connected areas. In addition, subsea telecom cables are shown, with international connectivity an important criterion for many industries.

The suitability of an area for the development of a GEP will largely be determined by the industrial make up of the proposed development, however broad trends are seen across all GEPs. These include the availability of renewable energy and critical infrastructure for transport of resources and personnel. Another key consideration for development is the existing energy demand. Areas of existing high energy demand will also mean increased competition for resources.

In summary, regions which have sufficient transport infrastructure and grid connectivity and currently show low energy demands but future potential for renewable energy generation are best suited to GEP development, as well as locations with high energy uses that could potential be incorporated into a GEP.

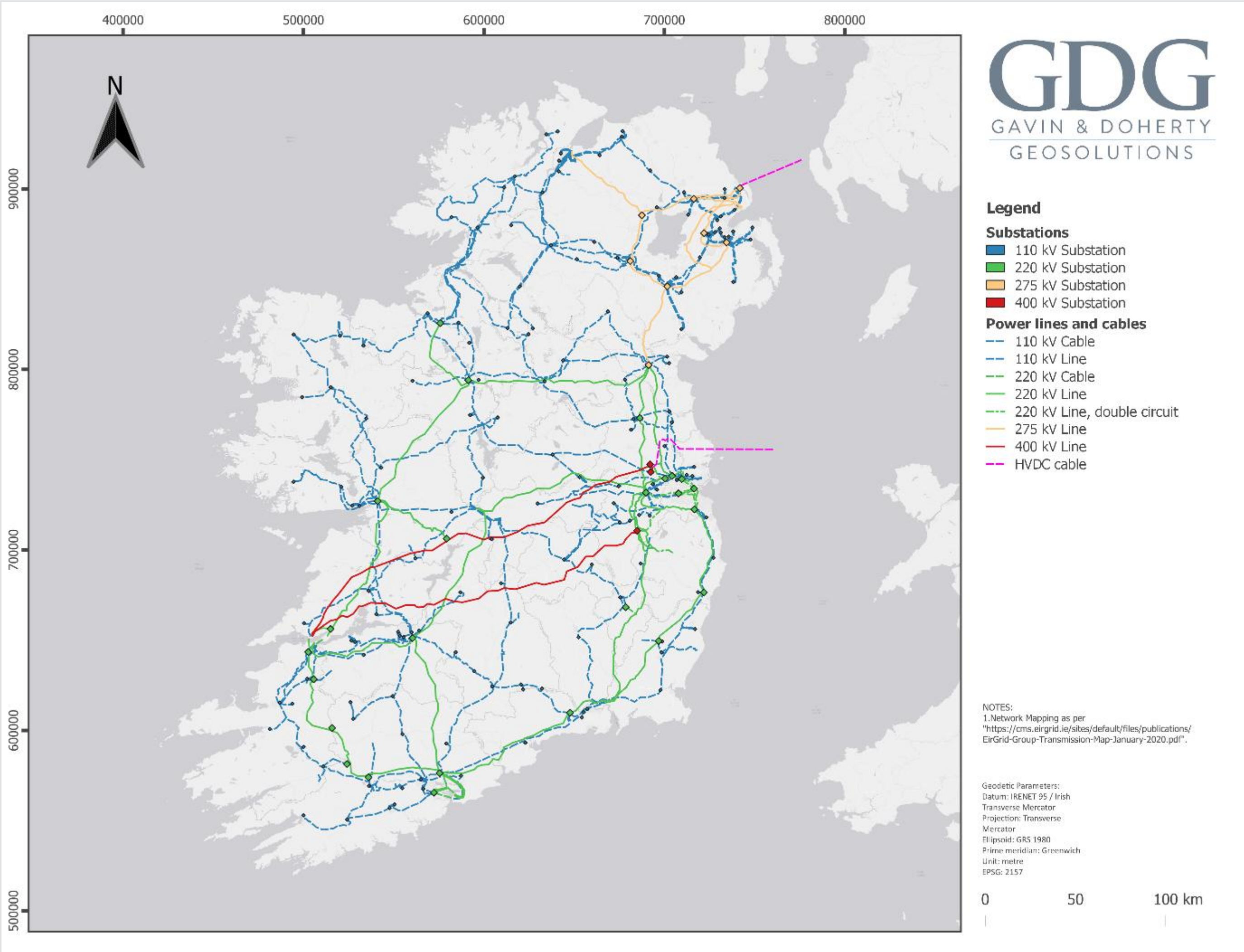


Figure 6-1 EirGrid network map

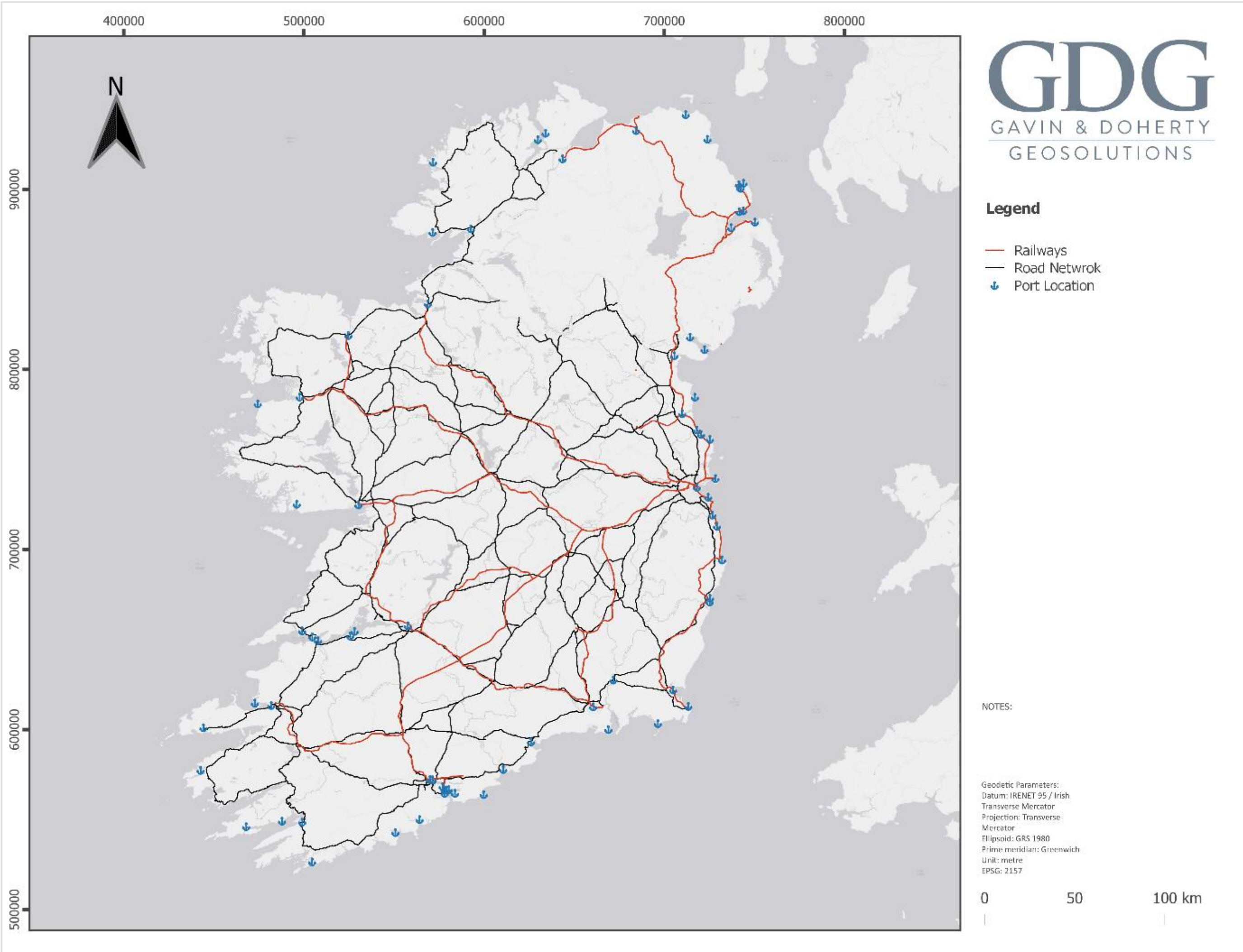


Figure 6-2 Transport infrastructure map

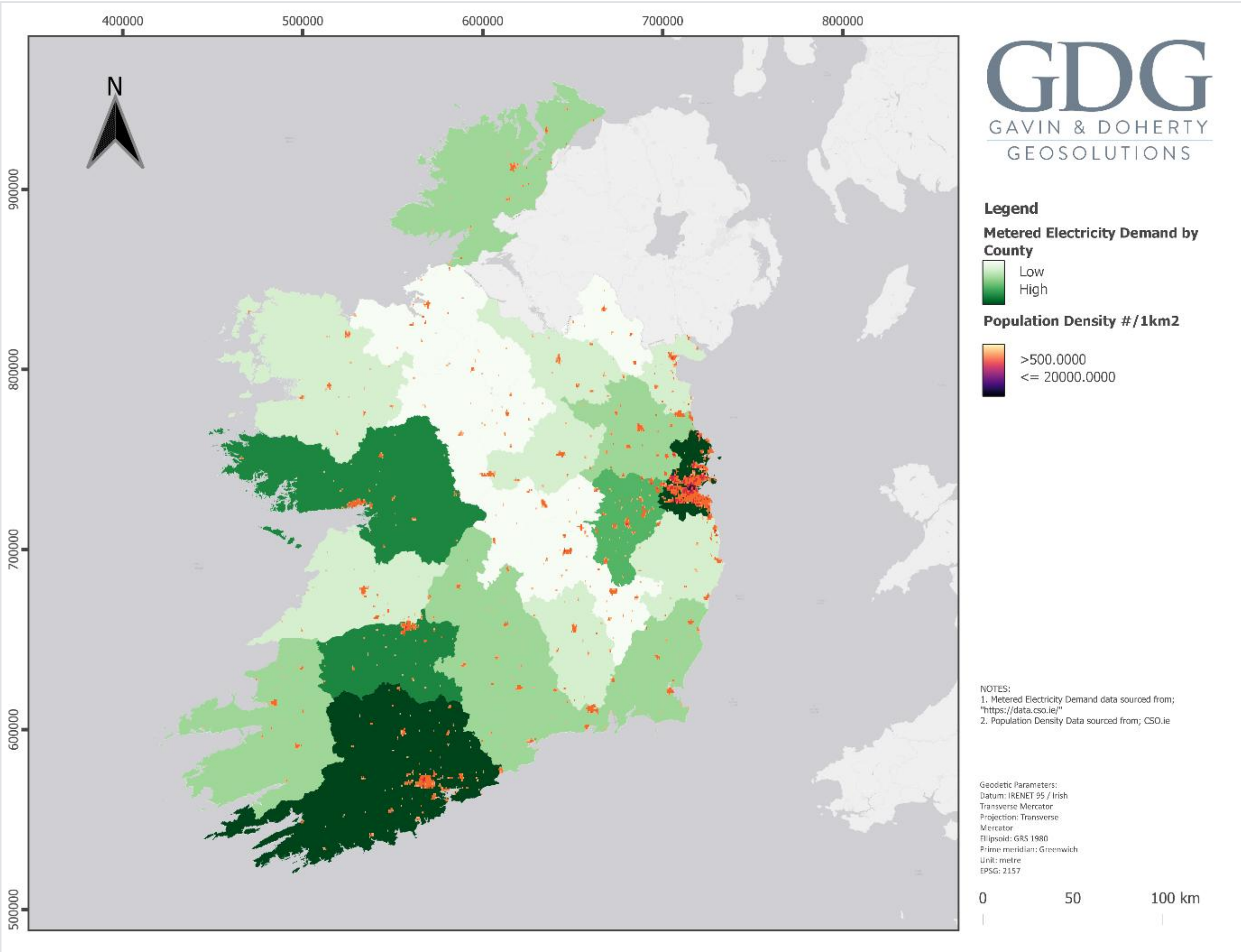


Figure 6-3 Energy demand map

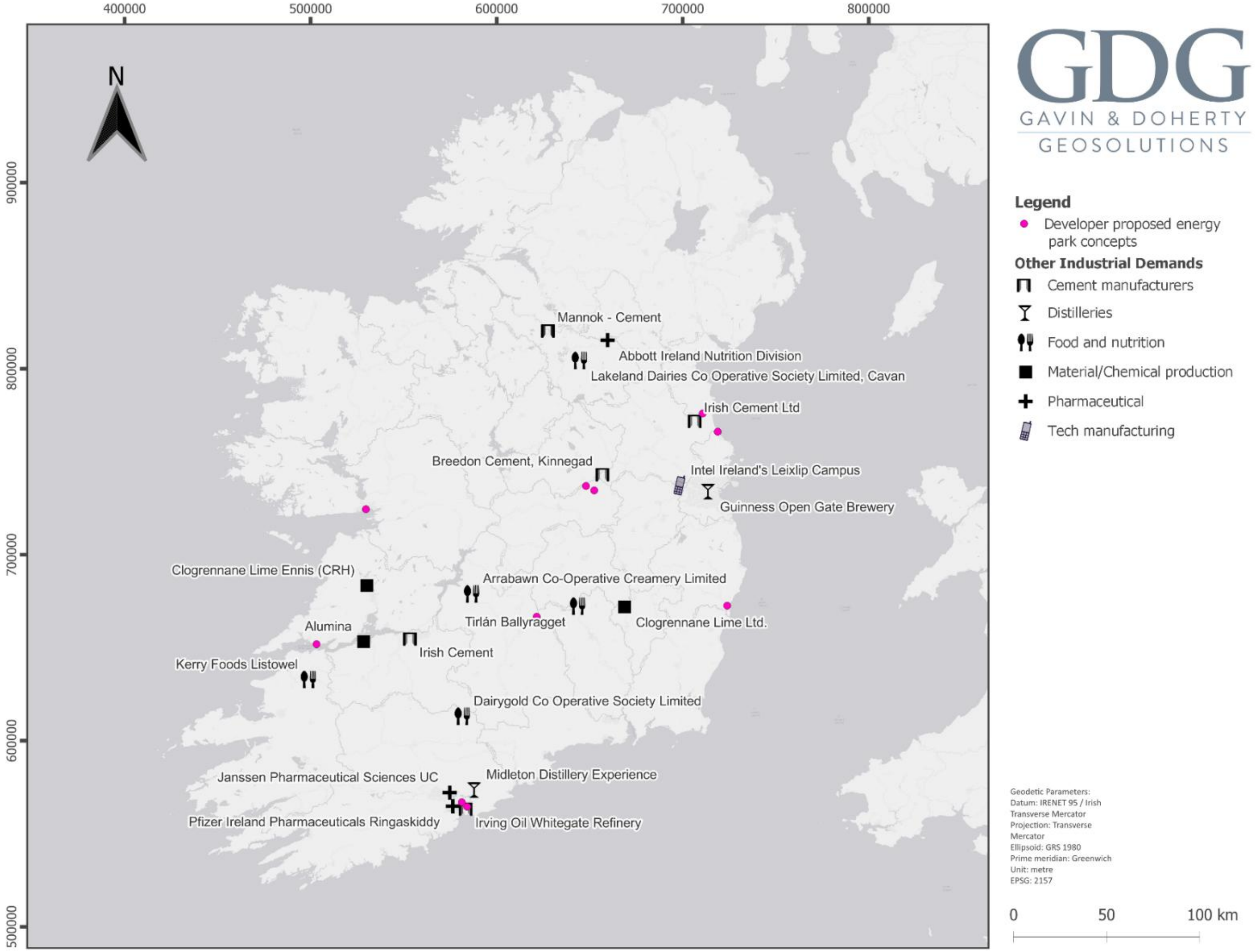


Figure 6-4 Major industrial demands for GEPs (Section 5.5 & A.1.1.1(a)Appendix B) and Irish GEP/co-location concepts (Section 5.1)

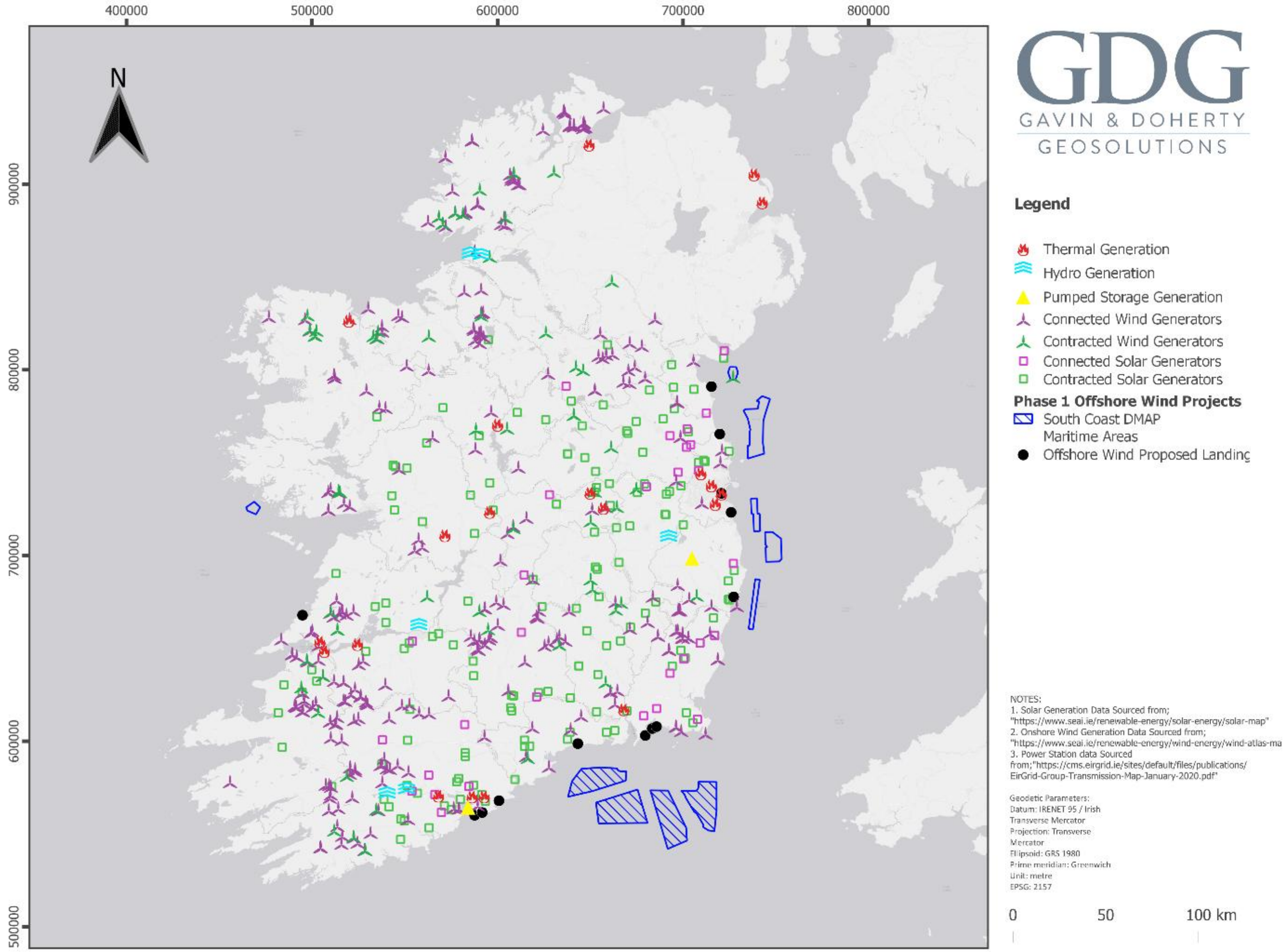


Figure 6-5 Energy generation map

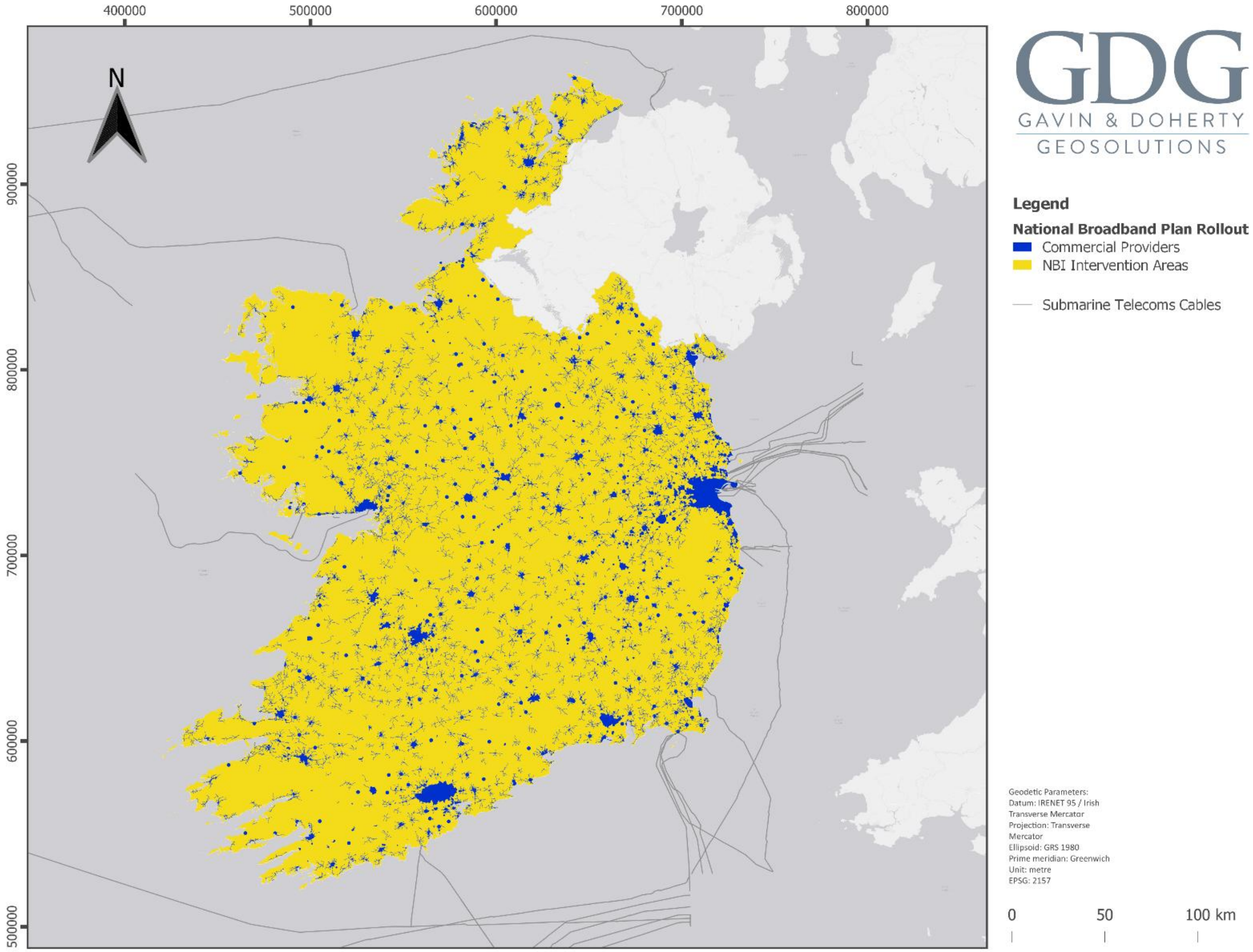


Figure 6-6 Telecoms infrastructure (DECC, National Broadband Plan map, 2024)

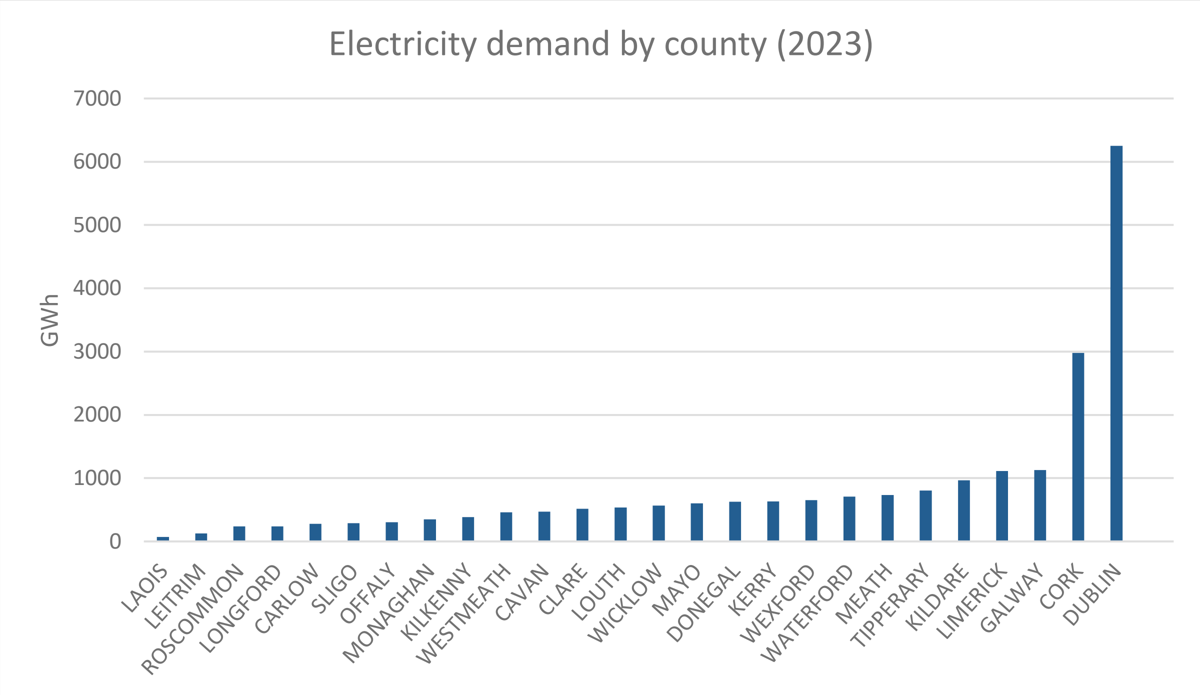


Figure 6-7 Total electricity demand by county in 2023 (CSO, 2023)

6.4 NORTHERN AND WESTERN REGIONAL ASSESSMENT

The Northern and Western Regional Assembly (NWRA) consists of two strategic planning areas and nine Local authorities [28]. The NWR has the lowest population combined with relatively low densities of large industrial energy users. This leads to the lowest energy demand of the three regions in Ireland. The highest energy demand (1127 GWh) and largest population centre in the NWR is in Galway. Donegal and Mayo are the second and third largest energy demands with 627 and 604 GWh respectively (Figure 6-8, Table 6-1).

Table 6-1 Northern and Western Regional Assembly structure

Regional Assembly	Strategic Planning Area	Local Authorities
NWRA	Border	Cavan, Donegal, Leitrim, Monaghan and Sligo
	West	Mayo, Roscommon, Galway and Galway City.

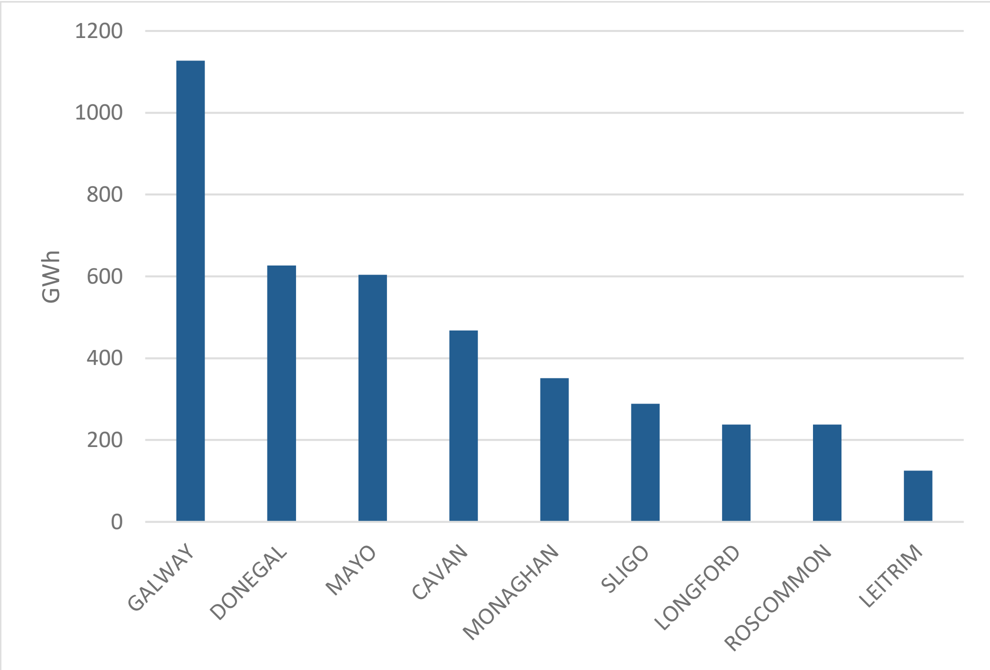


Figure 6-8: NWR electricity demand

The NWR has a current maximum installed export capacity of 1788MW produced by onshore wind, this figure is to be extended to 2454MW by 2030, with an additional offshore wind capacity of 450MW also planned. As it stands Donegal has the most connected onshore wind farms followed by Galway and Mayo. The region currently only has one minor solar generation connection of 0.12MW in county Cavan. Solar generation in the region is expected to extend to 262MW by 2030 with major installations in Galway and Roscommon (Figure 6-9).

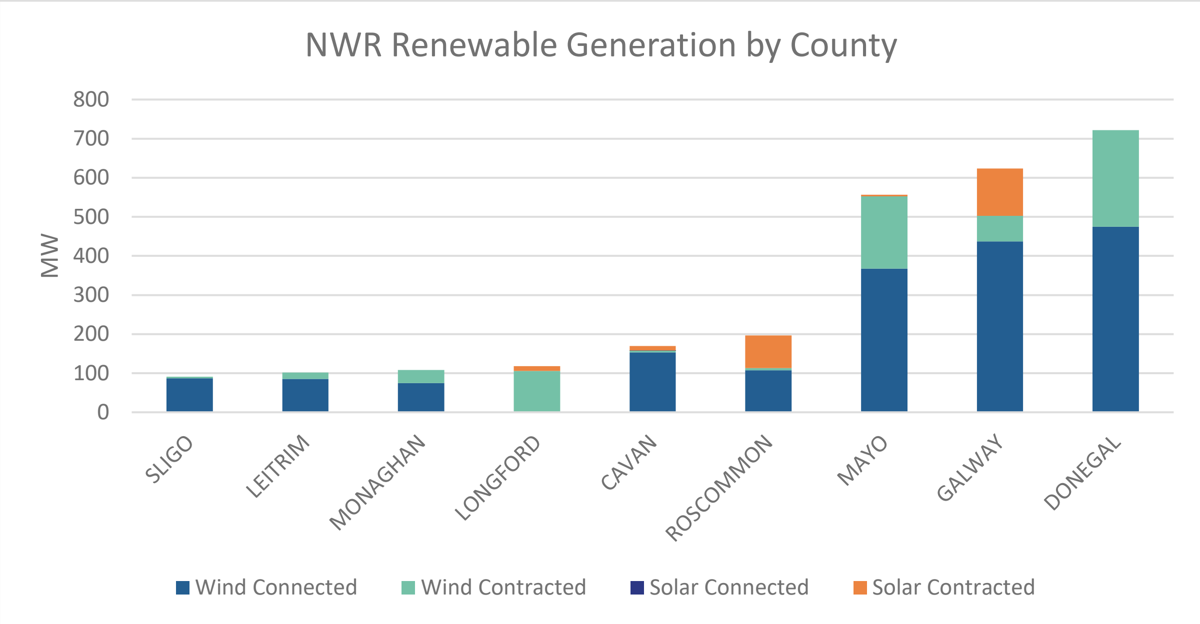


Figure 6-9: NWR renewable energy generation

6.4.1.1 NORTHERN AND WESTERN REGION SPATIAL ASSESSMENT

Galway is the major population centre of the NWR and shows promise for the location of a GEP. This area has significant benefits with good transport infrastructure and a strong grid network. Galway has the highest number of contracted solar installations in the NWR and a relatively high onshore wind pipeline. Galway has the highest existing energy demand in the region, locating additional high energy users in this area could put additional strain on resources and the local grid in times of poor generation.

Donegal has the second highest energy demand in the NWR and highest level of connected onshore wind projects. Donegal's renewable pipeline is also greater than Galway but with a focus on onshore wind, with a current lack of planned solar and offshore Wind. With low density population centres the rate of energy demand increase in Donegal is anticipated to be relatively low in comparison to other areas of NWR. This combination of high renewable energy generation and relatively low energy demand would make Donegal a good candidate for GEP development. Donegal's main constraints are a lack of infrastructure and grid network, with no rail connection and a low-capacity grid network. The county has relatively low population density centred around Letterkenny and Donegal but the development of GEPs could provide an economic boost to the county.

Mayo shows a similar energy demand and generation profile to Donegal, with very similar population densities also. Mayo's major benefit over Donegal is the better transport network with good rail connectivity and a slightly higher capacity grid network. Finally, Roscommon has significant potential, although it has a relatively low generation capacity compared to the top three generating counties in the NWR. It also has a very low energy demand. Roscommon's geospatial location between population densities in Galway and Westmeath combined with good transport and grid infrastructure make it a potential location for GEP development. The area is reviewed in Figure 6-10.

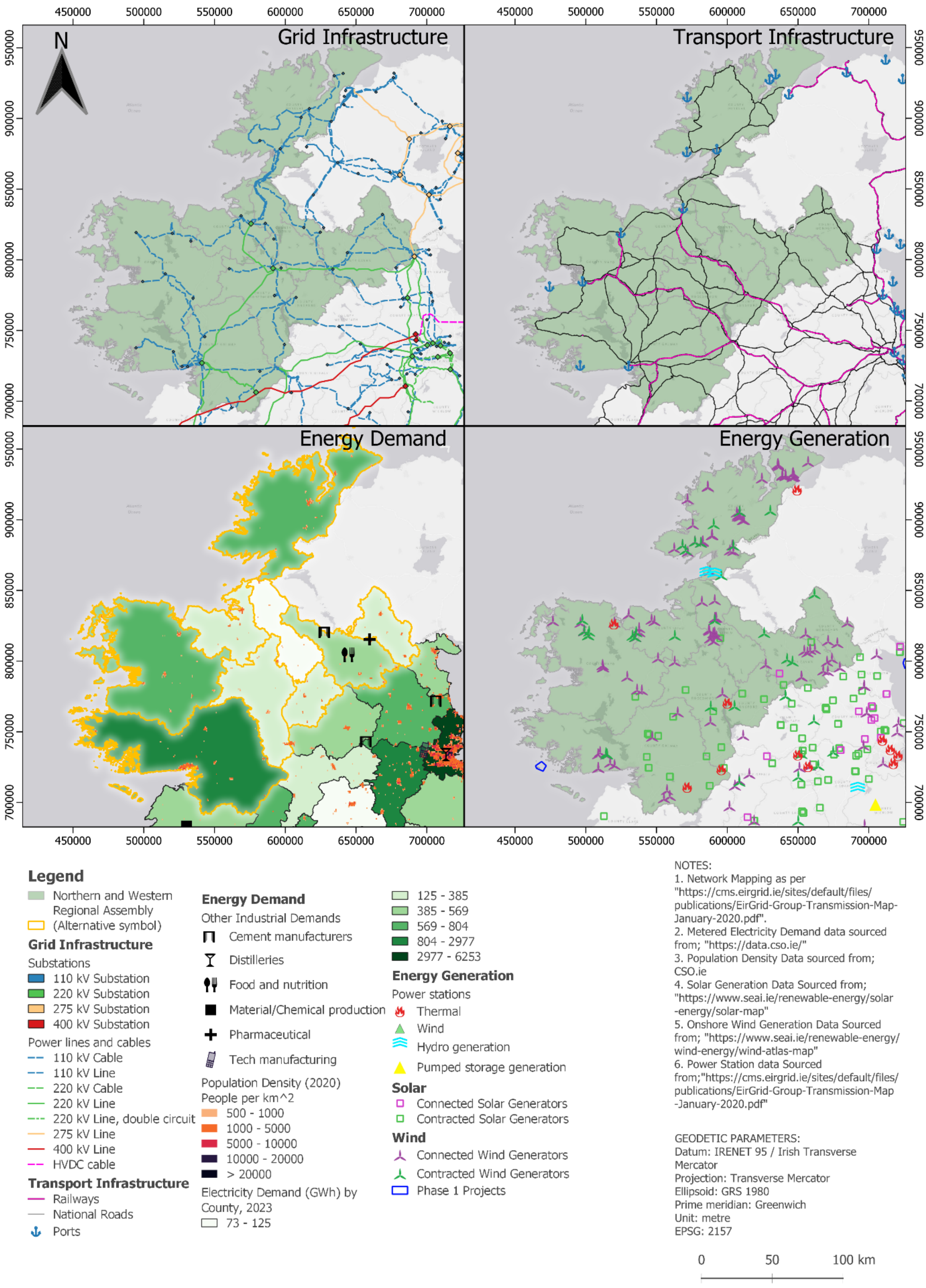


Figure 6-10: Overview of NWR

6.5 SOUTHERN REGIONAL ASSESSMENT

The SR consists of three strategic planning areas and ten Local authorities [30] (Table 6-2).

Table 6-2 Southern Regional Assembly structure

Region	Strategic Planning Area	Local Authorities
Southern Regional Assembly	Mid-West	Clare, Tipperary, Limerick City & County
	South-East	Carlow, Kilkenny, Wexford, Waterford City & County
	South-West	Kerry, Cork and Cork City

The SR has the second highest population combined with relatively high densities of large industrial energy users primarily located near Cork. This leads to the second highest energy demand of the three regional assemblies in Ireland. The highest energy demand (2977 GWh) and largest population centre is in Cork. With several relatively high population centres spread across the SRA in Cork, Limerick, Waterford, Wexford and Kilkenny. The population and energy demand is more spatially diffuse than seen in the EMRA and the NWRA. This lends itself to the development of GEPs due to generally good transport and grid infrastructure spread across the SRA (Figure 6-11).

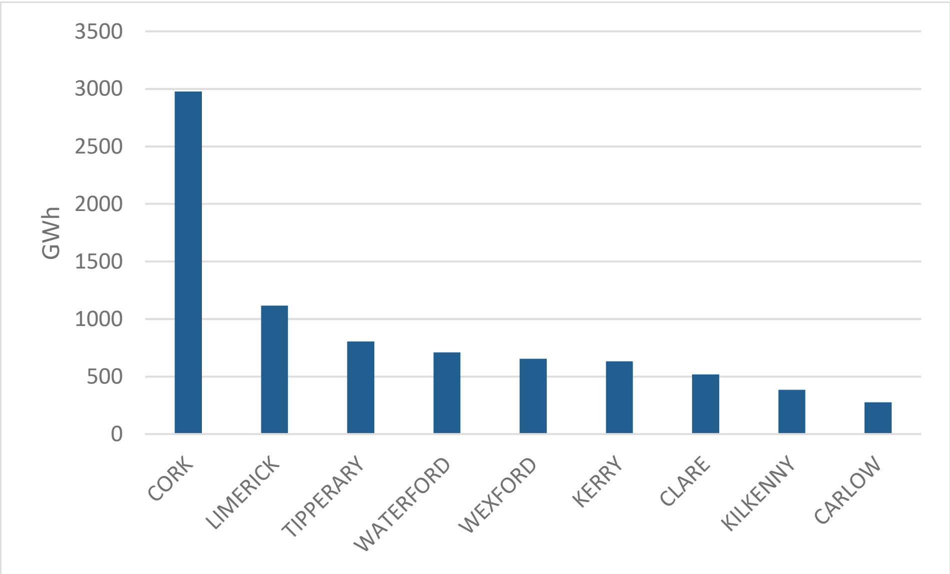


Figure 6-11 SR energy demand by county

The SR has a current maximum installed export capacity of 2546 MW produced by onshore wind, this figure is to be extended to 3134MW by 2030, with an additional offshore wind capacity of 900MW also planned as part of the ORESS 2.1 auction of the SC-DMAP area Tonn Nua (discussed in 2.2.3). As it stands Kerry has the most connected onshore wind farms followed by Cork and Tipperary.

The SR currently only has 283MW of solar generation, primarily located in Wexford and Cork. Solar generation in the region is expected to extend to 1960MW by 2030 with additional major installations in Wexford and Cork as well as other areas across the SR (Figure 6-12).

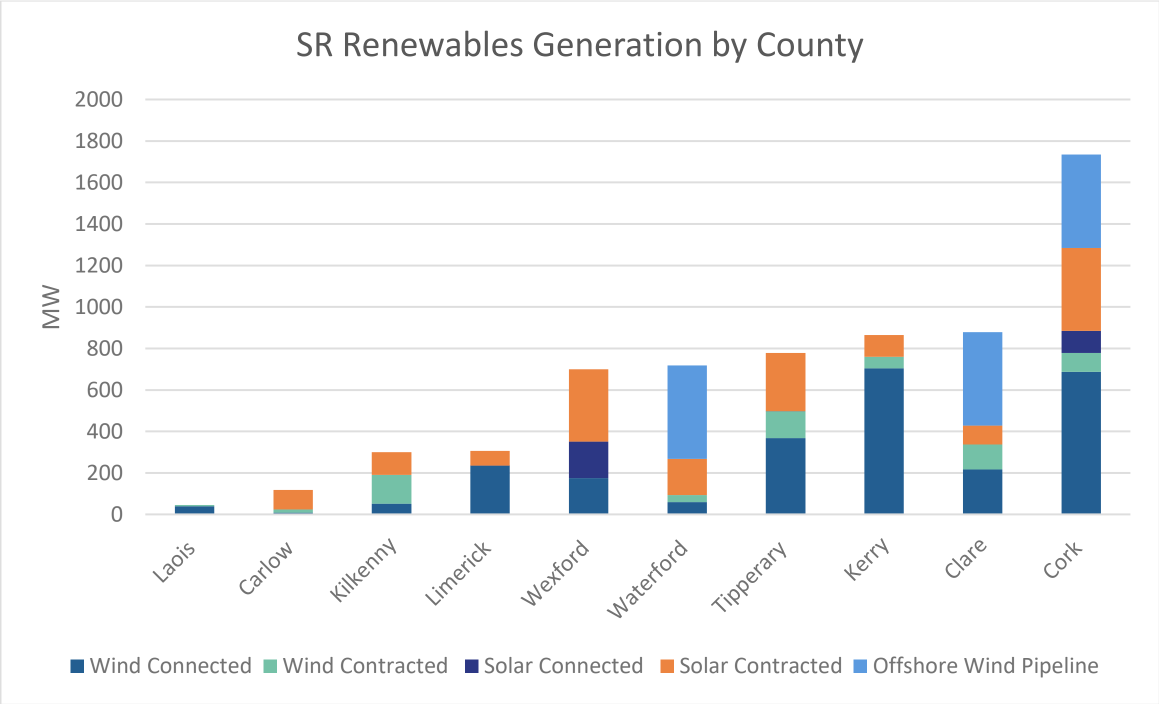


Figure 6-12: SR renewable energy generation

6.5.1 SOUTHERN REGION SPATIAL ASSESSMENT SUMMARY

The SR has the most spatially dispersed energy demand of the three assemblies, with LEUs and population centres relatively well distributed across the assembly. Cork is the primary population centre of the SRA, and this area has significant potential for GEP development with good transport infrastructure, port access and a strong grid network. Cork has the largest renewable energy generation potential with the inclusion of the ORESS 2.1 project Tonn Nua. Cork has a varied generation profile with significant capacity potential from onshore wind, offshore wind and solar. This diversity of generation profile would be beneficial to a GEPs which are reliant on consistent renewable energy generation. Cork does have the highest existing energy demand in the assembly and second largest in the country after Dublin, locating additional high energy users in this area could put additional strain on resources and the local grid in times of poor generation.

Limerick has the second highest energy demand in the SR and although it does not have the strongest pipeline of renewable energy generation, when considered in combination with neighbouring areas of Clare and Kerry, the region around the Shannon Estuary shows significant potential for GEP Development. This area has a notably strong grid network with the highest capacity powerlines and a large thermal generation station at Moneypoint which ESB has long signalled its intent to cease burning coal at Moneypoint by the end of 2025, and close the station by 2029. This opens significant potential capacity for renewable energy sources to join the grid. This area is further bolstered by the planned connection of the ORESS 1 offshore wind project Sceirde Rocks, which despite being off the Galway coastline in the NWR it has a planned connection into Moneypoint with a export cable landfall along the Clare coastline.

Given the direct power connection to the high energy demand in Dublin there is a risk that potential future connections of renewable energy source in this area are not utilised locally. Looking at the combined generation capacity of Limerick, Kerry and Clare whilst also considering the coastline off the Shannon estuary has seen extensive interest by offshore wind developers over the past five years, the south-west region could have significant potential for GEP development.

Tipperary, Wexford and Waterford all show very similar population densities, energy demand and generation capacity as well as good transport infrastructure, and these areas could be considered as good locations for GEP development. Waterford and Wexford do show more potential for GEP development. These areas were shown to be some of the largest population growth centres during the last census in 2022. This region also has slightly stronger grid network and higher potential renewable generation capacity from offshore wind, with the SC-DMAP potentially providing for over 3500MW of potential offshore wind beyond the aforementioned Tonn Nua site in Lí Ban, Manananan and Danú. These Maritime Areas are not anticipated for development until mid-2030s at the earliest, therefore while Waterford and Wexford are well placed for development of GEPs this region is less suitable to immediate deployment and could be considered a longer-term option with the development to coincide with the offtake of large capacity offshore wind energy. The area is reviewed in Figure 6-13.

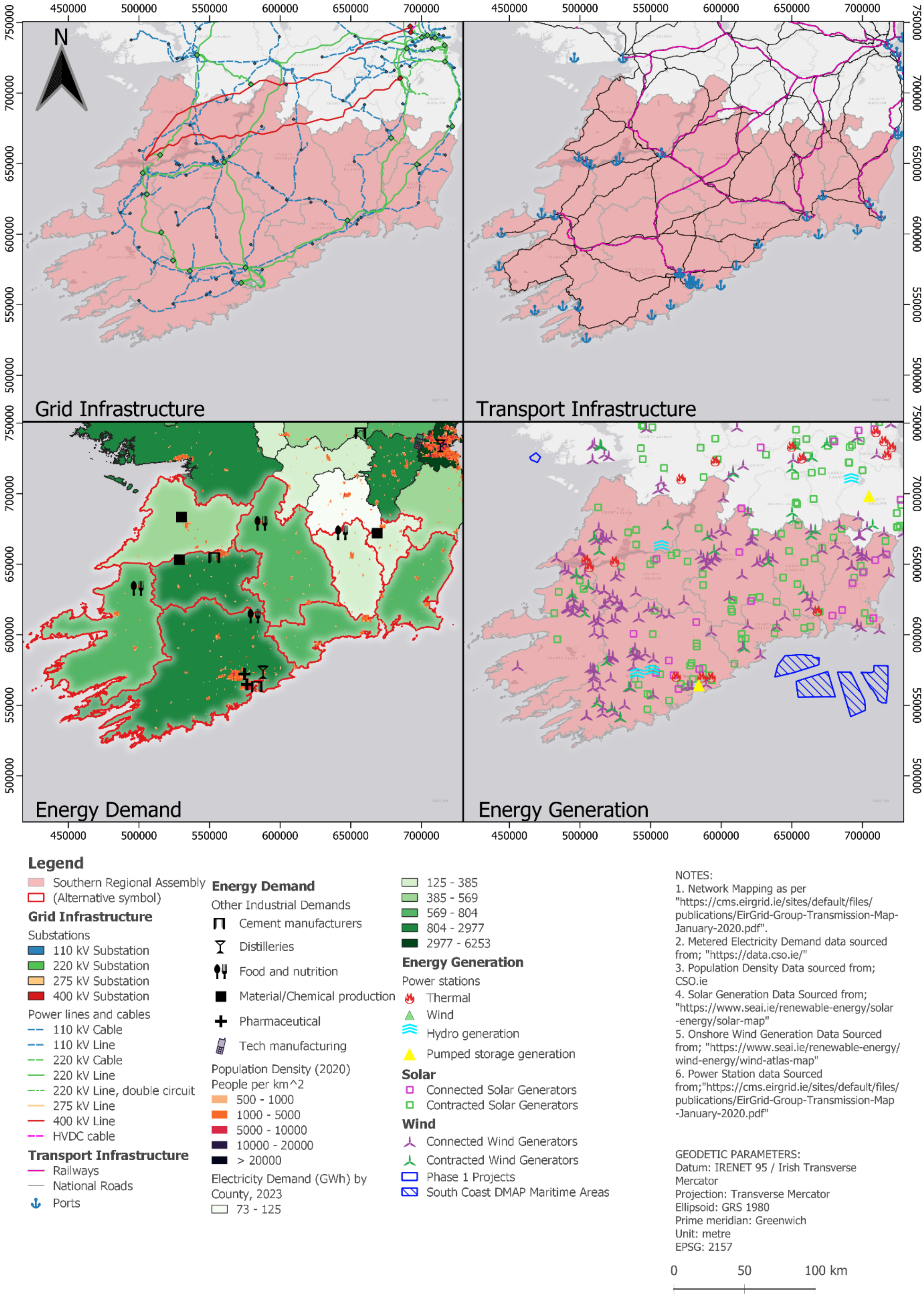


Figure 6-13: Overview of the SR

6.6 EASTERN AND MIDLAND REGIONAL ASSESSMENT

The Eastern and Midland Regional Assembly (EMRA) consists of three strategic planning areas and twelve Local authorities [29] (Table 6-3).

Table 6-3 Eastern and Midland Regional Assembly structure

Regional Assembly	Strategic Planning Area	Local Authorities
Eastern and Midland Regional Assembly	Dublin	Dublin City, Dún Laoghaire–Rathdown, Fingal and South Dublin
	Eastern	Kildare, Louth, Meath and Wicklow
	Midland	Laois, Longford, Offaly and Westmeath

The Eastern and Midland Region (EMR) has the highest population density centred around Dublin, with several high energy users in close proximity to Dublin including the majority of data centres developed in Ireland to date. This equates to the highest energy demand of the three regional assemblies with a total metered demand in Dublin of 6252 GWh (Figure 6-14). The energy demand in this region tends to sprawl outward from Dublin with relatively lower demands towards the midlands and further north and south along the coastline. Dublin being the capital has some of the best transport infrastructure in the country. There is currently a high demand on grid network, but several upgrades are planned across this region to accommodate the first phase of offshore wind projects.

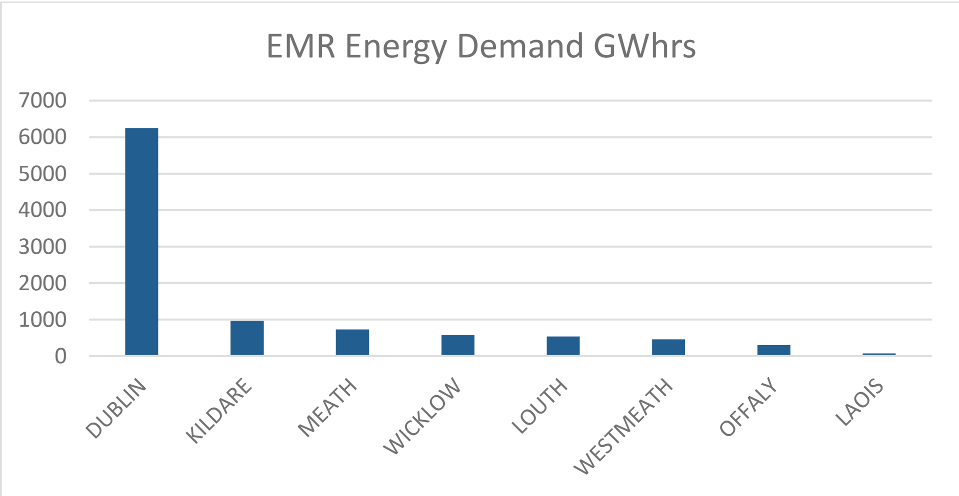


Figure 6-14 EMR energy demand

The EMR has a current maximum installed export capacity of 288MW produced by onshore wind, this figure is to be extended to 992MW by 2030. The majority of early-stage offshore wind development in Ireland to date, has been focused on the east coast, there are currently 5 proposed offshore wind projects along the east coast who have submitted planning applications this year. The total combined capacity of these 5 projects is 3800MW. To date Meath has the most installed renewable capacity with 323MW connected Solar generation. The Solar generation for the EMRA is set to extend to 1890MW by 2030 (Figure 6-15).

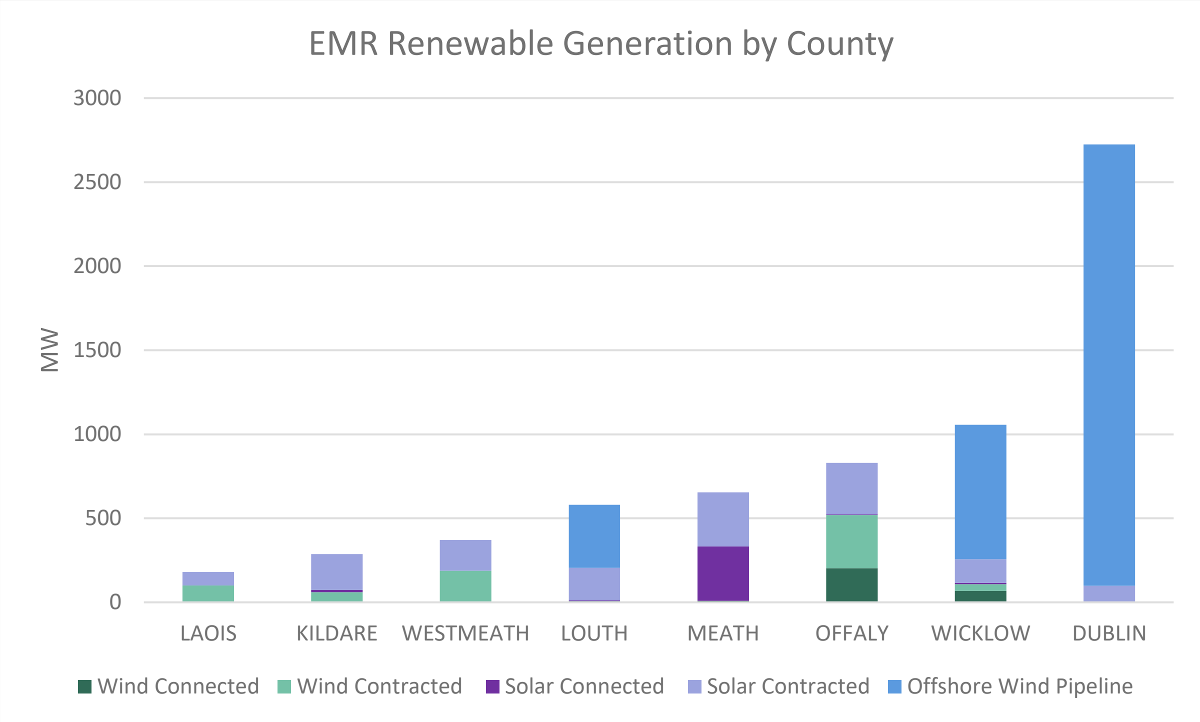


Figure 6-15 EMR renewable energy generation

6.6.1 EASTERN AND MIDLAND REGION SPATIAL ASSESSMENT SUMMARY

The EMR has the highest population density and the strongest transport infrastructure. This region has seen the development of approximately 69 data centres to date [64], primarily located in close proximity to Dublin. Despite the high population and good infrastructure Dublin may be less suitable to GEP development given the spatial and grid constraints and cost of land for development. Surrounding counties may offer a better solution whilst benefitting from proximity to the country's capital.

Currently Meath and Offaly show the highest connection of onshore renewables. These counties have large population centres in Navan and Tullamore. Transport infrastructure in these areas is also very good with easy access to Dublin and the associated ports and international airport. These counties offer a good option for initial deployment.

With the progression of offshore wind along Ireland's East coast, coastal counties such as Louth, Meath and Wicklow show high potential for GEP development, these counties currently have relatively low energy demand with some industrial use in place already. They benefit from high population sprawling from Dublin and with strong infrastructure. These counties currently have very low renewable energy generation but are likely to see offshore wind development in the future. The area is reviewed in Figure 6-16.

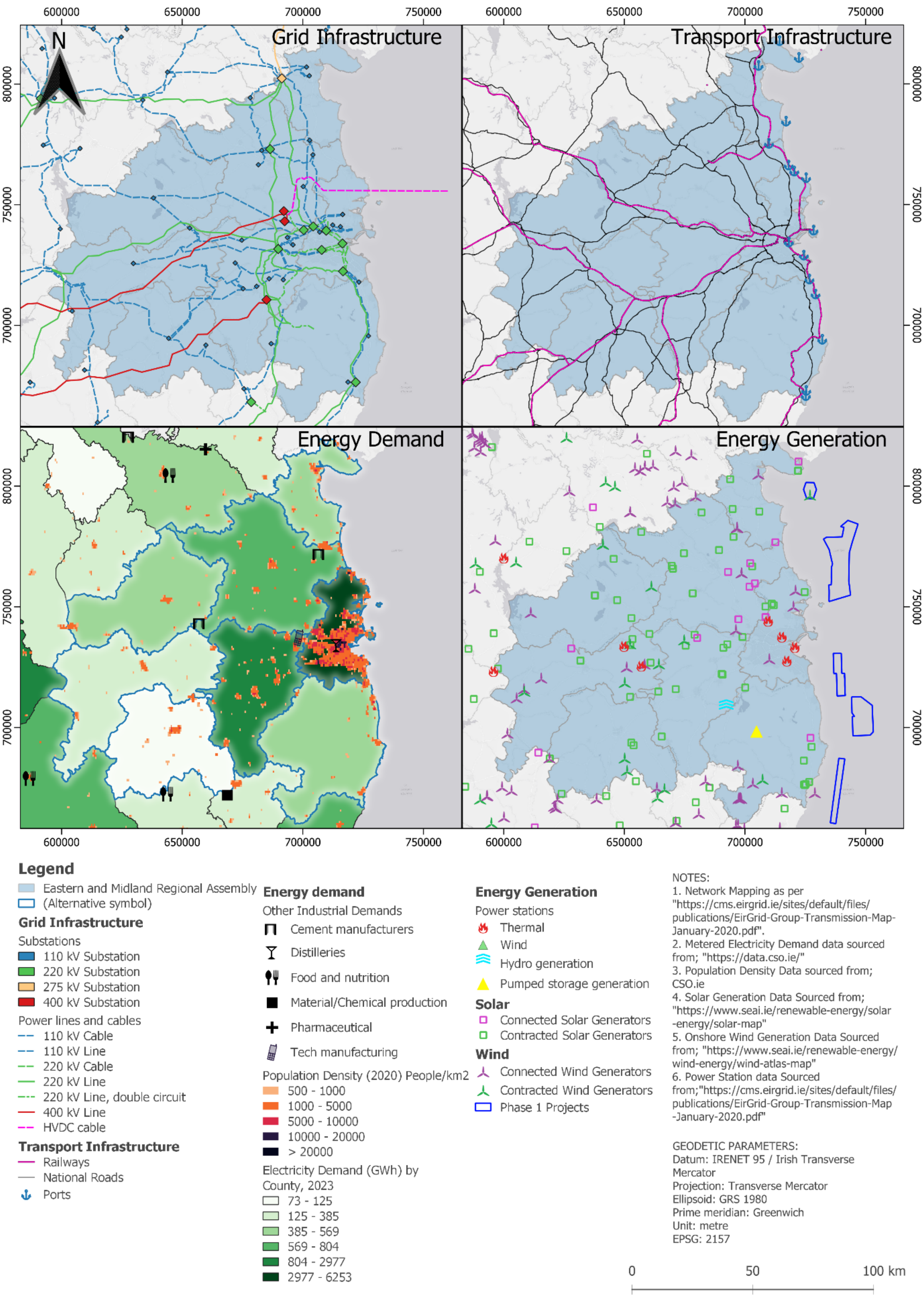


Figure 6-16: Overview of the EMR

6.7 SUMMARY AND CONCLUSION

The three regions present diverse opportunities and challenges for the development of GEPs. A strategic approach that leverages each region’s unique strengths with consideration of the renewable energy resources, infrastructure, and demand distribution is essential for effective deployment. Balancing these factors ensures that GEPs not only contribute to energy sustainability but also align with the broader regional and national energy strategies.

It should be noted that given the plan-led development regime for offshore wind going forward, and the seeming policy preference for GEPs to be powered by offshore wind primarily, the provision of future DMAPs or the identification by the State of an offshore wind site to feed into a GEP project could have a major bearing on future GEP development plans. As outlined in Section 2.2.3, terrestrial planning has also moved to a much more plan-led process, so the identification and designation of sites on land for development will be equally important.

The NWR has the lowest energy demand and population density among regions. Overall, the NWR has strong onshore wind capacity with plans to reach 2454MW by 2030 but limited solar development. The NWR has not been seen as a high-priority area for offshore wind development by developers to date, although some projects were proposed in the area before the move to plan-led development and some areas do show strong potential into the future for floating wind. The DMAPs being produced by DECC could identify potential for offshore wind development in this region, which would increase its potential for GEP development.

The key areas in the NWRA that show potential for GEP development area;

- **Galway** stands out as a regional hub with a high and growing energy demand driven by its status as a commercial, industrial, and population centre in the NWR. Galway has good existing infrastructure with a well-connected road network, a major railway lines, and access to Galway Port. Additionally, the county benefits from a relatively strong grid capacity compared to neighbouring areas. The county's renewable energy pipeline is limited, with few large-scale projects planned beyond its existing onshore wind capacity.
- **Donegal** possesses one of the highest renewable generation potentials in Ireland, particularly due to its onshore wind resources. Its coastal geography also offers potential for future offshore wind development. Donegal’s infrastructure may pose a barrier to GEP deployment. The county’s transport network is underdeveloped, with no rail connectivity and less developed motorway network. Additionally, Donegal has a relatively low population density and energy demand compared to other counties, which may limit the local market for energy-intensive industries or services associated with GEPs. The grid infrastructure in the area is also highly constrained.
- **Mayo** has an energy profile similar to Donegal, with moderate energy demand and strong renewable generation potential, particularly from onshore wind. Mayo also shows a better transport network compared to Donegal, including rail connectivity and a slightly higher-capacity grid network. Mayo offers a balance of good renewable energy resources and adequate infrastructure, making it a viable candidate for GEP development.

- **Roscommon** has a very low existing energy demand and modest renewable generation capacity compared to Mayo, Donegal, and Galway. Transport and grid infrastructure are quite strong in Roscommon with a strategic location between high-demand areas like Galway and Westmeath.

The SR has a high energy demand, with population and energy demand more spatially dispersed across the region. The SRA has a key benefit over the other regions with a diverse generation mix which will help limit generation downtimes periods. The key areas in SRA for the development of GEPs are;

- **Cork** boasts the largest renewable energy capacity in the SRA, with significant onshore wind, offshore wind, and solar generation potential. Cork has a high existing energy demand, the second highest in the country after Dublin. This poses a risk of resource competition which could impact GEP operations reliant on consistent energy availability. Cork's strong transport infrastructure, including ports and rail connections, makes it well-suited for large-scale GEP development.
- **The Shannon Estuary area**, encompassing Limerick, Clare, and Kerry, benefits from a strong grid network, including Moneypoint, Ireland's largest thermal generation station. With ESB's plans to transition Moneypoint from coal to renewable sources, the area has significant capacity for integrating renewable energy into the grid. The estuary's central location and its combination of renewable generation potential, industrial infrastructure, and grid capacity make it an ideal candidate for GEP development. Future policy around floating wind development will be an important driver to development in the Shannon Estuary area.
- **Waterford and Wexford** are both strategically positioned for future offshore wind development, with sites like Lí Ban, Manannán, and Danú identified for development in the mid-2030s. These counties have experienced some of the highest population growth rates in Ireland, suggesting a growing energy demand and workforce availability to support GEP development. With good transport and grid infrastructure, Waterford and Wexford are well-placed to support GEPs. However, their development may align better with the timeline for offshore wind energy becoming operational in the mid-2030s.

The EMR has the highest population and energy demand, centred around Dublin. The onshore wind (992MW by 2030) and solar (1890MW by 2030) potential are relatively low in comparison to other region with more available land for development. The key renewable generation for the EMRA into the future will be offshore wind with 3800MW of offshore wind projects in the pipeline. The key areas in EMRA for the development of GEPs are;

- **Dublin** as the capital is the most densely populated region in Ireland, Dublin faces significant spatial constraints that limit its suitability for GEP development. Land costs are among the highest in the country due to competing uses for commercial, residential, and industrial developments, which can make large-scale GEP projects economically challenging. Dublin also has the highest energy demand in Ireland, driven by population density as well as energy-intensive industries such as data centres. While this demand highlights the potential for a ready market, it also poses risks of resource competition during periods of low renewable generation, which could strain the grid.

- **Meath and Offaly** are well-positioned to support the early stages of GEP development due to their existing renewable energy infrastructure. Meath leads in solar generation capacity within the EMRA while Offaly is the strongest in current onshore wind generation. Both counties benefit from robust transport networks, including road and rail systems, facilitating easy access for construction and operation. Additionally, their proximity to Dublin ensures strong grid connectivity, which is critical for addressing baseload requirements. While not as densely populated as Dublin, these counties have growing population centres (e.g., Navan and Tullamore), which provide a stable local workforce and moderate energy demand. This balance makes them ideal for initial smaller-scale GEPs.
- **Louth and Wicklow** are both coastal counties strategically located near the east coast's offshore wind developments. These areas are poised to become key hubs for integrating offshore wind energy into Ireland's grid as the projects along the eastern coastline mature. Louth and Wicklow currently exhibit relatively low energy demands compared to other parts of the EMRA. This allows for easier integration of new renewable energy without having to serve a large existing energy demand. Both counties have strong transport networks, including proximity to ports, which will be crucial for supporting offshore wind construction and maintenance activities. Their location near Dublin further enhances their attractiveness as future centres for renewable energy innovation and supply. These counties are well-suited for medium-term GEP development, with growth potential aligned with the timeline for offshore wind energy projects expected to come online in the next decade.

7 ECONOMIC ASSESSMENT

7.1 MARKET ASSESSMENT

The global energy market has faced significant challenges, particularly following the 2022 energy crisis triggered partly by the Russian invasion of Ukraine, which caused significant increases in gas, electricity, and oil prices [81]. Europe, reliant on imported fossil fuels, was particularly impacted, although the situation began to improve in 2024 as pressures eased, volatility remains due to ongoing geopolitical tensions and economic challenges.

This crisis, alongside concerns about climate change, has accelerated the transition to renewable energy. Investment in clean energy has surged [82], with a global push to reduce greenhouse gas emissions and achieve net-zero goals. The EU aims for net-zero emissions by 2050 and has set interim renewable energy targets [83]. Ireland aligns with these goals, aiming for 80% renewable electricity by 2030, which will require substantial infrastructure development [84].

Projections suggest that global demand for fossil fuels will peak before 2030, with renewable energy sources growing rapidly. In Europe, the shift to renewables is evident, with renewables generating 52% of electricity in 2024, a significant rise from previous years [85]. The EU is also working to reduce its dependence on imported energy, especially following Russia's invasion of Ukraine and the subsequent sanctions on Russian energy. Before this Russia was the major extra-EU supplier of energy to the EU. Whilst efforts have been made to increase domestic energy production in Europe and import rates have dropped [86], a lot of this energy supply has just shifted to other extra-EU suppliers, such as Norway and the USA.

The energy crisis highlighted Europe’s vulnerability due to its heavy reliance on energy imports. In response, European nations are diversifying suppliers and boosting domestic energy production, especially renewable sources, to ensure more energy security in the future. These shifts indicate the growing role of renewable energy and the need for transformative changes in energy generation and consumption to meet climate goals.

7.1.1 IRISH ENERGY DEMAND

7.1.1.1 ENERGY SYSTEM OVERVIEW

The entire island of Ireland (Northern Ireland and the Republic of Ireland) shares a single energy market called the Single Electricity Market (SEM). The SEM is where electricity generators and suppliers trade the power used by homes and businesses across the island. The SEM allows electricity to be freely traded between market participants in either jurisdiction. The market is connected via two interconnectors to Great Britain: the Moyle Interconnector (500 MW) between Northern Ireland and Scotland; and the East-West Interconnector (500 MW) between the Republic of Ireland and Wales. The 500 MW Greenlink interconnector between Wexford and Pembrokeshire, Wales, commenced operation in January 2025. In addition, the 700 MW Celtic Interconnector linking Ireland and France is scheduled to be in operation by 2026, and the proposed 750MW MaresConnect (Wales to Ireland) is targeting 2029 for operation.

The total energy supply of Ireland is dominated by fossil fuels. Oil (46% of the total supply) is the most significant energy type, followed by natural gas (32% of the total energy supply) (Figure 7-1). Renewables make up a much smaller proportion, with 13% of the primary energy requirement coming from renewable sources in 2022. This, however, is a substantial increase on previous years. Renewables have grown by 127% since 2002 and are becoming a much more significant factor in the Irish energy system year-on-year.

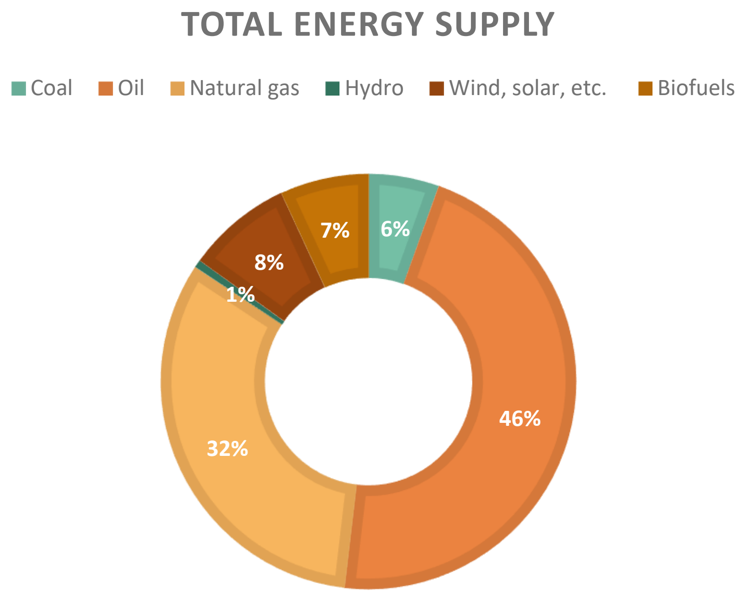


Figure 7-1: Ireland's total energy supply [87]

Ireland is currently highly reliant on energy imports to meet the demands of its energy system, importing 86% of the total energy consumed in 2023 [87]. Much of Ireland's imported energy comes from the UK, with 74% of Ireland's natural gas coming from imports through two interconnectors from the UK [88]. The remaining 26% comes from the Corrib gas field, located off the coast of Mayo. The opening of the Corrib gas field in 2015 led to a sharp decline in the rate of import dependency however this has since steadily climbed.

All oil consumed in Ireland is imported as the country has almost no internal supply. In 2022, oil accounted for 66% of all primary energy imports into Ireland. Energy import dependency could be radically reduced by further deployment of renewable energy infrastructure. If the targets set by the Irish Government to increase the share of renewable energy to 80% are hit, import dependency will decrease significantly. More will have to be done to reduce dependency on imported fossil fuels, particularly in the transportation sector including the deployment of electric vehicles (EVs).

7.1.1.2 SECTOR-SPECIFIC DEMAND

The greatest consumer of fossil fuels in Ireland is the transport sector. In 2022, 93.3% of road transport energy came from fossil fuels, and electricity accounted for just 0.5% [89]. At only 3.6%, EVs comprise a relatively small proportion of Ireland's total vehicle fleet. However, EVs have grown in popularity in recent years, with 45.9% increase in the total number of EVs in use between 2022 and October 2023. Demand for energy in the transport sector is growing as the sector continues to rebound following the COVID-19 pandemic. Demand from the sector was 19.9% higher in 2022 than in 2021. Energy demand from international and domestic flights was 128% higher, which has been a significant contributor to the general increase in demand.

Whilst overall emissions from the Irish energy system have declined by 1.7%, emissions from transportation rose between 2021 and 2022 by 0.7 $MtCO_2$. At an EU level, the share of renewable energy sources in transport reached 9.6% in 2022 [90]. This is a slight increase (+0.5%) on 2021, however it is far from the EU target of 29% of energy used in transport to be from renewable sources. In Ireland, only c6% of energy used in transport came from renewable sources in 2022, showing the country to be behind other European nations in this regard. Current trends in popularity of EVs paired with EU directives to reduce transport related emissions will likely lead to a significant rise in EVs by 2030 and, therefore, significant increases in demand for electricity.

A sectoral analysis of Ireland's electricity demand shows that the majority of electricity demand in the last decade (2012 to 2022) has come from the commercial services sector. Electricity demand in this sector has increased by 61.5% since 2012, whilst demand from all other sectors has only increased by 8% [89].

Within the broader commercial services sector, the information and communication sub-sector is the most significant energy user, increasing by 562% since 2012. This rapid increase in electricity demand is largely driven by the increased energy demands from data centres, an infrastructure that expanded rapidly across Ireland. In 2022, 82% of all information and communication electricity demand came from data centres. Current projections suggest electricity demand from this sub-sector is likely to exceed the demand from the residential sector. 68.2% of the final energy consumption of commercial and public service sectors is from electricity, followed by natural gas (18.33%) and oil (10.31%). Renewables only account for 2.73% of total energy usage across the information and communications sectors. Whilst renewables are still a small percentage of the broader energy usage of the commercial and public services, they have grown significantly in recent years. Since 2012, the share of energy from renewables in these sectors has risen 69.7%.

Other industries within the commercial and public service sectors have significant energy demands. Wholesale, retail and vehicle repair accounts for 21% of the total energy consumption in the commercial sector. The public sector is relatively evenly split in terms of its energy usage: public administration accounts for 32.9%; education 25.4%; health, residential care and social work 22.8%; and water supply, sewerage and waste management 18.9%. Levels of energy usage in these sub-sectors have not changed significantly in recent years, suggesting there is little to no scope for growth in demand without significant change in technology.

Section 5.5 and [79] demonstrate energy usage by large industry energy users in Ireland, based on emissions. Utilities companies and hyperscale data centres run by operators such as Microsoft, Vodafone and Facebook are large consumers of energy in Ireland. There are also many ancillary demands in the service and commercial sectors which whilst not representing the greatest demand for energy, still have significant energy requirements that could be sustained through increased renewable energy generation.

The Large Industry Energy Network (LIEN) is a membership network for companies with an annual energy spend over €1 million [91]. This network allows large companies to work together and share learning and best practice, with support from Sustainable Energy Authority of Ireland (SEAI), to improve their energy performances, reduce emissions and support others. 205 of Ireland's largest energy users are member of LIEN and 18% of Ireland's total primary energy requirement is by LIEN members. In order to join LIEN, companies have to commit to an energy management programme and action plan that involves setting and reviewing targets, with annual energy performance reporting. Companies are also required to publish energy usage data in efforts to ensure transparency and accountability. These published figures show that members of LIEN had a combined total primary energy requirement (TPER) of 30,327 GWh in 2022, accounting for 18% of Ireland's TPER [91]. The total CO_2 emissions reported by LIEN members in 2022 was 5.018 million tonnes, representing a 1% reduction on the year before and accounting for 8.1% of national emissions.

TPER data is broken down by sector, showing which sectors of the Irish economy are responsible for the most energy consumption. The most significant sector is 'other', which includes retail, technology, and services companies, and some of the more traditional 'heavy industries'. This sector accounts for 59.3% of LIEN's TPER. Other significant sectors include food and drink (which is the largest portion of LIEN membership and accounts for 18.9% of TPER and 18.2% of emissions), pharmaceuticals and chemicals (representing 22% of LIEN membership and 9.5% of TPER), and electronics (which accounts for 8.4% of TPER and 9.5% of emissions). Healthcare is the only other sector represented in LIEN and makes up 12.8% of the network's membership and 3.8% of TPER. This suggests that sectors such as pharmaceuticals and chemicals, food and drink and healthcare may not be proportionally as energy consumptive as other LIEN member industries as their proportion of TPER is smaller than their proportion of LIEN membership.

Data from LIEN is aligned with the earlier analysis presented, showing that most of the energy demand in Ireland comes from commercial services (more specifically the information and technology sectors and the associated data centres). These data centres are crucial infrastructure for supporting these sectors, but they do require significant energy to operate. Providing this energy while hitting the Government's net zero targets and ensuring energy security and efficiency for the residents and economy of Ireland is a core challenge.

7.1.2 EXPORT MARKETS

To assess which markets may have demand for Irish generated renewable energy and to explore potential for export, European countries that exhibit one or more of the following characteristics were considered:

- Markets that are presently reliant on imported energy from fossil fuels and renewable sectors (Figure 7-2)
- Markets that have limited potential to generate their own renewable energy
- Markets that are influenced by emissions reduction or renewable energy uptake targets, under a policy and legislative-driven pressure to increase their usage of renewables
- Markets with high demand levels that they currently struggle to meet

Using these criteria, a number of potential export markets were found, as explored below. The cases selected are representative of potential opportunities to export energy to the rest of Europe. They are not exhaustive and there are definitely other markets that share similar characteristics to the cases explored that would be worth exploring as potential options. These cases illustrate a range of market sizes, and whilst some countries may be heavily import reliant their relatively small energy markets may deter from the expense to export there. It is important to note that whilst there is potential for export, the levels of demand within Ireland and its reliance on energy imports suggests that there will be little surplus energy available for export, at least in the short-to-medium term. Ireland has one of the most import-reliant energy systems in Europe, lagging behind much of Europe in terms of deployment of renewable energy systems. Furthermore, the results of stakeholder consultation on the concept of GEPs found that there are high levels of demand for data centres on the GEP site, powered by the renewable energy generated. In the scenarios established through this stakeholder consultation, it appears that there is minimal scope for the export of surplus energy from GEPs in the medium term. As such, the following discussion of potential export markets also offers some insight into the demand for data centres and other functions of the GEPs as potential streams of income.

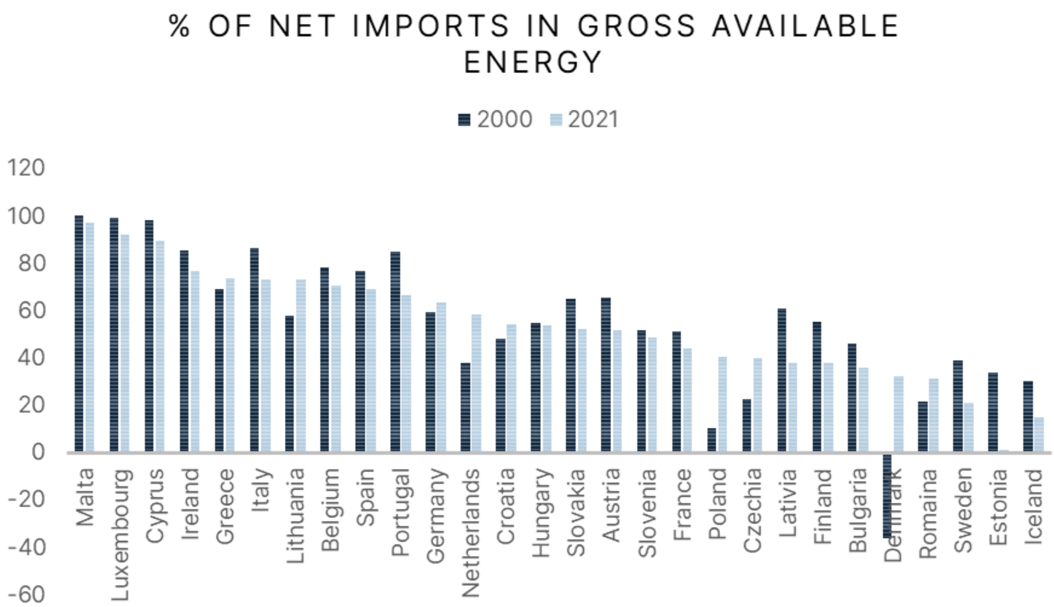


Figure 7-2: Energy import dependency in European nations [92]

7.1.2.1 LUXEMBOURG

Luxembourg's electricity consumption per capita has decreased by 29% since 2000 to 11.143 MWh/capita [93]. This is, however, still slightly more than double the European average and is the fifth highest of any European nation. The country's energy intensity[5] has declined significantly in the same period, by 47% to 1800.324 MJ/thousand USD; it has one of the least energy intense economies in Europe, ranking 39th out of 43 nation states. This is due, in large part, to the industrial composition of Luxembourg's economy which is predominantly made up of service industries and specifically finance, which tend to demand a lot less energy than heavier manufacturing industries.

Luxembourg had the lowest deployment of renewables of any EU MS in 2023, with renewable energy accounting for 12% of total energy consumption. Between 2022 and 2023, the country's renewable energy output decreased by 2% [94]. The energy system of Luxembourg is fossil fuel intensive, driven primarily by high demand for transportation fuels to support the transit and freight industries and high demand from commuters. The Luxembourg Government set out legally binding targets for a 55% emission reduction by 2030 and a climate neutrality target by 2050. With its geography also limiting its potential for large scale renewable energy deployment, and to hit these targets, Luxembourg may have to import significant amounts of renewable energy.

7.1.2.2 GERMANY

In 2023, Germany imported 68.6% of its energy, an increase on 2022 at 63.4% and higher than European averages. The country is also the greatest importer of energy in Europe in terra joules (TJ) of energy, importing 9,760,090 TJ in 2022 [95]. This is significantly more than the second greatest importer (the Netherlands: 7,812,258 TJ) and illustrates the energy consumptive profile of Germany's economy. Since 2000, the net total of imported electricity has risen by 54%. Oil products are the largest proportion of the final energy consumption in Germany, accounting for 39.3% in 2022 (followed by natural gas at 25.3%).

In terms of energy consumption by sector, Germany's energy consumption is evenly spread across multiple sectors: the residential sector accounts for 26.6%; the industry sector accounts for 25.6%; and the transport sector accounts for 24.3%.

Germany has substantial deployment of domestic renewables already, but legislative targets call for further uptake and broader renewable usage. In 2022, renewable energy accounted for 43.7% of the total electricity generated in Germany, a 605% increase on 2000. Wind energy is the largest source of non-combustible electricity produced in Germany, accounting for 62% of total renewables generation. Germany was an early adopter of offshore wind technologies and as such has fairly evolved and expansive wind energy infrastructure. However, current projections by Deutsche WindGuard suggest that Germany will not meet its wind power expansion targets by 2030 [96]. Current targets to have an almost entirely renewable electricity supply by 2035 are unlikely to be met if wind power output does not increase.

Whilst Germany has had a relatively successful rollout of renewable technologies, and the country is successfully incorporating renewable energy into its energy supply, it is still reliant on fossil fuels. In terms of electricity generation, Germany's coal use is still high, with 26.6% of electricity coming from

[5] The total energy supply of a country per unit of GDP.

coal in 2023. This makes coal the second most significant energy source for electricity generation after wind, and the burning of coal to generate electricity accounts for 80.3% of energy-related CO_2 emissions in Germany. In terms of electricity consumption, industry is the area with the highest levels of demand, accounting for 43% of the total final consumption of electricity in Germany.

This data shows that Germany has a highly energy consumptive economy that is currently highly reliant on imported energy, with no major oil and gas reserves. However, Germany does have a successful renewable energy sector that generates a significant portion of the county's electricity needs and does have capacity to expand. This offers a somewhat mixed picture of Germany as a potential export market.

Additional to note, there is an existing relationship between Ireland and Germany through its Joint Declaration of Intent, as the countries are working collaboratively to study the production of green hydrogen and its derivatives in Ireland, and the potential transportation pathways to export any excess to Germany [97]. This is the first project in the energy partnership between Ireland and Germany and indicates the potential for future development of exports to Germany. Germany's most recent Import Strategy for hydrogen and hydrogen derivatives is centred around the goal of having a secure and sustainable supply of imported hydrogen. They specifically want to import from neighbouring European countries who have a high renewable energy potential, with the aim of diversifying their supply sources. Germany is one of the world's largest importers of hydrogen, and recent developments suggest that this is an important market, and relationship, for the Irish energy sector to explore [98].

7.1.2.3 THE INTERNATIONAL DEMAND FOR DATA CENTRE SERVICES

Through stakeholder engagement, data centres have been identified as the most likely primary form of demand for the GEPs and, therefore, the most likely tenant, as discussed in Sections 3 and 5.4.

Data centre provision is central to the Irish technology sector and the economy in general. Ireland's technology sector accounts for €52 billion (16%) of gross value added and employs 140,000 people (6% of total national employment with 40% growth over the last five years) [18]. With the developments of AI technologies, 5G and virtual reality systems the demand for data centres is set to increase.

Europe's data centre capacity is primarily based in five key clusters: 1) Frankfurt; 2) London; 3) Amsterdam; 4) Paris; and 5) Dublin. Dublin has become a hub for hyperscale and co-location centres given its success in attracting technology companies, temperate climate and large wind energy resources (see Section 5.4).

Global data centre demand is increasing rapidly, with studies finding that that the total value of investment into global data centre infrastructure has more than doubled in recent years [99]. Large corporations still struggle to secure data centre capacity despite this investment due to a lack of supply and power shortages. The European data centre market grew by nearly 20% year-over-year in Q1 2024 [100] however supply shortages persist across the continent, especially in core markets like Frankfurt. Preleasing new facilities has become common, indicative of a need for ongoing investment in data centre development. Power sourcing remains a key challenge and block to development.

7.1.2.4 INTERNATIONAL DEMAND FOR PHARMACEUTICAL MANUFACTURING

Through stakeholder engagement, pharmaceutical manufacturing plants have been identified as a likely primary form of demand for the GEPs and, therefore, a likely tenant.

Ireland is a leading country for the pharmaceutical industry in Europe, and it is a global player in production of pharmaceuticals. The industry in Ireland is comprised of a mixture of international and local companies. Approximately 120 overseas companies have plants in Ireland including nine of the 10 largest pharmaceutical companies in the world [101]. The industry has evolved rapidly over the last 50 years, and today is at the forefront of the world's pharmaceutical production as well as research and development.

Ireland is the largest net exporter of pharmaceuticals in the EU, accounting for over 50% of all exports from the country. In 2022, Ireland exported $83.5B in pharmaceutical products, making it the fourth largest exporter of pharmaceutical products in the world [102]. A profile of Ireland's pharmaceutical export is shown in Table 7-1.

Table 7-1: Profile of Ireland's pharmaceutical export [102]

Export market	Export value ($ billion)
The USA	31
Belgium	10.6
Germany	10.4
China	4.22
The Netherlands	3.41

The fastest growing export markets between 2021 and 2022 were Belgium (which grew by $3.81 billion), the USA (which grew by $2.08 billion), and Germany (which grew by $1.85 billion).

7.1.3 IRELAND'S RENEWABLE POTENTIAL

Ireland's most significant potential for renewables development is in offshore wind due to its location in the Atlantic Ocean and substantial coastline. A study conducted by the Energy Sector Management Assistance Program (ESMAP) assessed the offshore wind technical potential of countries around the world [103], considering wind speed and water depth, offering an estimate of the energy generation capacity that could be technically feasible. The study found that Ireland has high levels of offshore wind power generation potential, with a total capacity for over 600 GW of energy generation, through a combination of fixed offshore windfarms and floating offshore windfarms. The waters surrounding Ireland are ideal for offshore wind due to its depth and the relatively high and consistent wind speeds. Off the west and north-west coasts, wind speeds regularly sit above 10 metres per second (m/s) [104] and have peaked at over 100 km/h on multiple occasions in storm conditions [105]. The west coast is the windward side of the island, where there are consistently high wind speeds that make it a prime location for an offshore windfarm.

The prevailing wind direction across the island is between south and west, with average annual wind speeds ranging from 3 m/s in Leinster to over 8 m/s in the north [106]. There is substantial diurnal variation of wind speeds across Ireland. On the west coast of Ireland, the diurnal range of wind speed is 11.5 m/s during winter and 8.4 m/s in the summer. This uses readings from the meteorological centre at Belmullet. A typical inland centre, such as the one at Clones, experiences a diurnal range in wind speed of 8.4 m/s in winter and 6.2 m/s in summer. On average, there are fewer than two days a year with gale wind speeds in inland Ireland, but in northern coastal locations such as Malin Head this rises to over 50 days a year. This shows that onshore wind speeds vary across the island and throughout the year. However, it is clear that areas in the west of Ireland experience the most consistent high wind speeds and that wind speeds intensify throughout winter. Beyond wind speeds, another factor that influences the efficacy of an onshore wind farm is the topography of the land on which it is built. Areas that are flatter or elevated generally lead to more efficient wind power generation as the wind is unobstructed in these areas and wind speeds tend to be higher as a result. Ireland's topography is characterised by a generally flatter lowland central region surrounded by more mountainous coastal areas. This topography lends itself to onshore wind generation. It is likely due to these physical and geographical attributes that wind is already far ahead of other forms of renewable energy in the country, generating 37% of the country's total electricity needs from September 2022 to 2023 [89].

Solar power is a major focus of the Irish Government's renewable energy development targets, with the aim to generate 8GW of solar power capacity by 2030. Current solar energy generation levels are at less than 1GW and as such significant development and advancement is necessary. Currently, a lot of solar power developments are located in the southeast of Ireland (the counties with the most sunlight: Cork, Waterford and Wexford, averaging over seven hours of daily sunlight during summer [107]). However, using the global horizontal irradiance, an indicator of how much energy from the sun reaches the earth's surface and, therefore, how much solar power can be generated, there is minimal difference between the north and south of Ireland. This indicator shows that there is only a 15% difference between Rosslare and Letterkenny in terms of sunlight and solar power generation potential [108]. The biggest weakness in the Irish solar power system is likely to be the seasonal variations in sunshine hours. In December, average daily sunshine ranges from one hour in the north to two hours in the southeast. This lack of consistent sunshine limits the potential to consistently generate solar power and emphasises the need for battery storage. Surplus power must be stored to ensure there is supply throughout duller months. As of March 2023, there was 1.9GW of solar farm capacity planned for grid-connection (with 34MW of that already connected) according to EirGrid.

Wind, both onshore and offshore, and solar power are all variable in nature. This means that at different times of day or times throughout the year the levels of energy that can potentially be generated through wind and solar power can fluctuate. This is due to simple variances in weather patterns and seasonal climate trends. Because of this high level of variability, renewable energy systems must be supported with significant investment in energy storage and dispatchable generation.

Another potential risk involved in the expansion of the renewable energy sector in Ireland is the pressures this could put on the national grid. The national grid of Ireland already experiences significant strain with growing electricity demand for all sectors of the Irish economy and population, but in particular from data centres which have seen a 600 GWh increase in demand since 2018 [18]. This has led to the decision to limit the addition of new data centres in Ireland, particularly in areas in and around Dublin. With limited grid capacity, not only in Dublin but in more rural areas as well, there are limited remaining locations where the power system could accommodate multiple data centres without becoming significantly constrained. As such, the construction of new data centres with a direct private wire connection to adjacent sources of renewable energy has been considered in this report. This way, the data centres could reduce potential additional strain on the national grid system and ensure they can consume renewable power when possible. This ensures that the technological innovation and enterprise activities that are associated with data centres, and core to Ireland's economy, can continue without overwhelming the grid. Ireland has more capacity for renewable energy generation than it does domestic demand for energy, so there is potential for a surplus of green energy on an annual basis. It is the perspective of the Irish Government that this surplus energy potential should be directed towards productive endeavours, such as data centres, exports or green hydrogen. However, given the variability in when this surplus energy is likely to be available, it will not be possible to rely entirely on it for supplying constant power demands. Many data centre operators have ambitious renewable targets and are aiming for 100% renewable electricity supply by 2030. However, data centre operators are also likely to need a continuously available electrical supply.

From a policy and regulatory perspective, Ireland is primed to make significant increases in its deployment of renewable energy technologies in the near future. There are multiple, cross-department government strategies that look to tackle climate change and accelerate the generation of renewable energy on a national scale. This is supported by international legally binding emission reduction targets set by the EU. Regulatory Indicators for Sustainable Energy (RISE) is a standardised scoring methodology to assess a country's policies and regulations in the energy sector, and how inclusive, progressive and efficient this sector is. Looking at RISE scores, Ireland ranks amongst the most advanced energy systems in the world, scoring 89 of 100 and ranking sixth of all countries included in the study [109]. With regard to the renewable energy system of Ireland, it scored 88 of 100 and ranked tenth. These high scores both indicate the strength of Ireland's policy and regulatory position on green energy and evidences the extent to which Ireland is world-leading in its approach to tackling energy concerns and innovating.

7.2 ECONOMIC IMPACT ASSESSMENT

7.2.1 INTRODUCTION

This section presents three potential scenarios that describe a potential GEP, and describes the processes and methods used to ascertain the economic impacts that the construction and operation of a GEP will bring to the State. Impacts are measured in employment, gross value added (GVA), and income. GVA and income are measured in Euros (€) at 2023 prices. Employment is measured in full-time equivalents (FTE), representing one full-time worker working for one full year.

The assessment considers direct and indirect impacts:

- Direct impacts: those created by the operation of the development (such as revenue generated by commercial developments) and those created by the work done on the construction of the development
- Indirect impacts: those created by the business-to-business transactions that are caused by the direct impacts.

Impacts are described as 'one-off' or 'continuous':

- One-off impacts: these impacts occur only once, but may be spread over a period of time, this will be generated by the Development Expenditure (DEVEX) and Capital Expenditure (CAPEX) of the site development
- Continuous impacts: these impacts will occur continuously once the development is complete, on an annual basis, and will account for economic activity of the businesses that occupy the site.

7.2.2 SCENARIOS

Three scenarios describing potential GEPs have been developed by Glic and GDG based on primary and secondary research, stakeholder consultations, and existing expertise and experience. Details on the methodologies, assumptions and key variables describing the scenarios are outlined in Appendix C1. Detailed Scenario Development Methodology.

It should be noted that the scenarios defined for the purposes of this assessment are hypothetical and chosen to be illustrative for this work and provide a basis for economic assessment.

Given the motivation of this work is the offshore wind industrial strategy, offshore wind is considered as the primary power source in all scenarios. This does not exclude the potential for onshore-only GEPs, which has been discussed in this report in Section 5.

The scenarios also assume that the GEP will have what has been termed a partial grid connection, which will be used to export to the grid in times of excess generation, and import from the grid in times of insufficient generation, with power generated in the GEP otherwise being used to power the demands on site. The likelihood of GEPs needing this connection to the grid for security of supply has been established through stakeholder engagement. Currently, partial grid connections are not a feature in Ireland. Parties connecting to the grid require a contracted Maximum Export Capacity (MEC) or MIC[6]. Although supply customers may have more generation installed than their MEC can accommodate, and demand customers may have more equipment installed than can be powered by their MIC, these are commercial decisions and would not be classed as partial grid connections.

It was also noted through stakeholder engagement that this arrangement would lead to overall system cost increases due to the potential to increase dispatch down (when exporting electricity to the grid at times of high renewable generation system wide), to increase the requirement for conventional generation (when importing electricity at times of low renewable generation system wide), and to

[6] MEC is the maximum amount of electricity in MW that a generator is contracted to export to the grid, while MIC is the maximum amount of electricity that a customer is contracted to import from the grid. Both are key requirements for planning for grid infrastructure.

require reinforcement to the grid to enable the connection. Under current market structures the majority these additional costs would be imposed on the wider customer base.

The scenarios also assume private wire connections are facilitated. As discussed in Section 2.2.3, this is currently not the case, but private wire policy is currently under review by Government.

The full implications of grid connection are not considered in this work and will require further assessment, as discussed in 8.1, including how GEPs would interact in the energy market and with the wider system.

There are several potential approaches that could be taken to grid connection within the GEP and with the transmission network that require further assessment. In all scenarios here it is assumed that the main demands (from the data centre and pharmaceutical manufacturing facility in the scenarios assessed in this report) would be grid connected to ensure security of supply. Certainty on the MIC of these demands would be required.

1. **Generation could be connected to on-site demand by private wire within the park, and not grid connected.** In this scenario, the sole purpose of the on-site renewable generation would be to service demand at the GEP, and generation would be directly connected to demand via private wires, with no connection of the generation to the transmission system, meaning the GEP could not export power to the grid. The battery storage would be co-located to store excess renewable power and discharge this to the on-site demand when generation is low, and when no power is available from on-site generation or storage, the demand would take power from the grid. Changes to private wire policy would be needed to accommodate this.
2. **Generation could be grid connected with no private wire connections.** On the other extreme, the generation and demand could be co-located physically, but all demand and supply would be directly connected to the grid, meaning on-site generation would be sent to the grid, and on-site demand would be satisfied by power taken directly from the grid. CPPAs could be agreed between the demand and supply, but there would be no direct use of the power generated on-site by the demand, as is currently the case for CPPAs as shown in Figure 5-8.
3. **Generation could be connected to the grid and have a private wire connection to the demand in a hybrid approach.** In this scenario, the generation could have a private wire connection to the demands, as well as a connection to the grid. The generation would prioritise supplying power to the on-site demand but could also export power to the grid in times of excess supply, should they occur, and the demand would take power directly from the on-site generation, but also have the ability to take power from the grid in times of excess demand relative to generation (and storage) on-site.

The approach to grid connection taken would have significant implications on a number of criteria, including grid infrastructure requirements, MEC/MIC, security of supply, decarbonisation etc. Some of these impacts are discussed for the different approaches in Table 7-2, but they are not considered for the purposes of this assessment.

Table 7-2: Overview of impacts of different grid connection approaches for generation at the GEP (assuming demand is grid connected in all scenarios)

Impact	1. Private wire only approach	2. Grid connected approach	3. Hybrid approach
Grid Capacity	No export of power from the GEP to the grid, but impact of MIC of the demand.	Grid connection needed for full MEC of the GEP, and MIC of demand.	In addition to MIC of demand, grid connection needed for export of power from the GEP, but reduced reliance compared to the grid connected approach.
Transmission Infrastructure requirements	No new transmission system infrastructure needed for generation, but reinforcements needed to accommodate demand.	Transmission upgrades will be needed to accommodate large MEC from generation and ensure grid stability, with reinforcements also required for demand.	Infrastructure required for export of excess generation to the grid, and import from demand, but this could potentially be optimised based on the GEP's requirements.
Security of supply	No direct impact on the system from generation within the GEP, but demand will take power from the grid, and power generated in the park cannot benefit the system. Increased demand may require new generation somewhere else in the grid to supply the demand of the GEP at times.	Large export capacity from the GEP can contribute to security of supply and system balancing, but will also add to constraint and curtailment.	System can benefit from some renewable integration in times of excess generation, but uncertainty on when this power would be available.
Emissions	Localised impacts from maximum use of renewable power generated on site, but no impact on decarbonisation of the grid.	Supports national emissions reduction by feeding renewables directly into the system.	Prioritises local consumption of renewables but allows for some export of renewables to the grid.

7.2.2.1 SCENARIO ONE

Scenario One is the most basic version of a GEP described in this section. It consists of a 1GW fixed offshore wind farm, an offshore substation, an onshore substation, battery storage, and a data centre.

Table 7-3 provides the key assumptions based on ORE Catapult's report on Fixed Bottom Wind Costs [110] which were used to inform costings for the assessed 1GW fixed offshore wind farm for the purpose of this assessment. It is noted that some of these assumptions e.g. year of operation, distance from shore, water depth, and potentially foundation type, would not be directly applicable to a SC-DMAP or Irish site, but they provide a useful reference for the purpose of this assessment.

Table 7-3: Key assumptions for Scenario One (offshore wind farm)

Parameter	Data
Year of final investment decision	2019
First operation date	2022
Turbine rating	15MW
Water depth at site	30 m
Annual mean wind speed at 100 m height	10 m/s
Distance to shore, grid, port	60 km
Foundation	Monopile
Substructure manufacturing Location	Europe
Currency conversion	Average annual £ to € conversion rate
Inflation	5.2% per year
Operating capacity	45%

Table 7-4 presents the estimated development and project management (PM), capital, installation, and operations, maintenance, and service (per annum) associated with the offshore wind farm, offshore substation, and onshore substation based on the assumptions outlined in Table 7-3 at 2023 prices. (Note that all figures are rounded to the nearest million, so totals may not sum exactly)

Table 7-4: Estimated expenditure (offshore wind farm)

Expenditure categories	Prices (€M)
Development and PM	
Development activities and consenting services	70

Expenditure categories	Prices (€M)
Environmental surveys	6
Resource and metocean assessment	6
Geological and hydrographical surveys	6
Engineering and consultancy	6
Other	75
Total	*168*
Capital	
Turbines	1,641
Array cable	51
Export cable	114
Cable accessories	7
Turbine foundations[7]	639
Offshore substation	168
Onshore substation	42
Operation base	4
Total	*2,665*
Installation	
Foundation installation	188
Offshore substation installation	91
Onshore substation construction	35
Onshore export cable installation	70
Offshore cable installation	125

[7] Average between MP or JCK, 30-40m WD

Expenditure categories	Prices (€M)
Turbine installation	103
Offshore logistics	5
Other	205
Total	*822*
Operations, maintenance, and service (per annum)	
Operations[8]	4
Other[9]	31
Turbine maintenance and service	46
Balance of plant, maintenance, and service	25
Total	*106*

Assumptions and key variables that describe the data centre are outlined in Table 7-5.

Table 7-5: Key assumptions for Scenario One (data centre)

Parameter	Data
Power capacity	500MW
Floor space	296,422 m^2
Employment	741
Power capacity utilisation	50%[10] [111]

There are several types of data centres including hyperscale, colocation, and wholesale. It is assumed in this scenario that the GEP will contain several data centre types. There is also a wide variety of activities that can be conducted in data centres; it is assumed in this scenario that the types of activities conducted in the data centres will be representative of the activities currently conducted in data centres across Ireland [112].

[8] Excludes insurance
[9] Insurance, environmental studies, and compensation payments
[10] To assess economic impacts, a 50% utilisation factor was assigned. This does not relate to MIC requirements. Utilisation will vary based on the users and type of data centre, but 50% was deemed appropriate for this assessment. This is not to state that a 500MW data centre would only require a 250MW MIC, and for the purposes of grid planning, a 100% utilisation rate may need to be assumed.

Based on these assumptions and key variables, the estimated development, capital, and construction costs of the data centre is €4,098M and the expected annual output in basic prices of the data centre is €1,217M.

It is difficult to assess the required size and scale of the battery storage that would be required for this system. However, most economic impacts associated with battery storage would be one-off, as ongoing maintenance is likely to be minimal. Furthermore, a significant proportion of the equipment used in the installation of the battery storage would be imported, further limiting the potential net economic impacts in Ireland.

7.2.2.2 SCENARIO TWO

Scenario Two builds on Scenario One with an additional 150MW onshore wind farm and a 150MW solar farm.

The estimated expenditure for the 150MW onshore wind farm is based on the average cost to construct and operate a large onshore wind farm in Europe [113]. Costs are based on 2018 market prices and have been converted to 2023 prices using GDP deflators. Cost estimates for development expenditure are based on that for an offshore wind farm and are appropriately modified. The onshore wind farm is assumed to have an operating capacity of 35%.

Table 7-6 presents the estimated development & PM, capital and construction, and operations, maintenance, and service (per annum) associated with the wind farm and onshore substation based on the assumptions outlined above in 2023 prices. (Note that all figures are rounded to the nearest million. Totals may not sum exactly due to rounding.)

Table 7-6: Estimated expenditure (onshore wind farm)

Expenditure categories	Price (€M)
Development and PM	
Environmental impact assessments	2
Development activities and other consenting services	11
Environmental surveys	2
Resource and metocean assessment	1
Geological and surveys	2
Engineering and consultancy	2
Project management	9
Total	*29*
Capital and installation	

Expenditure categories	Price (€M)
Wind generator	114
Internal electrical installations	10
Electrical substation and power lines	29
Engineering design and construction	12
Additional expenses	3
Total	*168*
Operations and maintenance	
Head office	4
Maintenance	4
Total	*8*

The estimated expenditure for the 150MW solar farm is based on the estimated cost of a solar farm in the UK [114]. Costs are based on 2019 prices in Pounds Stirling at market prices and have been converted to Euros using average annual exchange rates, and to 2023 prices using GDP deflators. The solar farm is assumed to have an operating capacity of 11%.

Table 7-7 presents the estimated development, capital and installation, and operations, maintenance (per annum) associated with the solar farm based on the assumptions outlined above in 2023 prices [114]. (Note that all figures are rounded to the nearest million. Totals may not sum exactly due to rounding:

Table 7-7: Estimated expenditure (solar farm)

Expenditure categories	Price (€M)
Development	
Head office	12
Systems design	3
Permitting	18
Total	*33*

Expenditure categories	Price (€M)
Capital and installation	
Modules	68
Inverters	10
Mechanical installation	18
Electrical installation	14
Inspection	2
Racking and mounting	9
Cabling / wiring	19
Safety and security	2
Monitoring and control	1
Total	*144*
Operations and maintenance	
Operations and maintenance	2
Total	*2*

7.2.2.3 SCENARIO THREE

Scenario Three is the most extensive scenario. It includes all aspects of Scenarios One and Two, as well as a green hydrogen production facility and pharmaceutical manufacturing facility. Table 7-8 presents the assumptions that describe the green hydrogen production facility.

Table 7-8: Key assumptions for Scenario Three (green hydrogen facility)

Parameter	Data
Hydrogen electrolyser plant CAPEX (€/kW)	1970
Installed power (MW)	20
Economic lifetime (years)	25
Theoretical energy consumption (kW/h/kg)	39.4
Electrolyser efficiency (%)	70.00%

Actual energy consumption (kWh/kg)	56.3
Stack durability (Operational Lifetime) (hr)	60000
Stack degradation (% per 1000h)	0.19%
Stack replacement cost (% CAPEX)	15.00%
Other OPEX (% CAPEX)	2.00%
Renewable energy connection	Direct
Operating hours (hr/year)	4383
Average electricity costs (€/MWh)	86.05
Grid fees (€/MWh)	0
Electricity taxes (€/MWh)	0
Cost of capital (%)	6%

Table 7-9 presents the estimated capital and construction, and operations and maintenance (per annum) associated with the green hydrogen facility based on the assumptions outlined in Table 7-8 in 2023 prices. (Note that all figures are rounded to the nearest million. Totals may not sum exactly due to rounding.)

Table 7-9: Estimated expenditure (green hydrogen facility)

Expenditure category	Price (€M)
CAPEX	
Electrolyser stack – labour, energy	0
Electrolyser stack - materials	3
Electrolyser stack – other	5
Balance of Plant (BoP) – power supply unit	6
BoP - other	6
Engineering, procurement, construction, and installation	18
Total	*39*

OPEX	
Electricity	8
Stake replacement	0
Labour costs	0
Other	0
Total	*9*

Assumptions and key variables that describe the pharmaceutical manufacturing facility are outlined in Table 7-10.

Table 7-10: Key assumptions for Scenario Three (pharmaceutical manufacturing facility)

Parameter	Data
Power capacity	100MW
Floor space	99,415 m^2
Employment	1,392
Power capacity utilisation	30%[11]

It is assumed in this scenario that the types of activities conducted in the pharmaceutical manufacturing facility in the GEP will be representative of the activities conducted in pharmaceutical manufacturing across Ireland.

Based on these assumptions and key variables, the estimated development and construction (excluding equipment) costs of the pharmaceutical manufacturing facility is €610M and the expected annual output in basic prices of the manufacturing facility is € 3,698M.

7.2.3 IMPACT ASSESSMENT

A structured national economic modelling technique has been used to calculate gross direct and indirect impacts. Net impacts at the national level were calculated following consideration of additionality (deadweight, displacement, and leakage).

Glic's economic modelling uses data from the Irish National Supply and Use Tables and Input-Output Tables provided by the Central Statistics Office (CSO) as well as industry specific secondary research. Metrics are calculated by classification of products and services by activity to the same level of granularity as the CSO Supply and Use tables.

[11] A 30% utilisation rate was assumed for the purposes of economic assessment, and does not relate to MIC. For the purposes of grid planning, a 100% utilisation factor may need to be assumed.

The most recent Supply and Use tables and Input-Output tables provided by the CSO are from 2020. It should be noted that economic data from this year may be skewed due to the COVID-19 pandemic and may not be entirely representative of the economy under normal circumstances.

The methodologies for the modelling of impacts during the construction and operations phases of the GEPs are presented in Appendix C4. Detailed Impact Modelling Methodology.

All impacts and figures are presented in 2023 prices; GDP deflators calculated from the National Accounts provided by the CSO are used to achieve this when required, allowing for like-for-like comparisons to be made.

7.2.3.1 ADDITIONALITY

Net impacts consider which impacts are additional to the counterfactual. This assessment takes the position that the developments created as part of the GEPs in the three scenarios would not otherwise occur, for the purposes of establishing a counterfactual, and net economic impacts.

It should be noted, however, that some of the developments described in the scenarios may occur without being part of the GEP. This is particularly the case for renewable energy generation given Irish Government renewable energy generation targets. A data centre and green hydrogen facility are assessed to be less likely to occur outside of a GEP due to current limitations in grid capacity. Pharmaceutical industry developments may occur without a GEP; however, the GEP may encourage and enable additional development. At this stage, there is not enough information to provide definitive conclusions. As such, this context is important to consider when interpreting the results.

Given this assumption, additionality is considered in two parts:

- Displacement: the extent to which economic activity created by an intervention is offset by the loss of economics activity elsewhere in the study area
- Leakage: the extent to which economic activity created by an intervention flows out of the study area.

With regard to displacement, where an intervention takes a share of resources (input market or labour) or a share of the product market from existing organisations, the scale of effects will vary depending on the nature of activity supported and the markets impacted by the activity. Considering power generation that is not used internally within the GEP (as Ireland is heavily reliant on imported energy) it is assessed that any displacement of energy production within Ireland is unlikely and it will instead expand Ireland's energy production market. Given that the activities associated with data centres are primarily exported, additional data centres are unlikely to displace current data centre activities within Ireland. The same assessment is made with regard to pharmaceutical production. Green hydrogen is assessed to be used internally within the GEP and this displacement does not need to be considered.

It is also assumed that there are sufficient resources, either in Ireland or available for import, and that there is a sufficient labour pool in Ireland, or that measures could be put in place to develop the labour force required, given the timescales of the projects. Thus, resource displacement is assessed to be zero. It should be noted that when locations of GEP sites have been determined, regional displacement may occur as a result of limited local labour or resource supply.

To account for potential leakage on a national level, a 'national expenditure' modifier is assessed and applied for each avenue of expenditure, representing the proportion of expenditure likely to occur in Ireland and capturing direct leakage. Leakage on the indirect impacts is captured within the economic modelling by considering the industry-by-industry imports.

Where detailed figures for national expenditure are not available[12], an assessment is made as to whether national content is expected to be zero, very low, low, medium, high, very high, or full (Table 7-11).

Table 7-11: National content modifiers

National content assessment	National expenditure modifier
Zero	0%
Very low	10%
Low	25%
Medium	50%
High	75%
Very high	90%
Full	100%

7.2.4 RESULTS

Table 7-12 presents a summary of the total impacts associated with the DEVEX, CAPEX, and OPEX of the three scenarios. Impacts are presented as both the one-off impacts of the development of the GEP and the continuous impacts of the operation and ongoing business activity within the GEP. One-off impacts will spread over the development and construction period. All figures are in 2023 prices. GVA and household earnings figures are rounded to the nearest million and employment is rounded to the nearest whole number. Totals may not sum exactly due to rounding.

Table 7-12: Summary of total impacts

	One-off impacts[13]			Continuous impacts		
Scenario	One	Two	Three	One	Two	Three
GVA[14] (€M)	822	851	1,190	1,063	1,160	3,069
Household earnings (€M)	326	337	475	79	81	181
Employment (FTE)	7,311	7,529	10,661	1,350	1,402	3,400

[12] In many cases this will not be available until more project specific details are available.
[13] These figures represent the total impacts during the development and construction of the sites which will be spread over several years.
[14] The cost to all electricity users of new grid infrastructure development and new dispatchable generation capacity development driven by GEP development could not be assessed in this study, however, this may reduce GVA, while potentially increasing household earnings and employment.

7.2.4.1 SCENARIO ONE

The one-off impacts associated with the DEVEX and CAPEX of the various developments described in Scenario One are presented in Table 7-13. All figures are in 2023 prices. GVA and household earnings figures are rounded to the nearest million and employment is rounded to the nearest whole number. Totals may not sum exactly due to rounding.

Table 7-13: One-off impacts associated with Scenario One

	1GW fixed offshore wind farm and substations	500MW Data Centre	Total
GVA (€M)	129	693	822
Household earnings (€M)	45	281	326
Employment (FTE)	914	6,397	7,311

It should be noted that the one-off impacts will be spread over several years. The impacts associated with the development of the data centre are particularly significant due to the large scale of the development, increasing the total data centre capacity in Ireland by approximately two thirds. This report does not provide an assessment of the length of time it will take to develop and construct a GEP. However, for the purposes of providing context to the one-off impacts, it can be assumed that the development and construction phases will take eight years in total to complete. This would mean that the average annual one-off impacts over this period associated with Scenario One would be €103M in GVA, €41M in household earnings, and 914 FTEs in employment.

The continuous impacts associated with the OPEX and direct activities of various developments described in Scenario One are presented in Table 7-14. All figures are in 2023 prices. GVA and household earnings figures are rounded to the nearest million and employment is rounded to the nearest whole number. Totals may not sum exactly due to rounding.

Table 7-14: Continuous impacts associated with Scenario One

	1GW fixed offshore wind farm and substations	500MW Data Centre	Total
GVA (€M)	579	484	1,063
Household earnings (€M)	13	66	79
Employment (FTE)	262	1,088	1,350

7.2.4.2 SCENARIO TWO

The one-off impacts associated with the DEVEX and CAPEX of the various additional developments as described in Scenario Two are presented in Table 7-15. Both a *total additional* and *combined total* figure is presented. The *total additional* figure represents the total additional impacts of the developments in Scenario Two compared with that of Scenario One. The *combined total* figure is inclusive of all development in Scenario Two (including those already assessed in Scenario One).

All figures are in 2023 prices. GVA and household earnings figures are rounded to the nearest million and employment is rounded to the nearest whole number. Totals may not sum exactly due to rounding.

Table 7-15: One-off impacts associated with Scenario Two

	150MW wind farm and substations	150MW solar farm	Total additional	Combined total
GVA (€M)	22	7	29	851
Household earnings (€M)	8	3	11	337
Employment (FTE)	162	56	218	7,529

As for Scenario One, for the purposes of providing context to the one-off impacts, it can be assumed that the development and construction phases will take eight years in total to complete. This would mean that the average annual combined total one-off impacts over this period associated with Scenario Two would be €106M in GVA, €42M in household earnings, and 941 FTEs in employment.

The continuous impacts associated with the OPEX and direct activities of various developments described in Scenario Two are presented in Table 7-16. All figures are in 2023 prices. GVA and household earnings figures are rounded to the nearest million and employment is rounded to the nearest whole number. Totals may not sum exactly due to rounding.

Table 7-16: Continuous impacts associated with Scenario Two

	150MW wind farm and substations	150MW solar farm	Total additional	Combined total
GVA (€M)	73	24	97	1,160
Household earnings (€M)	2	0	2	81
Employment (FTE)	42	10	52	1,402

7.2.4.3 SCENARIO THREE

The one-off impacts associated with the DEVEX and CAPEX of the various additional developments as described in Scenario Three are presented in Table 7-17. Both a *total additional* and *combined total* figure is presented. The *total additional* figure represents the total additional impacts of the developments in Scenario Three compared with that of Scenario Two. The *combined total* figure is inclusive of all development in Scenario Three (including those already assessed in Scenarios One and Two). All figures are in 2023 prices. GVA and household earnings figures are rounded to the nearest million and employment is rounded to the nearest whole number. Totals may not sum exactly due to rounding.

Table 7-17: One-off impacts associated with Scenario Three

	20MW green hydrogen facility	100MW pharmaceutical facility	Total additional	Combined total
GVA (€M)	6	333	339	1,190
Household earnings (€M)	3	135	138	475
Employment (FTE)	57	3,075	3,132	10,661

As for Scenarios One and Two, for the purpose of providing context to the one-off impacts, it can be assumed that the development and construction phases will take eight years in total to complete. This would mean that the average annual one-off impacts over this period associated with Scenario Three would be €149M in GVA, €59M in household earnings, and 1,333 FTEs in employment.

The continuous impacts associated with the OPEX and direct activities of various developments described in Scenario Three are presented in Table 7-18. All figures are in 2023 prices. GVA and household earnings figures are rounded to the nearest million and employment is rounded to the nearest whole number. Totals may not sum exactly due to rounding.

Table 7-18: Continuous impacts associated with Scenario Three

	20MW green hydrogen facility	100MW pharmaceutical facility	Total additional	Combined total
GVA (€M)	2	1,907	1,909	3,069
Household earnings (€M)	1	99	100	181
Employment (FTE)	10	1,988	1,998	3,400

7.2.4.4 TAX AND COMMUNITY BENEFITS

In addition to the economic benefits highlighted above, there will also be tax benefits for the Irish Government and community benefits for local communities under RESS (note that even if projects are not developed through RESS, it is assumed they would still need to contribute to community benefits as a condition of their planning).

A full and detailed tax projection has not been developed as part of this assessment. Annual corporation tax potential has been calculated for each of the developments across the three scenarios. Corporation tax potential is the maximum potential direct corporation tax revenue before deductions (including capital and R&D) are taken into account. The estimated annual corporation tax potential for each of the developments and their associated assumptions are presented below:

- 1GW offshore wind farm: €68M
- 150MW onshore wind farm: €8M
- 150MW solar farm: €3M
- 500MW data centre: €52M
- 100MW pharmaceutical manufacturing facility: €216M
- Green hydrogen facility: €0M

In addition to corporation tax, it is assumed offshore wind farms will pay a levy based on their revenue as part of their Maritime Area Consent (MAC)[15]. Under current price and capacity assumptions, the estimated annual offshore wind levy is €13M. Additional tax revenue will be created as a result of employment taxes and indirectly as a result of increased supply chain revenue and increased household income.

There will also be community benefits associated with the development of GEPs. Community benefit contributions from renewable energy developments are €2 per MWh of electricity generated. The estimated annual community benefit contribution created from the renewable electricity elements of the GEPs are presented below:

- 1GW offshore wind farm: €8M
- 150MW onshore wind farm: €1M
- 150MW solar farm: €0M

7.3 POTENTIAL FOR SMES

7.3.1 BACKGROUND

Ireland's GDP is expected to shrink by 0.5% in 2024, driven by a contraction in the multinational sector during the first half of the year. Economic growth is anticipated to recover to 4.0% in 2025 and 3.6% in 2026, supported by a robust labour market, low inflation, and a favourable external environment.

[15] 2% of revenue

Inflation is forecast to remain low throughout the period. Public finances are projected to stabilise, with revenue surpluses and increased expenditure contributing to normalisation [115].

The latest S&P Global Ireland Business Outlook survey shows that Irish private sector firms remain among the most globally optimistic about output growth over the next 12 months. The survey noted that the confidence levels were +39% in June 2024 ahead of the eurozone average of +20% [116].

Bibby Finance publishes an SME Confidence Tracker. The latest edition, published in Q3 2024, analysed c220 SME owners and decision-makers, and noted that the sector remains confident, but is facing headwinds [117]:

- 67% of SME expect sales to grow in the next six months despite rising costs of business
- 68% of SME report longer payment delays from customers compared to 2023.

Key drivers of optimism include new product offerings, tourism, international demand, increased sustainability budgets, digitisation, AI adoption, and higher consumer disposable income.

Challenges include high labour costs, staff shortages, supply chain issues, geopolitical tensions, high interest rates, and potential resurgent inflation.

7.3.1.1 STRUCTURE OF ECONOMY

In 2022, the business economy in Ireland generated a total turnover of €1,288.7 billion with GVA at €424.2 billion [118]. The service sector dominates the economy with 63% of activity associated with this element (Figure 7-3).

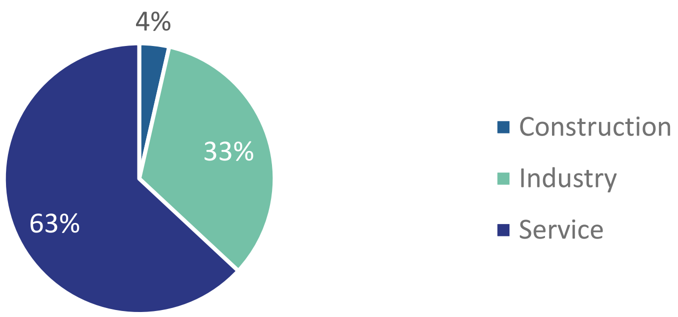


Figure 7-3: Ireland's economic structure [119]

There were 389,654 enterprises with a total of 2,292,598 people employed in 2022 [120]. Of these, 12,579 (3.2%) were foreign-owned employing 623,128 (27.2%) staff. Note: Ireland was the only EU country to avoid a recession during the COVID-19 pandemic, due to the strong performance of pharmaceutical and ICT multinationals that bolstered economic activity [121]. Among foreign-owned enterprises in Ireland, US-owned entities accounted for the largest presence, generating 52.7% of total turnover in the Irish business economy.

7.3.1.2 DOMESTIC V FOREIGN OWNERSHIP

Labour productivity in Ireland is among the highest in the EU. This performance is driven by a small number of foreign-owned multinationals; the European Commission noted in 2023 that this has effectively created a two-speed economy in the country [122].

7.3.2 SMES IN IRELAND

In Ireland, as in many western European economies, SMEs comprise most of the business community both in terms of number of enterprises and people employed, but not in terms of turnover and GVA (Table 7-19).

Table 7-19: Breakdown of structural business statistics[16]

	Total	SME (%)	Large (%)
Enterprises	389,654	99.8	0.2
Persons engaged	2,292,598	67.9	32.1
Turnover (€M)	1,288,729	43.1	56.9
GVA (€M)	424,183	40.6	59.4

Small enterprise (i.e. those with 10 or fewer employees) accounted for 92.3% of enterprises in the economy in 2022 and 26.9% of people engaged. Medium enterprise (those with 11 to 250 employees) accounted for 7.5% of enterprises and 41.0% of people engaged.

Table 7-20: Characteristics of SME in Ireland compared to the wider EU [123]

	Ireland	EU27
Contribution to economy	69% employment; 35% GVA	67% employment; 50% GVA
Sectoral focus	Concentrated in services and construction	Evenly distributed across sectors
Export orientation	58-65% do not export	More export-oriented

SMEs in the EU generally have lower labour productivity compared to large firms. This is evidenced by a firm-size productivity gap, defined as the difference in value added per employee between SMEs and large firms. In Ireland, the productivity gap is most noticeable in the industrial sector, driven by the dominance of highly productive multinational corporations, particularly in high-skilled services and ICT sectors [124].

7.3.3 CHALLENGES FACING THE SME BUSINESS BASE [122]

The European Commission 2023 Country Report highlighted a number of issues currently impacting on the SME community. These are described below.

7.3.3.1 LABOUR SHORTAGES

Labour and material shortages are a constraint on activity. Ireland's rapid recovery in employment to pre-pandemic levels has intensified labour and skills shortages, particularly in information and communication roles, engineering, and construction [125]. Labour shortages can impact on

[16] NACE sectors B to S (excluding O and S94): https://www.cso.ie/en/releasesandpublications/ep/p-biiim/businessinireland2022-insightsonmultinationals/foreign-ownedmultinationalsinireland/.

investment and innovation, with 92% of firms citing a lack of skilled staff as a barrier to investment—one of the highest rates in the EU.

7.3.3.2 PAYMENT TERMS

In 2022, businesses waited an average of 54 days for business-to-business payments and 74 days for payments from the public sector. The payment gap (between agreed terms and actual payment) is among the widest in the EU, averaging 14 days for business-to-business transactions and 19 days for public sector payments. Although the situation has improved, over half of businesses remain concerned about late payments; 75% indicate that faster payments would enable them to meet supplier obligations more effectively.

7.3.3.3 ACCESS TO FINANCE

While Ireland's score on the EIF Access to Finance Index has improved in the recent past, high credit costs remain a major barrier [124]. As of Q2 2024, Irish SMEs face higher borrowing costs compared to their European counterparts. The weighted average interest rate on new SME loan drawdowns in Ireland stood at 5.49%, reflecting a 10-basis point increase from the previous quarter. In contrast, the euro area average interest rate for new SME loans was approximately 2.4% during a similar period.

Elevated lending rates in Ireland can be attributed to factors such as limited competition among domestic banks and a higher risk premium associated with SME lending. These conditions pose challenges for Irish SMEs in accessing competitively priced finance, potentially hindering their growth and investment capabilities.

The Bibby Financial Services SME Confidence tracker Q3 2024 [126] highlights that 34% of SME said that they had been rejected for external finance in the previous 12 months; 38% had been denied finance due to their business being considered high risk. Finally, even for those who had been approved, 53% said their bank or financier had reduced the amount of cash or credit offered from the original ask.

7.3.4 BENEFITS OF USING SMES ON LARGE CAPITAL PROJECTS

While SMEs are unable to take full contracts on themselves, they can be well suited to operating as part of the supply chain of larger organisations. The development and operation of a GEP will require a large number of niche skills and products to ensure that the system works as effectively and efficiently as possible.

7.3.4.1 INNOVATION AND RESPONSIVENESS

In sectors undergoing rapid change and ongoing innovation, SMEs can demonstrate greater flexibility compared to large enterprises, a characteristic that can provide them with a competitive advantage in dynamic and rapidly evolving environments. Characteristics of SMEs that facilitate this ability to innovate and respond to opportunities and challenges include:

- SMEs typically have flatter organisational structures, enabling faster decision-making processes. Fewer bureaucratic layers mean that SMEs can quickly respond to market changes, customer needs, or emerging technologies

- SMEs are often more willing to pivot their strategies in response to feedback or new opportunities. Their smaller scale allows them to implement changes with less disruption compared to larger enterprises
- SMEs embrace an entrepreneurial mindset, encouraging creativity and experimentation. This is particularly evident in startups and high-growth SME, which thrive on innovation as a core component of their business model
- SMEs can be closer to their customers and more attuned to their needs. This proximity enables them to tailor solutions quickly and effectively, which is crucial in innovative sectors where customer requirements may evolve rapidly
- SMEs often specialise in niche markets or technologies, allowing them to innovate within a specific area. This specialisation makes them valuable partners in industries like technology, renewable energy, and healthcare, where the ability to innovate is key
- While SMEs face resource constraints, they are often more willing to take calculated risks in adopting or developing new technologies. Their smaller scale means the stakes of failure, though significant, are often less daunting than for larger enterprises with more entrenched systems
- SMEs can be more open to partnerships and collaborations with other firms, research institutions, or startups to co-develop innovative solutions. These partnerships enable SME to access new knowledge and technologies while remaining agile.

7.3.4.2 SUPPLY CHAIN

SMEs expand and enhance supply chains. The Irish Academy of Engineering emphasises that involving SMEs in major capital projects can lead to more resilient and adaptable supply chains, as they often provide specialised services and products that complement larger firms' capabilities [127].

7.3.4.3 ECONOMIC BENEFITS

SMEs allow for economic impacts to be dispersed into communities. Engaging SMEs in large projects stimulates economic growth and employment within a locale. Directing funds to local SMEs drives local economic development by facilitating secondary expenditure in the supply chain and via household spending. Leakage of economic benefits is reduced by investing close to the point of activity.

Table 7-21 and Table 7-22 show identified sectors that could deliver products and services to the GEP initiative.

Table 7-21: Number of people employed by activity and size [128]

Sector	SME	Large	Total
Construction (F)	127,982	16,638	144,620
ICT Services (G465, J582, J61, J62, J631, S951)	71,227	68,707	139,934
Financial and Insurance Activities (K)	55,012	71,123	126,135

Sector	SME	Large	Total
Activities of Head Offices; Management Consultancy Activities (M70)	37,458	19,528	56,986
Legal and Accounting Activities (M69)	29,546	18,173	47,719
Architectural & Engineering Activities; Technical Testing & Analysis (M71)	32,459	9,403	41,862
Land Transport and Transport Via Pipelines (H49)	32,830	8,221	41,051
Office Administrative, Office Support and Other Business Support (N82)	13,461	12,130	25,591
Manufacture of Computer, Electronic and Optical Products (C26)	4,282	18,192	22,474
Basic Metals and Fabricated Metal Products (C24,C25)	18,601	2,902	21,503
Warehousing and Support Activities for Transportation (H52)	20,223		20,223
Security and Investigation Activities (N80)	9,353	7,296	16,649
Other Professional, Scientific and Technical Activities (M74)	14,056		14,056
Telecommunications (J61)	4,943	8,900	13,843
Manufacture of Machinery and Equipment n.e.c. (C28)	8,900	4,574	13,474
Electricity, Gas, Steam and Air Conditioning Supply (D)	1,817	10,315	12,132
Manufacture of Chemicals and Chemical Products (C20)	4,757	6,747	11,504
Manufacture of Other Non-Metallic Mineral Products (C23)	7,519	3,150	10,669
Manufacture of Rubber and Plastic Products (C22)	8,211	1,871	10,082
Scientific Research and Development (M72)	4,917	4,055	8,972
Repair and Installation of Machinery and Equipment (C33)	7,700		7,700
Manufacture of Electrical Equipment (C27)	2,845	1,808	4,653
Mining and Quarrying (B)	3,163		3,163
Water Transport (H50)	896		896
	522,158	**293,733**	**815,891**

Table 7-22: Active enterprises by activity and size [128]

Sector	SME	Large	Total
Construction (F)	77,648	28	77,676
Land Transport and Transport Via Pipelines (H49)	19,619	6	19,625
Financial and Insurance Activities (K)	17,366	72	17,438
ICT Services (G465, J582, J61, J62, J631, S951)	15,431	72	15,503
Activities of Head Offices; Management Consultancy Activities (M70)	14,763	20	14,783
Legal and Accounting Activities (M69)	12,233	15	12,248
Architectural & Engineering Activities; Technical Testing & Analysis (M71)	10,219	21	10,240
Other Professional, Scientific and Technical Activities (M74)	9,940		9,940
Basic Metals and Fabricated Metal Products (C24, C25)	3,877	8	3,885
Office Administrative, Office Support and Other Business Support (N82)	3,196	21	3,217
Warehousing and Support Activities for Transportation (H52)	2,037	11	2,048
Repair and Installation of Machinery and Equipment (C33)	1,849	4	1,853
Manufacture of Other Non-Metallic Mineral Products (C23)	1,350	8	1,358
Security and Investigation Activities (N80)	1,062	10	1,072
Scientific Research and Development (M72)	1,004		1,004
Electricity, Gas, Steam and Air Conditioning Supply (D)	873		873
Telecommunications (J61)	700	8	708
Manufacture of Machinery and Equipment n.e.c. (C28)	681	10	691
Mining and Quarrying (B)	485		485
Manufacture of Rubber and Plastic Products (C22)	477	4	481
Manufacture of Chemicals and Chemical Products (C20)	461		461
Manufacture of Computer, Electronic and Optical Products (C26)	420	11	431
Manufacture of Electrical Equipment (C27)	286	4	290
Water Transport (H50)	242		242
	6,219	**333**	**196,552**

This analysis indicates that at a macro level, c50% of all enterprises and c34% of all employees employed in the SME community could potentially deliver services to the GEP during the DEVEX, CAPEX and OPEX phases.

7.3.5 CALCULATION OF POTENTIAL SME EMPLOYMENT OPPORTUNITIES – SCENARIO THREE

The expected annual need for staff based on the findings from the EIA have been analysed. The direct activities that will be required during the DEVEX, CAPEX and OPEX phases include:

- Construction
- Other Professional, Scientific and Technical Activities (M74)
- Manufacture of Basic Pharmaceutical Products and Pharmaceutical Preparations (C21)
- Activities of Head Offices; Management Consultancy Activities (M70)
- ICT Services (G465, J582, J61, J62, J631, S951)
- Repair and Installation of Machinery and Equipment (C33)
- Manufacture of Electrical Equipment (C27)
- Architectural and Engineering Activities; Technical Testing and Analysis (M71)
- Office Administrative, Office Support and Other Business Support Activities (N82)
- Water Transport (H50)
- Basic Metals and Fabricated Metal Products (C24, C25)

To calculate the annual needs by activity, DEVEX is expected to take place over 3 years, CAPEX is expected to take 5 years.

Table 7-23 shows the activity, FTE requirements during specific phases and available FTE resources (at the national level).

The analysis shows:

- Discrete activities are needed during specific periods of activity
- There is sufficient capacity at the national level to provide the needed resources from the SME community with limited to no negative impacts on other activities
- At the regional/local level there could be impacts on the economy due to the allocation of resources to GEPs; further research is needed to identify local impacts.

Table 7-23: Skills by sector (required versus available)

	Per annum			Total	Available	% of available resources
	DEVEX FTE	CAPEX FTE	OPEX FTE			
	3 years	5 years	Ongoing			
Construction		1,156		1,156	127,982	0.9%
Other Professional, Scientific and Technical Activities (M74)	91			91	12,028	0.8%
Manufacture of Basic Pharmaceutical Products and Pharmaceutical Preparations (C21)			1,392	1,392	3,230	43.1%
Activities of Head Offices; Management Consultancy Activities (M70)	67		65	132	37,458	0.4%
ICT Services (G465, J582, J61, J62, J631, S951)			712	712	71,227	1.0%
Repair and Installation of Machinery and Equipment (C33)		5	197	202	5,709	3.5%
Manufacture of Electrical Equipment (C27)		83		83	2,845	2.9%
Architectural and Engineering Activities; Technical Testing and Analysis (M71)	13			13	3,020	0.4%
Office Administrative, Office Support and Other Business Support Activities (N82)		5		5	13,461	0.0%
Basic Metals and Fabricated Metal Products (C24, C25)		3		3	18,601	0.0%
Total	**171**	**1,252**	**2,366**	**3,789**	**295,561**	**1.3%**

7.3.6 BARRIERS TO ENTRY

There are several barriers to entry for SMEs when looking to secure work on a large capital project. Many barriers are related to the comparative lack of resources of SMEs compared to larger enterprises. Challenges include:

- Risk aversion by clients: clients may view SMEs as higher-risk due to their limited financial reserves and lack of experience with projects of similar scale
- Legal and contractual obligations: SMEs may struggle to understand or meet complex contractual terms, such as liability clauses or performance guarantees
- Administrative burden: the tendering process for large projects is often complex and time-consuming, requiring extensive paperwork, compliance with strict regulations, and detailed cost breakdowns
- Lack of familiarity: SMEs may lack the expertise or experience in navigating procurement frameworks, such as public-sector e-tendering platforms or pre-qualification questionnaires.

These barriers can be addressed. The UK Government Department for Business, Energy & Industrial Strategy's SME Action Plan: 2022 – 2025 [129] details actions that can be taken to alleviate barriers to entry. These include:

- Requiring large enterprises with contracts of over £1M to publish relevant subcontracts
- Mapping supply chains to improve visibility of different opportunities at different layers within the supply chain
- Proactively considering new procurement for opportunities to engage with SMEs
- Using a procurement platform for better visibility of barriers to and representation of SMEs
- Holding insight sessions to identify challenges and barriers for SME in bidding for government work
- Developing case studies with SMEs to share their experiences of winning contracts.

Actions 9 and 10 of the Powering Prosperity are early-stage solutions to addressing some of these barriers.

7.3.6.1 CASE STUDY: CROSSRAIL

The Crossrail project provides an example of what can be achieved. Crossrail, now known as the Elizabeth Line, was a highly ambitious and significant infrastructure projects in the UK, to improve public transport capacity and connectivity across London and its surrounding regions.

Approximately 62% of the project's Tier 1 suppliers were SME, with c76% SME in Tier 2. 43% of contracts were awarded to businesses from outside of London and the southeast to ensure that SME across the UK benefitted from the project.

Multiple methods were used to deliver these results:

- Crossrail set internal targets for SME participation to encourage inclusion and accountability within the project teams

- The project developed a comprehensive supply chain map to identify and engage SME, ensuring a diverse range of suppliers. Crossrail specifically sought SME with niche expertise for specific project needs
- Crossrail worked with a number of large Tier 1 contractors who were responsible for managing many of the smaller Tier 2 and Tier 3 subcontractors. This ensured that SMEs could participate without needing to directly engage with the complexities of the overarching project
- Crossrail used an online supply chain platform, to post contract opportunities. This tool was specifically designed to give SMEs visibility on upcoming opportunities and help them connect with Tier 1 contractors. Crossrail ultimately advertised over 1,200 contract opportunities. This transparency enabled SMEs to compete effectively for contracts
- NEC3 contracts were used, a framework for managing construction and engineering projects. It was part of the New Engineering Contract (NEC) suite, which provided standardised contractual terms designed to foster collaboration, improve efficiency, and manage risk in construction and infrastructure projects. NEC3 has been used in a range of sectors, including major infrastructure projects, construction of public facilities and international development and engineering projects. NEC3 was replaced by NEC4 in 2017, which introduced enhancements to address modern project management needs, including digital tools and improved clauses for early contractor involvement
- Crossrail invested in training programmes for SME to enhance their capacity to meet project demands, including compliance with safety and quality standards. Workshops and information sessions were run to help SME understand procurement requirements and how to compete effectively. Workshops and collaborative forums allowed SME to learn from larger contractors and other industry experts
- The project employed simplified tendering processes where possible, reducing the administrative burden on SMEs that might not have the resources to handle complex bid requirements
- Fair payment terms ensured that SMEs were paid promptly to support their cash flow
- Crossrail partnered with local Chambers of Commerce and SME networks to identify capable SMEs and help them prepare for project opportunities
- SMEs were invited to contribute to innovation challenges and workshops, recognising their agility and creativity in problem-solving.

Through these combined efforts, Crossrail created a robust ecosystem where SMEs could thrive, contributing significantly to the project while benefitting from the opportunities it provided. This approach evidences a potential route to integrating smaller businesses into major supply chains. It may be possible to develop specific work streams and programmes delivered by the economic development agencies in Ireland to advance this agenda.

7.4 SOCIAL IMPACT ASSESSMENT

The potential social impacts of the GEP concept are assessed using the National Strategic Outcomes laid out in the NPF of the Irish Government's Project Ireland 2040 [26]. These outcomes underpin the Government's strategic priorities and decision-making processes moving forward and highlight the major targets to achieve by 2040. The outcomes are:

- Compact growth
- Enhanced regional accessibility
- Strengthened regional economies and communities
- Sustainable mobility
- A strong economy supported by enterprise, innovation and skills
- High-quality international connectivity
- Enhanced amenity and heritage
- Transition to a low carbon and climate resilient society
- Sustainable management of water, waste and other environmental resources
- Access to quality childcare, education and health services

This assessment is also guided by the principles laid out in the Irish Government's framework for a Just Transition [130], which must be reflected in the delivery, design and implementation of the GEP concept. The principles are:

1. An integrated, structured, and evidence-based approach to identify and plan our response to just transition requirements
2. People are equipped with the right skills to be able to participate in and benefit from the future net zero economy
3. The costs are shared so that the impact is equitable and existing inequalities are not exacerbated
4. Social dialogue to ensure impacted citizens and communities are empowered and are core to the transition process

Due to the early development stages of the GEP concepts, there is limitations on the extent and detail to which an assessment of social impacts can be conducted. As such, impacts here represent a high-level assessment of the potential social impacts that may occur based on the assumptions defined in section 7.2.2. Scenario Three will be used as the basis for this assessment as it is fully inclusive of all potential developments presented across all three scenarios. This will include a 1GW offshore wind farm, a 150MW onshore wind farm, a 150MW solar farm, a 500MW data centre, a 100MW pharmaceutical manufacturing facility, and a 20MW green hydrogen facility.

The lack of confirmed geographic locations limits the scope at which social impacts can be assessed, as local conditions cannot be taken into consideration. As such, an assessment of localised, community-based social impacts cannot be made at this stage. The social impact assessment is largely produced on the national level.

7.4.1 EMPLOYMENT

All proposed scenarios lead to significant employment opportunities in the development, construction and operational phases of the GEPs. Employment levels are currently based on the assumptions described in the scenarios. More will be known about the specific job opportunities created as the potential tenants become known. However, significant job creation in the fields of engineering, construction, manufacturing, pharmaceuticals, and information and communication technologies can be assumed.

Scenario Three, as laid out in the Economic Impact Assessment (Section 7.2), will generate almost 2,500 additional FTE jobs once fully operational. This level of job creation could have a significant positive impact on Ireland. Creating opportunities for people to enter full time employment has significant positive impacts on an economy and a society, increased economic stability and productivity allows people to spend and invest in their local economies and supports broader economic growth. This employment could have a particular notable positive impact if it creates new opportunities for rural communities. Whilst unemployment is broadly low in rural Ireland, lower than more urban areas [131], the counties with the highest rates of unemployment are all rural (Louth, Longford and Donegal; all 11% unemployment) [132]. Rural areas also have the highest rates of long-term unemployment, (6%; Donegal and Louth). Youth unemployment is a concern across Ireland, with the national rate sitting at 10.4% unemployment in November 2024 [133]. Youth unemployment is often more prevalent in rural areas where young people have little opportunities for work that is aligned with their skills or training, and in some cases, they may feel they have to move to a city to pursue employment opportunities [134]. A development such as a GEP could help to address these unemployment concerns and create opportunities for people in rural areas, younger people in particular, to find fulfilling, skilled, and stable work.

In this sense, the GEP concept is largely aligned with the National Strategic Outcomes through the impact these employment opportunities will have on rural economies and communities, and the broader strengthening of the economy through promotion of enterprise, innovation and skills. Increased levels of employment across the population will positively impact a range of other outcomes in the NPF. For example, people who are gainfully employed experience improved health and wellbeing through regular income, social interaction, and sense of purpose [135].

7.4.2 RURAL INFRASTRUCTURE

As discussed, there is currently no proposed location for a GEP site. For the purposes of this assessment, it is assumed that a GEP will be in a rural area. The proximity to Ireland's natural resources (that will be necessary for renewable energy generation) makes this case likely. A development of this scale will have significant impact on, and thus require significant concurrent investment in, local infrastructure. For example, roads improvements to ensure easy transportation of construction materials and people during the development and construction phases, or investment in new housing to accommodate an influx of new workers once the site is operational will be required. This may improve access and infrastructure for rural communities.

There is also scope for negative impacts on local communities depending on the scale of the development and its potential proximity to rural settlements. The local community may feel overwhelmed by the project and all the activity it will bring to the area and may feel resistant to significant development. However, definitive conclusions cannot be made without community consultation, which would have to come at a later stage of the GEP development. It is possible that the positive impacts felt by the local community, such as increased employment and economic regeneration, will outweigh any negative impacts from the development. To ensure this is the outcome and to maximise the local support for the project, public consultation and regular, clear communication with the affected communities as the project progresses is strongly recommended.

This is aligned with the National Strategic Outcomes around enhancement of rural infrastructure and the strengthening of rural economies and communities.

7.4.3 RURAL ECONOMIES

There will be significant impact on the economies of rural areas of Ireland, dependant on where the GEPs are based. They offer an opportunity to diversify rural economies, creating varied employment opportunities in a range of industries that may not be otherwise associated with rural Ireland. This may help to retain young people who previously have had to leave the rural areas to access employment and training opportunities.

SMEs play a significant role in the rural economy of Ireland. There are significant opportunities for SMEs to be involved in the development, construction and operation of the GEPs. This collaboration between companies of different sizes will significantly strengthen local rural economies through generating employment and encouraging secondary expenditure in the local supply chain. The specific locale of these economic benefits is dependent on the location of the GEP.

By recognising the natural strengths of rural areas across Ireland and investing in the infrastructure necessary to maximise the positive output of these resources, the GEP concept will be able to create robust rural enterprise clusters. GEPs may be able to drive economic development in the associated regions and attract investment to regions that may historically not have been viewed as industrial centres. Core to this is collaboration between companies of various sizes to ensure that local companies can be engaged with developments in their area. This is aligned with the Irish Government’s ambitions to strengthen and diversify the rural economy of Ireland as set out in the National Strategic Outcomes.

This is also firmly in line with the Powering Prosperity. In particular, the aim of this strategy to deliver a domestic offshore wind industry that can leverage opportunities in offshore wind energy potential to deliver balanced regional economic development.

7.4.4 SKILLS DEVELOPMENT AND INNOVATION

One of the aims of the GEP is to create a space that encourages collaboration and innovation. The co-location of renewable energy supply and industrial demand and activities could help to make GEPs centres for expertise and hubs where industries could cluster and support mutual development. This would make GEPs ideal for RD&I activities, with high potential for testing energy transition technologies such as green hydrogen, e-fuels and energy storage. The specific RD&I activities that could be conducted within the GEPs will be highly specific to their location and the industries that are present.

This is, again, in line with Powering Prosperity which identifies a range of unique RD&I opportunities that are associated with the increased deployment of offshore wind energy and technology. These development opportunities would align with existing industry capability in Ireland and will strengthen Ireland's offshore wind energy offering overall. The more innovation that can be fostered in Ireland's offshore wind energy industry, the stronger the supply chain will be. This will, therefore, drive even more innovation.

This is firmly aligned with the Irish Government's National Planning Outcomes, specifically their vision to create a strong economy that is supported by enterprise, innovation and skills. The creation of energy self-sufficient industrial hubs that promote innovation, and new technological development would significantly benefit the Irish economy and people. GEPs could create spaces where skills development is at the forefront, through the development of professional skills for those working at the various stages of the project, or for students who could be involved in collaborative studies between GEP industries and Irish universities. The high potential for innovation necessitates a high level of skills development.

Furthermore, the potential for the GEPs' rural location and use of Ireland's strong base of SMEs maximises the spread of this skills development opportunity, ensuring the involvement of people from a range of backgrounds and industries to diversify and strengthen the rural economy.

7.4.5 RENEWABLE ENERGY

GEPs could massively increase Ireland's renewable energy generation capacity by providing a route to market for renewables. This is regulatorily significant as explored throughout this report, the Irish Government has ambitious net-zero and renewable energy deployment targets that drive planning decisions. Achieving these targets is a statutory requirement but will also have significant social benefits. Reducing Ireland's reliance on fossil fuels will improve the country's environment and reduce levels of pollution. This will have a direct positive impact on the health and wellbeing of the population [136]. It will also play a role in mitigating the impacts of climate change, which can disproportionately affect the most vulnerable communities [137]. Furthermore, the generation of Irish energy will reduce the nation's reliance on imported energy and improve the accessibility of energy [138].

In this capacity, the GEP concept is effective at achieving the National Strategic Outcomes focused on the transition to net-zero and the responsible management of natural resources. It also has consequential impacts on health and wellbeing related outcomes.

7.4.6 SUMMARY

Overall, the GEP concept is firmly aligned with outcomes detailed in the National Planning Framework, with the potential to offer social benefits across a range of sectors. Economic development for rural communities, improved infrastructure, the promotion of innovation, opportunities for work and skills development, and the improvement of Ireland's natural environment could all be achieved through progression of the GEP concept.

7.5 DISCUSSION ON THE POTENTIAL IMPACTS OF GREEN ENERGY PARKS ON IRISH EMISSIONS

The GEP's focus on renewable energy production is critical to achieve Ireland's renewable energy and net-zero targets. Tying future industrial developments to renewable energy production will help to ensure Ireland's economic growth does not come at a carbon cost. Excess green energy produced by the GEP where available may help to offset current fossil fuel electricity production in Ireland, thus achieving net positive environmental benefits.

Section 7.1 explores current renewable energy production and renewable energy targets. It highlights that although renewable energy production has increased significantly over the past several years, Ireland is still far behind its renewable energy targets.

This assessment considers the environmental impacts associated with the development of GEPs in terms of CO2 equivalent (CO2e). CO2e is a unit of measurement used to express the total global warming potential of different greenhouse gases in terms of the amount of carbon dioxide that would cause the same amount of warming. The three scenarios presented in Section 7.2 are used as a basis for assessing the environmental impacts. Both positive and negative environmental impacts are considered. Positive impacts occur as a result of the green energy production negating the need for actual or potential fossil fuel usage. Negative impacts occur as a result of increased economic activity generating greenhouse gases.

Over the past ten years in Ireland, wind as a source of electricity production has increased significantly and coal as a source of electricity production has significantly decreased. Other electricity sources have remained relatively steady. This is shown in Table 7-24.

Table 7-24: Sources of electricity as a proportion of total electricity production [139]

Source	2013 (%)	2023 (%)	Change (%)
Natural gas	50.7	49.0	-3
Coal	25.3	4.3	-83
Wind	17.5	37.0	111
Hydro	3.6	3.9	8
Biofuels	1.6	1.6	1
Oil	0.7	0.7	0
Waste	0.5	2.1	294
Solar	0.0	1.3	NA

Due to data limitations on carbon emissions in 2023, data from electricity production by source from 2022 is used in this assessment. Such data is presented in Table 7-25.

Table 7-25: Electricity production data used in current assessment [139]

Source	Electricity production (GWh)	Percentage of total production (%)
Natural gas	16,529	48.8
Coal	2,613	7.7
Wind	11,208	33.1
Hydro	948	2.8
Biofuels	666	2.0
Oil	1,075	3.18
Waste	665	2.0
Solar	148	0.4
Total	33,852	100.0

Electricity production in Ireland has increased by 31% since 2000, highlighting the need to provide renewable energy alternatives to prevent an increasing use of fossil fuels. As of 2022, electricity generation accounted for 29% of Ireland's CO2 emissions according to the International Energy Agency. Table 7-26 shows the total emissions from electricity generation by source in 2022, percentage of total emissions, and the total emissions per GWh of electricity produced [139].

Table 7-26: Total emissions from electricity generation in 2022

Source	Total emissions ($MtCO_2$)	Percentage of total emissions (%)	Emissions per GWh produced (tCO_2/GWh)
Natural gas	6.1	65.0	368
Coal	2.5	26.4	946
Oil	0.8	8.6	752
Total	*9.4*	*100.0*	*463*

7.5.1 METHODOLOGY

To assess the positive environmental benefits associated with the GEP, it is assumed that the electricity produced by green sources will result wholly in the reduction of requirements for fossil fuel produced electricity (on a 1-to-1 base). Thus, the positive environmental benefits associated with the GEP can be calculated as the total emissions that would be produced if the electricity was produced by a fossil fuel source. The weighted average emissions per GWh produced by fossil fuel sources is used to calculated this (463 tCO2/GWh). It should be noted that coal and oil electricity production produces significantly more CO2/GWh than natural gas. Thus, if coal and oil sources of electricity production were the first to be reduced as a result of green energy production, the positive environmental benefits could be higher than average. It should also be noted that natural gas stations are currently needed to offset the intermittency of wind and other renewable sources [140]. As such, emissions may not decrease by the full 463 tCO2/GWh as a result of decreased fossil fuel usage.

The negative environmental impacts associated with the increase in economic activity is assessed in terms of direct and indirect impacts used a similar framework to the economic impacts. Direct impacts are associated with the direct economic activity and indirect impacts are associated with the indirect economic activity. Direct and indirect economic activity has been calculated in Section 7.2. Data provided by the CSO on CO2e emissions by industry and output by industry is used to create a metric for each industry by CPA code for the CO2e emissions per Euro of economic output. Combining this with the economic output modelled for each industry in the economy by CPA code in Section 7.2 provides the estimated direct and indirect increase in CO2e emissions as a result of the increase in economic activity. The most current ratios use data from 2022. It is important to note that typically CO2e emissions associated with data centres are typically high due to the vast amounts of electricity they use, however, given that within the GEPs the electricity used will be from renewable sources, the CO2e emissions generated are lower.

7.5.2 ADDITIONALITY

National content considerations that effect leakage have already been accounted for in the economic impact assessment. Beyond this, it is expected that the environmental impacts will be fully additional.

7.5.3 RESULTS

7.5.3.1 POSITIVE ENVIRONMENTAL IMPACTS

The continuous annual impacts associated with the proposed renewable energy generation projects as laid out in Section 7.2.2 for the GEPs are presented in Table 7-27. All figures are rounded to the nearest whole number. Totals may not sum exactly due to rounding.

Table 7-27: Continuous annual impacts: All scenarios

	t CO2e
1 GW offshore wind farm (Scenario One)	1,825,249
150MW Onshore wind farm (Scenario Two)	212,946
150MW Solar farm (Scenario Three)	69,968
Total	**2,108,163**

7.5.3.2 NEGATIVE ENVIRONMENTAL IMPACTS

The one-off impacts associated with the DEVEX and CAPEX of the various developments described in Scenario One are presented in Table 7-28. All figures are rounded to the nearest whole number. Totals may not sum exactly due to rounding.

Table 7-28: One-off impacts: Scenario One

	tCO_2e
1GW Offshore wind farm	11,486
500MW Data centre	125,323
Total	136,809

The continuous impacts associated with the OPEX of the various developments described in Scenario One are presented in Table 7-29. All figures are rounded to the nearest whole number. Totals may not sum exactly due to rounding.

Table 7-29: Continuous impacts: Scenario One

	tCO_2e
1GW Offshore wind farm	1,636
500MW Data centre	16,250
Total	17,886

The one-off impacts associated with the DEVEX and CAPEX of the various additional developments as described in Scenario Two are presented in

Table 7-30. Both total additional and combined total figures are presented. The total additional figure represents the total additional impacts of the developments in Scenario Two compared with that of Scenario One. The combined total figure is inclusive of all development in Scenario Two (including those already assessed in Scenario One). All figures are rounded to the nearest whole number. Totals may not sum exactly due to rounding.

Table 7-30: One-off impacts: Scenario Two

	tCO_2e
150MW Onshore wind farm	1,709
150MW Solar farm	313
Total additional	2,022
Combined total	138,831

The continuous impacts associated with the OPEX of the various developments described in Scenario Two are presented in Table 7-31. All figures are rounded to the nearest whole number. Totals may not sum exactly due to rounding.

Table 7-31: Continuous impacts: Scenario Two

	tCO_2e
150MW Onshore wind farm	227
150MW Solar farm	73
Total additional	301
Combined total	18,187

The one-off impacts associated with the DEVEX and CAPEX of the various additional developments as described in Scenario Three are presented in Table 7-32. Both total additional and combined total figures are presented. The total additional figure represents the total additional impacts of the developments in Scenario Three compared with that of Scenario Two. The combined total figure is inclusive of all development in Scenario Three (including those already assessed in Scenarios One and Two). All figures are rounded to the nearest whole number. Totals may not sum exactly due to rounding.

Table 7-32: One-off impacts: Scenario Three

	tCO_2e
100MW Pharmaceutical manufacturing facility	67,483
20MW Green hydrogen facility	1,109
Total additional	68,592
Combined total	207,423

The continuous impacts associated with the OPEX of the various developments described in Scenario Three are presented in Table 7-33. All figures are rounded to the nearest whole number. Totals may not sum exactly due to rounding.

Table 7-33: Continuous impacts: Scenario Three

	tCO_2e
100MW Pharmaceutical manufacturing facility	50,111
20MW Green hydrogen facility	39
Total additional	50,150
Combined total	68,337

8 CONCLUSIONS AND RECOMMENDATIONS

This report has sought to provide a wide-ranging initial analysis to inform GEP development for Ireland, by reviewing key policy drivers at a national and international level, completing case studies for relevant projects to identify learnings, engaging with key stakeholders to inform the assessment, undertaking a mapping assessment of Ireland to review areas of potential for GEP development, and performing economic analysis of potential GEP scenarios.

When defining what a GEP means for Ireland, this report has set out to provide some key characteristics that GEPs should have. These are sites that:

- Co-locate LEUs, such as data centres or large industrial demand, with renewable energy generation.
- Have some level of self-sustainability / security of supply and are not over- or fully-reliant on the grid.
- Are primarily powered by renewable energy, and are or can transition to be net-zero or below a certain emissions threshold.

To maximise benefits, GEPs will need to become sites that naturally promote cross-industry and community collaboration for common benefits, and ultimately develop into centres of expertise in areas such as supply chain or RD&I related to the uses at the site. A prime example here is the potential seen for hubs to be established around harbour regions which are developed to support the installation or maintenance of offshore wind projects, which could then develop into supply chain bases, where other associated industries could become established. Similar collaborative examples for other industries can be envisaged. This very much feeds into the concept of a GEP, and these types of initiatives should be encouraged to be developed in parallel to or as part of GEPs.

Beyond this, GDG does not believe there is value to setting a strict definition or definite criteria for a GEP at this stage, as this would most likely hinder development. This review has shown above all else that plans and concepts for GEPs or similar vary greatly in design and development processes, so this needs to be accommodated for to allow projects to develop in phased manners. Initiatives that link renewable energy supply with industrial demand in some manner can allow concepts to be proven which can pave the way for larger-scale GEPs with more strictly defined criteria. At a high level for example, onshore wind, solar, and/or battery project at or near the development stage could be used in the relatively near term to prove many of the concepts of co-location and direct connection that could potentially be scaled up to include offshore wind and floating offshore wind longer term.

This report also demonstrates that although there are examples of energy parks that co-locate demand and energy supply, and ambitious plans for more integrated energy parks in many places, GEPs of scale as ultimately envisioned for Ireland have not been developed to date. There is no standard approach to developing GEPs that has been used elsewhere and can be applied here.

While there is no standard approach, there are many characteristics which are common to most of the plans/sites reviewed as part of this work, including: having existing infrastructure in place and legacies of industrial activity, proximity to the transmission system and available grid capacity, available land bank for development/expansion, availability of renewable sources of power (existing and proposed), water supply, and availability of thermal/dispatchable generation. Any sites which are identified for the future development of GEPs in Ireland will need to have a strong combination of these characteristics. Our mapping assessment has identified locations which demonstrate potential for GEP development, based on assessing many of these criteria. As outlined in Section 2.2.3, terrestrial planning has moved to a much more plan-led process, so the identification and designation of sites on land for development will be an important part of the development process.

In addition to site characteristics onshore, locations identified by the State for offshore wind development under the plan-led system will be a key driver for the future location of GEPs in Ireland. Clarity needs to be given by the state on the timing and proposed offtake solution for ORE deployments in the SC-DMAP, future DMAP plans, and how these will interact with GEP development. Consideration may be given to earmarking a site in the SC-DMAP or a future DMAP for the development of a GEP and running a competitive process to award development rights to a developer or project consortium (which could include supply and demand). The use of non-price criteria to this process as discussed in the NZIA could be a good mechanism to build in assessment criteria relevant to GEP development.

The key power supplies for GEPs in Ireland will be; offshore wind, onshore wind, and solar, backed-up by battery storage and most likely some form of dispatchable generation/power from the grid. Dispatchable generation in the near-to-medium term can most likely be expected to come from gas-fired power plants, although plans will need to be progressed for these sources to be decarbonised and replaced with other fuels such as green hydrogen or hydrogen-derived fuels. Relying solely on electricity storage for security of supply is not feasible given current technologies, nor those on the horizon, particularly considering the potential for Dunkelflaute conditions, where power yields from renewables can be reduced for prolonged periods.

Consideration also needs to be given to what the key industrial demands or anchor tenants for future GEPs will be. This report has found that data centres are seen as a key potential demand for GEPs here. There are clear synergies here, as offshore wind needs the demand that data centres can provide as a route to market, while data centres will need large-scale, reliable sources of carbon free power if they are to locate in Ireland in the future. There are challenges technically which will need to be overcome for data centres to be powered by renewables, given their flat demand profiles and high levels of power consumption. Large levels of storage will be required, and some level of demand flexibility will need to be provided by data centres. Further engagement between interested parties on this matter will be needed to find potential solutions.

But data centres are not the only potential tenants for GEPs. This report has found other relevant sectors which should be viewed as potential tenants, including Material / Chemical Production, Cement Manufacturers, Irving Oil Whitegate Refinery, Food and Nutrition, Distilleries, Pharmaceuticals, and Tech Manufacturing. Many of the companies active in these sectors have established footprints in Ireland and will not be able to easily re-locate, but where this is the case, strategic GEP locations near these developments could be considered. Further engagement with these sectors should be undertaken to establish their appetite for GEP development, as demand should be involved with the initial planning for GEPs.

Outside of the demand specific challenges discussed above, there are development challenges more generally which will need to be overcome to facilitate GEP development. Some key challenges identified through this work are: limited grid capacity nationally, long and uncertain permitting timelines, long and uncertain development timelines for offshore wind relative to demand tenants' requirements, the high price of electricity, potential labour supply constraints, policy uncertainty around private wire connections, LEU connection policies and future DMAPs, and clarity on the State's role in site selection and supporting GEP development.

If challenges can be overcome, there are huge potential benefits to GEP development in Ireland. The economic analysis undertaken as part of this work has shown that the development of a hypothetical GEP scenario could add as much as €3,069M GVA and 3,400 FTE jobs annually once operational, while mitigating up to 2,108,163 t CO2 equivalent. An additional €1,190M GVA and 10,661 FTE jobs could be created over the development and construction period. The fully-developed scenario assessed considered the development of a GEP comprising; a 1GW fixed offshore wind farm, an offshore substation, an onshore substation, battery storage, a 150MW onshore wind farm, a 150MW solar farm, a 500MW data centre, a 20MW green hydrogen production facility and a 100MW pharmaceutical manufacturing facility. This provides clear motivation to solve the challenges and facilitate GEP development in Ireland.

Table 8-1 below sets out what are seen as useful next steps to help support the development of GEPs in Ireland.

Table 8-1: Report recommendations on next steps to support GEP development in Ireland

Action	Description	Lead & supporting bodies	Date for completion
A1: Develop a National Energy Park Strategy	Prepare a National Energy Park Strategy, as discussed in the SC-DMAP. This should set out the State's plans and expectations for GEP development in Ireland, provide clarity to the market, and enable plans to be progressed with more certainty and in line with Government expectations in advance of key facilitating actions being taken. Any such Strategy must align with other policies and strategies within Government and avoid duplication or contradiction. Further detail on what this Strategy should consider is included in this report.	**LEAD:** DETE & DECC **SUPPORTS:** Regional and Local Authorities, Offshore Wind Delivery Taskforce, DHLGH	Q1 2026
A2: Complete a Spatial Mapping Assessment	As per Article 15(b) of the Renewable Energy Directive (RED III), by 21 May 2025 the State is required to carry out a national mapping assessment for the deployment of renewables and related infrastructure to identify the domestic potential and the available land and sea area that is necessary for development. As part of this work currently being undertaken under the ARET (Accelerating Renewable Energy Taskforce), identifying areas with high potential for the development of GEPs could be considered, taking account of the key characteristics discussed in this report, mapping undertaken and plans identified, including the location of DMAPs and IDA Ireland's work on industrial parks. Potential pre- and post-2030 should be considered, although GEP development post 2030 is most likely. This work should be brought forward to the ARET for consideration.	**LEAD:** DECC through the ARET **SUPPORTS:** DHLGH, DETE, Local and Regional Authorities, EirGrid, ESBN, GNI, MARA	Q2 2025
A3: Designate RAAs and Implement RED Timelines	As per Article 15 (c) of RED III, by 21 Feb 2026, the State should designate at least one Renewable Acceleration Area (RAAs) suitable for the development of renewable energy projects and associated infrastructure. In setting these areas, consideration should be given to aligning RAAs with areas suitable for GEP development (informed by A2). The preferable planning provisions outlined in RED III should be applied to these areas, and best endeavours should be made to achieve the permitting timelines (including grid connection permits) set out in RED III. As part of this exercise, consideration could be given to the provisions in the NZIA for the establishment of net-zero strategic projects, which receive priority status at national level, faster permitting, focused attention in the Net-Zero Europe Platform, and urgent treatment in judicial and dispute resolution procedures.	**LEAD:** DECC and DHLGH **SUPPORTS:** DETE	Q1 2026

Action	Description	Lead & supporting bodies	Date for completion
A4: Consider the Implications of Future Policy Decisions on GEP Development	There are several areas of policy broadly related to GEP development which are currently under consideration. These include: plans to develop a Private Wires Policy Framework, the CRU's proposed decision on LEU connections policy, the publication of a roadmap for future DMAPs and a decision on ORE deployment timelines and methodology for the SC-DMAP. It is important that consideration is given to GEPs in all future policy formation, and efforts are made to create a supportive and certain policy environment for GEP development. Key State Agencies, Line Departments and other stakeholders will need to be aligned on the importance of unlocking their element of the critical enablers discussed in this report.	**LEAD:** Policy makers **SUPPORTS:** Regulatory bodies, Local Authorities, State Agencies	Ongoing
A5: Plan and Invest in Grid	Low available grid capacity has been cited as a key barrier to GEP development in Ireland. When compared to a counterfactual of having supply and demand in different locations it is expected that GEPs will lead to more efficient use of grid and limit the need for grid upgrades to a degree. However, GEPs will still need to be grid connected for the foreseeable future, and significant grid upgrades will still be required. In Shaping Our Electricity Future, EirGrid has outlined plans for renewable hubs, an approach which could be considered as an enabler for GEPs. This concept should be progressed in addition to longer term planning for grid upgrades, which includes plans for upgrades to facilitate GEPs in strategic locations, informed by A2/A3. Investment in the wider grid is a key strategic action needed to support the wider rollout of renewables in Ireland, not just GEPs. This analysis should consider the value of interconnectors and potentially hybrid interconnectors.	**LEAD:** EirGrid **SUPPORTS:** The CRU, ESBN, DECC	Ongoing
A6: Undertake Engagement with Potential Anchor Tenants	Data centres have been identified as a key potential anchor tenant for GEP development, but other potential sectors have also been identified (Material/Chemical Production, Cement Manufacturers, Food and Nutrition, Distilleries, Pharmaceuticals, and Tech Manufacturing). Engagement by the State should be undertaken with key potential demand stakeholders to fully inform strategy and policy development to support GEPs. This exercise should also consider engaging further with representatives of the national and international case studies identified in this work.	**LEAD:** DETE **SUPPORTS:** IDA, and Enterprise Ireland	2025 and Ongoing

Action	Description	Lead & supporting bodies	Date for completion
A7: Establish a Working Group to Progress GEP Concepts	A working group should be formed to coordinate and monitor key actions for GEP development. This group could be formed under the Offshore Wind Delivery Taskforce, but will require input from both offshore- and onshore-focused stakeholders. In addition to key State bodies, the group should include representatives from industry, on both the supply and demand sides. Existing working groups within Government should be used to support this work where possible.	**LEAD:** Offshore Wind Delivery Taskforce **SUPPORTS:** Key Government Departments and State bodies, (Industry, Regional and Local Authorities	Q3 2025
A8: Lead a Public Awareness and Engagement Campaign	GEPs are a new concept to many people in the industry, as well as members of the public. In parallel with the development of GEPs in phases, a public engagement and awareness campaign could be beneficial to explain GEPs as a concept and highlight the benefits of GEPs and renewable energy to local and regional communities. While it may be too early for such a campaign at this stage, consideration should be given to this once work on GEPs and a National Strategy has progressed.	**LEAD:** DETE	2026

8.1 AREAS FOR FUTURE RESEARCH AND CONSIDERATION

In addition to the actions set out above, this report has identified a number of areas for future research and consideration. Primary areas identified for future research and consideration are discussed below and have been informed by the research undertaken for this report, as well as stakeholder engagement and input received from Steering Group during the project.

8.1.1 PROVIDING FURTHER DETAIL ON GEP CRITERIA AND DEFINITIONS

This report has provided a definition for a GEP which essentially sets out the key characteristics which a GEP should comprise, and the benefits which it should be designed to achieve. Beyond this, the report has not sought to set strict criteria at this preliminary stage. As discussed in Section 2.3, GDG does not see a great benefit to this, and some of these decisions are policy choices. When/if setting stricter criteria, a balance will need to be found between facilitating the development of GEP concepts, while also ensuring they are designed with efficiency and sustainability in mind, and can help Ireland in its climate ambitions.

For example, feedback from some stakeholders suggests that GEPs should be multi-GW developments which are 100% powered by renewable electricity and net-zero by design. While this is seen as the ideal, this is not practical at this stage. The other end of the spectrum could assume GEPs are simply business parks as operating today, with the additional co-location of grid-connected renewable generation. This approach seems limited in ambition. This all suggests a phased and flexible approach, with the long term ideal in mind, is the best approach for GEP development. While more simple co-location between supply and demand could be used to prove concepts initially, future-proofing plans should be ensured, so that developments could eventually be more in line with what is imagined of a large-scale GEP assessed in this report.

It will be useful for the State to provide more clarity on what it expects from GEP developments and the key characteristics they should comprise, ownership models, how they will be facilitated or incentivised etc. but setting any criteria around security of supply, grid reliance, emissions etc would need to be very carefully examined.

8.1.2 GRID INFRASTRUCTURE, NETWORK INTERACTION, AND THE FUTURE ROLE OF PRIVATE WIRES

The potential for GEP developments to minimise grid infrastructure requirements has been noted as a key potential benefit, but the approach to grid upgrades and connections has emerged as a key point of interest from this work, as discussed in Section 7.2.2 and elsewhere.

While GEPs can minimise and make more efficient any grid upgrades needed, this is compared to the alternative of developing the same developments in a more separate and less coordinated way. If GEPs of the scale envisaged (multi-GW) are to be added to the system, there will clearly still be significant requirements for grid upgrades to accommodate these. This is exemplified by EirGrid's approach to renewable hubs in SOEF1.1. These hubs will be designed to provide a more efficient approach to getting large levels of renewables on the system, but there will still be significant infrastructure requirements to establish the hubs.

Further, Government has already committed to investing in the national electricity grid to ensure security of supply and support decarbonisation, in addition to supporting other Government priorities. It is understood that EirGrid is undertaking analysis to understand the sequence and scale of future grid investment required longer-term. How plans for GEPs and associated grid infrastructure interact with these plans must be considered, as well as how costs for grid upgrades for GEPs and associated infrastructure would be attributed.

Something that will inform this and need to be understood is how GEPs may interact with the electricity network. As mentioned in the report, partial grid access is likely to be needed for times when renewable energy may not be available. It is difficult to see how this would work in practice with current technology mixes. It is likely that GEPs would require power from the grid at times when renewable generation is low (and on-site storage is depleted), which would be the same time that renewable generation would be low across Ireland and margins would be low across the grid. In this situation, the GEP would put more pressure on security of supply for the Irish grid as a whole, and impact system operations. Additionally, if GEPs are reliant on the grid to fully balance their demand, the grid infrastructure may then still need to be capable of managing the full demand of the park at any one time, negating many of the expected benefits in minimising grid requirements.

If the GEP only requires the grid to provide a capped level of the park's total demand at any one time, then the park will need to be able to balance supply and demand beyond the grid access level. This will require a large on-site storage capacity, likely in the form of battery storage for short- to medium-term variations in electricity supply. The potential and future capacity for batteries to provide this large-scale storage should be assessed.

During prolonged shortages of renewable energy, however, additional storage beyond flexible batteries will be necessary. Long term storage of hydrogen could potentially support GEPs, but this is also an area in need of further research to establish how this would work.

Information on the use of partial grid connections internationally was sought as part of the research for this report, but could not be found. This may require further in-depth investigation.

With regards to private wires, the GEP scenarios used in this report include for the use of private wires. As discussed, private wire connections are currently not permitted in Ireland, but this policy is being reviewed. Any policy changes to enable the use of private wires and internal networks for GEP development would need to be in line with the Private Wire Guiding Principles for Policy Formulation from DECC.

8.1.3 FURTHER ENGAGEMENT WITH LEUS

While efforts have been made to engage with representatives of LEUs as part of this work (both data centres and the other industrial users identified in this work), due to time constraints and other reasons, interviews could not be arranged with any LEU representatives outside of data centres. Further engagement with LEUs identified in this work is recommended.

To reduce emissions and maximise the use of renewables, this engagement could explore if any tenants are able to operate using variable demand profiles. This would reduce the need for support from dispatchable generation and would reduce security of supply issues.

8.1.4 THE REQUIREMENT FOR BACK-UP DISPTACHABLE GENERATION AND STORAGE AND THE IMPLICATIONS OF THIS

If the reliance of GEPs on grid for security of supply is to be accommodated for, this may cause a need to expand the gas-fired generation fleet. The costs of this additional generation and how those costs are met will have to be considered, as well any wider grid reinforcement required to accommodate the power flows. Under current arrangements, these costs are shared across all power system users.

Given our climate ambitions, it is not a desired outcome for the development of GEPs to lead to an increase in fossil-fuel use. Plans will need to be progressed to decarbonise the gas-fleet in Ireland, likely through the use of hydrogen or biomethane, or potentially carbon capture and storage.

Gas Networks Ireland has outlined plans to decarbonise the gas grid by 2045 in its Pathway to a Net Zero Carbon Network report [141] outlining a longer-term plan for the grid to transport approximately 30% biomethane and 70% green hydrogen. Progress in this regard could play an important role in the future development and design of GEPs.

8.1.5 MARKET AND REGULATORY BARRIERS

Depending on the characteristics of a particular GEP, the regulatory, operational and market barriers may be different. Further work on exploring the operational characteristics of these sites would be useful to identify potential barriers and inform legislative and regulatory changes that might be required. An example raised in stakeholder engagement is a need for EirGrid to introduce more dynamic market mechanisms to enable LEUs to optimise their energy usage to match more closely renewable energy generation. Other areas to consider include electricity market access, licensing, tariffs, consumer protections and standards.

8.1.6 FURTHER ECONOMIC MODELLING

A detailed economic appraisal, including a cost-benefit analysis, should be considered. This will examine the potential costs to the State and the consumer associated with various scenarios, including but not limited to potential grid requirements or State support mechanisms. It is likely that more detail pertaining to the GEPs will be required before such an assessment can be undertaken. A full cost assessment will ultimately need to be conducted, the results of which will further contribute to the economic modelling. Other important considerations that will support a cost-benefit assessment and further build on the assumptions outlined in this report include:

- Modelling various levels of grid access and internal storage capacity and assessing the associated implications for the development of GEPs as well as costs to the State and consumers.
- Assessing potential limitations in export capacity particularly during periods of high energy production and low on-site demand, and evaluating the potential economic consequences of lost productivity.
- Completing a labour and skills needs assessment to build on the assumptions outlined in this report.
- Further analysing and refining assumptions related to additionality and the counterfactual as more information becomes available.

8.1.7 THE ROLE OF THE STATE IN GEP DEVELOPMENT AND POINTS TO CONSIDER IN A NATIONAL STRATEGY

This report has recommended that National Energy Park Strategy be prepared by the State. A comprehensive National Energy Park Strategy should build on this report and:

- Define what the State views as the key characteristics of a GEP and the benefits expected, without being overly prescriptive
- Clarify the role the State intends to take in the development of GEPs, including any proposed supports or incentives to be provided and how these may interact with the ORESS or its successors
- Discuss the key barriers and how these will be addressed;
- Set out key actions the State will take in the near term to facilitate development.

Such a Strategy will need to align with other policies and strategies from Government to avoid duplication or contradiction and ensure a coordinated approach.

It will be important to understand the broader consequences of GEPs, particularly if they involve directing employment-intensive industry away from centres of population which have the supporting infrastructure, services and amenities needed to support industry and attract FDI, as well as the available skills and workforce in close proximity. In addition, the potential costs and benefits should be examined in a broader way as part of the development of a National Strategy, looking at potential spatial, economic, environmental and societal implications across a range of different GEP scenarios.

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APPENDIX A – INTERNATIONAL CASE STUDIES

Kalundborg Eco-Industrial Park

Kalundborg Eco-Industrial Park [142] is located in Kalundborg, Denmark, which is considered the first successful example of the Eco-Industrial Park concept outline by UNIDO [143]. It is an industrial symbiosis network, with its centre being a 1500 MW coal-fired power station. Industrial collaboration at the site includes surplus heat from the power plant being used to heat 3500 local homes and a nearby fish farm, sludge from the fish farm being sold as fertiliser, steam from the power plant sold to a local pharmaceuticals company, gypsum (a by-product from the power plant) being used by a local wallboard manufacturer, and fly-ash and clinker from the power plant being used for road building and cement production. Whilst this would not be considered a GEP example, due to its power being supplied by a coal plant, it serves as a useful example for how exchanges of waste, water and materials can greatly increase environmental and economic efficiency.

Barsebäck Clean Energy Park, Sweden

Barsebäck is the site of a decommissioned nuclear power station in Barsebäck, Skåne, Sweden [144]. Uniper, together with Ideon and other partners, is leading an initiative to develop a "Clean Energy Park" at the site. Uniper outlines this Clean Energy Park as being an *"Integrated energy system where production and industrial processes are combined"* [145]. The site currently has the nuclear power plant which is in the process of being decommissioned, a reserve power plant, electrical distribution infrastructure and an industrial port. The project is at an early stage of development, with Uniper exploring different options for the site. Solar cells, battery storage, hydrogen production though electrolysis, biogas plants, industrial establishments and greenhouse farms are options being explored. Uniper has also outlined an ambition for a campus for research and entrepreneurship to be located at the site, and as a first step has aims to build a 45 MW solar park, and 25 MW battery park. Beyond the solar and battery park, it is not currently clear what other renewable energy generation, storage, and industrial processes will be located at the site. It is also currently unclear how these processes will interact with one another in an integrated system.

CCB Energy Parks, Norway

CCB Energy Holding is developing an Energy Park concept at Øygarden, Bergen, Southwest Norway [146]. Much of the goals for developing this energy park are related to the site's potential for carbon capture and storage (CCS). The park is home to the Northern Lights facility, which opened in September 2024 [147], the "world's first" commercial facility that transports and permanently store CO_2 beneath the seabed. It is the aim of the CCB Energy Park concept that industrial end users that capture CO_2 will therefore locate at the site, so that they can dispose of captured CO_2 locally and with the lowest carbon footprint. The energy park also aims to be a location for the large-scale production of hydrogen and hydrogen-based energy carriers, from natural gas with CCS. It is the aim of the CCB Energy to create synergies at the site for different industries, with short-distance access to clean hydrogen, CO_2 storage, natural gas and LNG, surplus heat, oxygen and water. The are multiple companies already located at the site, including an aero services company, a seafood company and several energy companies.

Akershus Energy Park, Norway

Akershus Energy Park is located in Lillestrøm, Norway. It is home to a large modern district heating system that produces district heating from local renewable energy sources, including from wood chips, heat pumps from sewage, landfill gas, bioenergy oil and solar energy [148]. The solar plant has a solar panel area of over 10,000 m^2, providing heat to the district heating system. The site is also home to the IFE Hydrogen Technology Centre, which includes a small-scale hydrogen refuelling station. This heat is supplied to a university, a research and development centre and a range of commercial and domestic buildings (Figure A-1)

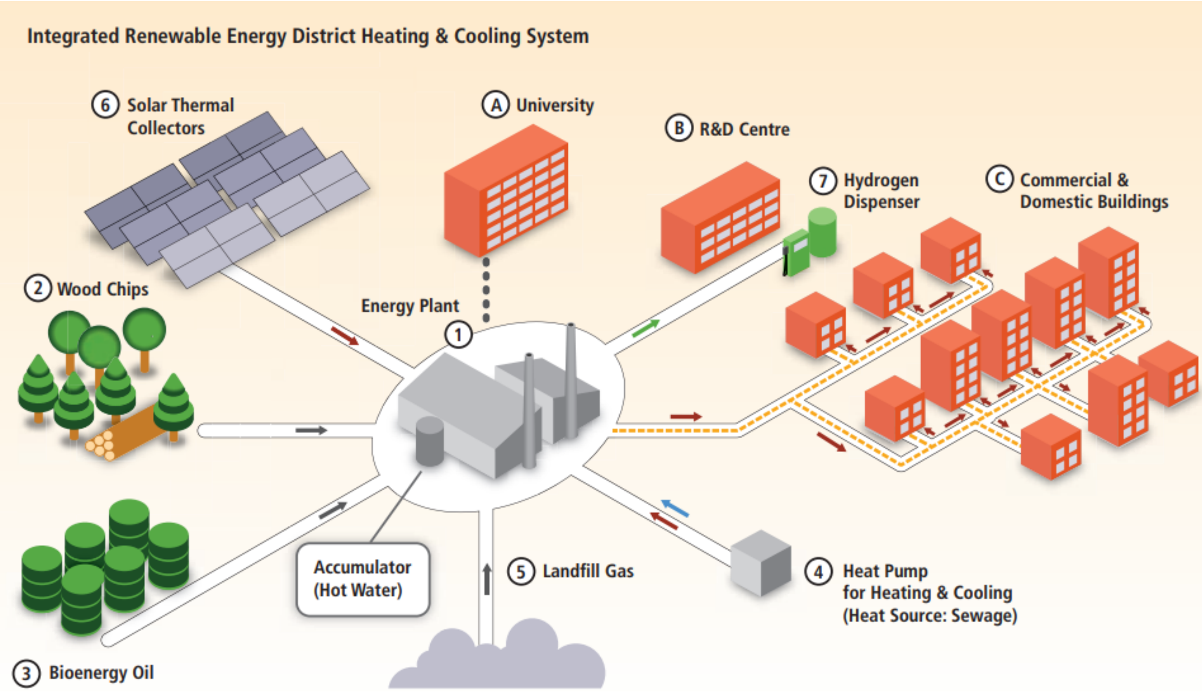

Figure A-1: Akershus Energy Park's district heating and cooling system from integrated renewable energy supplies: (1) Central energy system with 1,200 m^3 accumulator tank; (2) 20 MW wood burner system; (3) 40 MW bio-oil burner; (4) 4.5 MW heat pump; (5) 1.5 MW landfill gas burner and a 5 km pipeline; (6) 10,000 m^2 solar thermal collector system (7) Fuel cell vehicle dispensing system [149].

Oakajee Strategic Industrial Area, Australia

The Oakajee project is planning to create a Strategic Industrial Area for industries including magnetite iron ore and other downstream processing industries, and a multi-user deep port, in Western Australia [150]. The port is being developed for the export of resources such as iron ore and gas. The site has over 6,400 hectares of land and has extensive wind and solar resources (270 MW wind, 1,250 MW solar potential generation capacity) [151]. The project is proposing to use this resource to supply the majority of the site's proposed industrial power requirements. It will also have gas and grid access. The project is also investigating the potential of developing a renewable hydrogen hub at the site, with the aim of producing renewables-based hydrogen and ammonia for export.

GreenLab, Denmark

GreenLab is a green and circular industrial park located in Skive, Denmark [152]. Renewable energy is generated, stored and shared with industries located at the park, via a direct connection to an 84 MW wind and solar farm located just south of the site. A key feature of the GreenLab model is its "SymbiosisNet", an intelligent network of energy and data that allows companies located at the park to share and monetise excess resources, including heat, syngas and biomass. GreenLab encourages collaboration between companies, where one company's waste or by-product (e.g. excess heat) can be used by another company in the park, creating a circular, sustainable and efficient system. GreenLab is also part of a 100 MW Power-to-X (PtX) project, GreenHyScale, with its facility being located at the park. In May 2023, an initial 6 MW PtX facility arrived at the site, with the first receiver of hydrogen being a factory producing protein for animal feed, located in Greenlab. Other industries located at the park include biofuel producers, synthetic fuel and chemical production from plastic waste, biogas producers and sustainable construction panel manufacturing.

The Smart Green Industrial Complex at Saemangeum, South Korea

The Saemangeum National Industrial Complex [153], South Korea, has been designated as Korea's first "Smart Green National Demonstration Industrial Complex" by the Korean Ministry of Land, Infrastructure, and Transport. The ministry defines a smart green industrial complex as an industrial complex that has "built infrastructure in a way that minimizes energy use and expands the supply of renewable energy". Ambitions for the site include developing 2029 MW of solar generation, including 30 MW of solar on the sites rooftop, development of a green hydrogen production cluster, development of an energy integration platform that "increases the energy self-reliance rate through energy data collection, utilization, and monitoring" and an energy storage system to balance the intermittency of renewable power sources. Through this the complex aims to attract companies committed to renewable energy usage. It is not currently clear how the development of this complex will unfold and how components will integrate with one another.

Ventspils Industrial Park, Latvia

This project in Ventspils, Latvia is aiming to integrate renewable energy, industrial demand and a deep-water port at Ventspils Industrial Park. It is a national level project, aimed to service and boost the uprising green economy in the region. The region where the park is being developed has been identified by solar and wind energy producers for its renewable energy capacity, and offshore wind farms are due to be developed close to the site. The site has three dedicated areas for industries to locate. Its *Green Tech Area* is earmarked as a manufacturing location for electricity, hydrogen and e-fuel powered vehicles and technologies, its *Green Energy Area* earmarked for green energy production (including solar, hydrogen, green methanol) and its *High Tech Area* for the development of smart materials, technologies and engineering systems, as well as information and communication technologies. The port at Ventspils has existing terminals that are capable of handling e-fuels, including green ammonia. The project hopes this will encourage the development of PtX and hydrogen at the site.

Haraholmen Green Industrial Park, Sweden

Haraholmen Green Industrial Park [154] is located close to Piteå in Norrbotten, North Sweden. The site aims to integrate renewable energy generation, with companies focussing on environmental sustainability. It is also aims to be a hub for resource-efficient transport, through its access to roads, railways and a deepwater port. It has two neighbouring sites that are planned for industrial use. The site is able to supply consumers with 100% renewable energy and low energy prices – as Norrbotten has 100% renewable energy production from hydro and onshore wind power [155]. The site also provides district heating and cooling from its on-site "SunPine" bio-refinery. The green industrial park is continuing to develop as new technologies and innovations emerge, and developers have identified the site as being an ideal location for green hydrogen development. In addition to the bio-refinery the other major company located at the site is "Lindbäcks Bygg" – a leading Swedish manufacturer of prefabricated wooden buildings.

Megaton Energy Park

The Megaton Energy Park [156] is currently under development by GreenGo Energy at Tarm, Denmark. The Megaton project is aiming to combine 4 GW of solar and wind power with an up to 2 GW electrolysis facility to produce over 1 million tons of green fuel annually. This will be developed in 2 phases – phase 1 with 200 MW onshore wind and 200 MW solar with an up to 200 MW electrolysis, and phase 2 with 800 MW offshore wind from the North Sea Tender Wind Farms to be matched with around 1,800 MW solar with and up to 1,800 electrolysis. The Megaton Energy Park aims to circularity and industrial collaboration in many of its processes. This includes the operational use of 7MT of purified seawater in electrolysis processes, minimising freshwater usage, and using carbon from a local biogas producer for e-fuel production, contributing to a circular carbon economy. In addition, surplus heat from the site will contribute to the local district heating system. It is also hoped that surplus heat and power at the site will encourage new industries to locate there. Developers are aiming for the project to be fully implemented by 2031.

Chelveston Renewable Energy Park, UK

Chelveston Energy Park is located in Northamptonshire, UK. The park utilises a number of renewable energy sources, including a solar and wind farm with a capacity of 85MW. There is also a 10MW hydrogen production plant on site as well as a 47MW peaking plant, a 20MW Lithium Ion battery store, a 26MWh import connection and an 80MWh export grid connection. Plans are also underway to expand the Chelveston Renewable Energy Park further and its developers have sought permission to construct an Innovation Park which will work to develop energy intensive businesses requiring large amounts of renewable energy which in turn encourages sustainable development while stimulating the economy through clean energy. This project is a good example of the co-location of renewable energy generation and industry and how these different types of energy can work in symbiosis generating capital as well as reducing the use of traditional sources of energy [157].

Net Zero Teeside, UK

Net Zero Teeside (Figure A-2) is a GEP concept located in Teeside, North England [158]. The developers behind the park are proposing to develop a collection of industrial, power and hydrogen business which decarbonise their operations via the deployment of carbon capture utilisation and storage (CCUS). The park's power generation will come from a proposed 860MW combined cycle gas turbine with CCUS. A Northern Endurance Partnership (NEP) will provide the infrastructure for transporting and storing carbon from the gas plant and other industries located within the plant, to offshore storage in the North Sea. There is a range of existing and proposed nearby industries, the East Coast Cluster, which can use the decarbonised power and also use the CCUS infrastructure to remove carbon emissions from their own processes. Existing and proposed industries include hydrogen production from natural gas with CCUS (Teeside Hydrogen, Kellas, BOC), energy-from-waste (SUEZ Tees Valley Carbon Capture plant, and the Tees Valley Energy Recovery Facility) and fertiliser manufacturing (CF fertilisers).

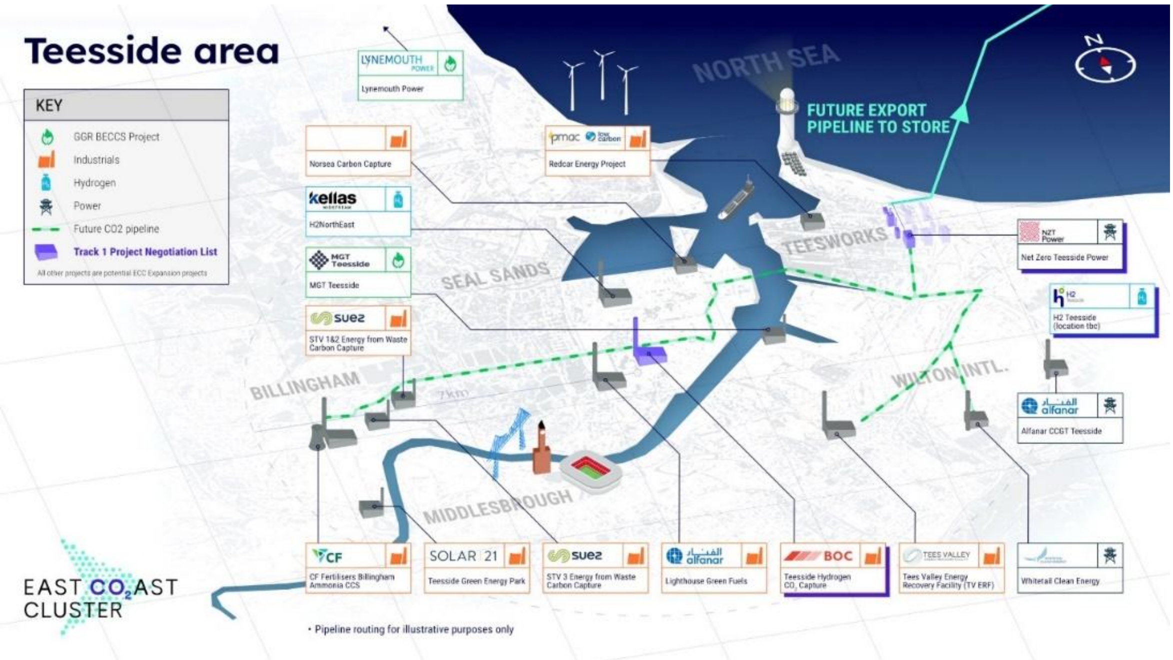

Figure A-2: Net Zero Teeside overview [158]

Green Energy Park, Zellik, Belgium

The Green Energy Park in Zellik is a collaborative initiative between the Vrije Universiteit Brussel (VUB - Free University of Brussels) and the UZ Brussel (UZB – Brussels University Hospital). This park features a state-of-the-art data centre, which opened in May 2024. The Nexus data centre is noted as Belgium's first ever 'sustainable by design' data centre [159], and operates entirely on renewable energy, some of which is generated on-site from a photovoltaic façade generating up to 0.5MW. The park developers do not include additional information on the source of renewable energy to the park. Heat from the data centre's servers is recovered, and rainwater is used for cooling. The data centre has a 7 MW IT-load based on a 12.5 MVA renewable power feed, spans approximately 10,000 square meters over eight floors and is designed to support advanced research in areas such as energy, mobility, climate, environment, health, robotics, artificial intelligence, and electronics. The data centre is also set to host a supercomputer from late 2025. Penta Infra acquired the data centre from developer Ghelamco in June 2024 [160]

In addition, the Green Energy Park features a “Smart Village Lab”, consisting of six houses that exchange electrical and thermal energy via a Smart Energy Grid, an energy network to which collective energy systems are connected, including community batteries and charging infrastructure for electric cars. With the Smart Village Lab, the park developers aim to offer companies and knowledge institutions a “real life” environment where they can safely experiment with the development of smart housing and residential neighbourhood systems that will contribute to this. The project aims to have a carbon-neutral, self-sufficient business park and campus by 2035 [161]. Limited information is available on the investment involved in the park or data centre, but the project could be one of interest to Ireland given the presence of a sustainable data centre.

APPENDIX B – ETS DATA REVIEW

Table B-1 below was compiled taking data from the European Environment Agency's EU ETS database [79] on verified emissions for 2023 by Irish EU ETS installations. To compile the table, results from aviation, data centres, and thermal power generation were removed, as were installations with blank entries for emissions in 2023. Results were then sorted from highest to lowest.

Table B-1: EU ETS data review of Irish emissions in 2023, extracted from [79]

LAST_NAME	INSTALLATION_NAME	CITY	VERIFIED_EMISSIONS_2023	Final Main Activity Type Code
Limerick Alumina Refining Limited	Aughinish Alumina	Askeaton	1015332	20
CRH plc	Irish Cement Limited (Platin Works)	Drogheda	988929	29
CRH plc	Irish Cement Limited (Limerick Works)	Castlemungret	716710	29
Mannok Cement Limited	Scotchtown Cement Works	Ballyconnell	609556	29
Breedon Cement Ireland Limited	Breedon Cement Ireland Limited	Kinnegad	386662	29
Irving Oil Whitegate Refinery Limited	Irving Oil Whitegate Refinery Limited	Cork	286922	21
Tirlán Limited	Glanbia Ireland DAC Ballyragget	Ballyragget	85544	20
Lakeland Dairies Co-operative Society Limited	Bailieboro Foods Limited	Cavan	76969	20
Clogrennane Lime Limited	Clogrennane Lime Lt. (Toonagh Lime Works)	Ennis	76529	30
Clogrennane Lime Limited	Clogrennane Lime Carlow	County Carlow	63157	30
Kerry Ingredients (Ireland) Limited	Kerry Ingredients (Ireland) Limited	Listowel	53696	20
Dairygold Co-Operative Society Limited	Dairygold CoOp Society Ltd. Mitchlestown	Mitchelstown	53076	20
Intel Ireland Limited	Intel Ireland	Leixlip	51274	20
Irish Distillers Limited	Midleton Distilleries	-	43154	20
Carbery Food Ingredients Limited	Carbery Food Ingredients Limited	Cork	40290	20

Diageo Ireland	St. James's Gate Brewery	Dublin	39402	20
Kerry Ingredients (Ireland) Limited	Kerry Ingredients (Ireland) Limited	Charleville	36902	20
Dairygold Co-Operative Society Limited	Dairygold Co-Op Society Limited (Mallow)	Mallow	36705	20
Tirlán Limited	Belview	Kilkenny	35159	20
Pfizer Ireland Pharmaceuticals	The Pfizer Biotech Campus at Grange Castle	Clondalkin	32849	20
Nutricia Infant Nutrition Limited	Nutricia Infant Nutrition Limited Macroom	Macroom	32277	20
Saint-Gobain Construction Products (Ireland) Limited	Kingscourt Works	Kingscourt	30890	34
Bord na Mona Fuels Limited	Bord na Mona Derrinlough Briquette Factory	Birr	29664	20
IFF N&H Ireland HC Limited	International N&H Mfg. Ireland	Little Island	27817	20
Aurivo Dairy Ingredients Limited	Aurivo Dairy Ingredients Limited	Ballaghadereen	26962	20
Eli Lilly Kinsale Limited	Eli Lilly Kinsale Limited	Cork	26584	20
Wyeth Nutritionals Ireland Limited	Wyeth Nutritionals Ireland Limited	Askeaton	24997	20
Abbott Ireland	Abbott Ireland Cootehill	Cootehill	24718	20
Tirlán Limited	Tirlán Limited (Virginia)	Cavan	23808	20
Pfizer Ireland Pharmaceuticals	Pfizer Ireland Pharmaceuticals - Newbridge	Kildare	23140	20
Arrabawn Cooperative Society Limited	Arrabawn Cooperative Society Limited	Nenagh	22487	20
Tipperary Co Operative Creamery Limited	Tipperary Co Operative Creamery Limited	Tipperary	19778	20

Baxter Healthcare SA	Baxter Healthcare SA	Castlebar	19579	20
College Proteins Unlimited Company	College Proteins	Nobber	17222	20
College Proteins Unlimited Company	Farragh Proteins	Crossdoney	17205	20
Anglo Beef Processors Ireland Unlimited Company	ABP Munster Proteins/ABP Cahir	Cahir	16845	20
Regeneron Ireland Designated Activity Company	Regeneron Ireland IOPS Raheen	Limerick	15982	20
Dublin Products Limited	Dublin Products Limited	Dunlavin	15488	20
Minch Malt Limited	Minch Malt Limited	Athy	14573	20
Anglo Beef Processors Ireland Unlimited Company	Waterford Proteins/ABP Waterford	Waterford	14188	20
Pelagia Feed (Ireland) Limited	Pelagia Killybegs	Killybegs	11846	20
Pfizer Ireland Pharmaceuticals	Pfizer Ireland Pharmaceuticals	Ballintaggart	10892	20
C&D Foods Unlimited Company	C&D Foods	Edgeworthstown	10413	20
Allergan Pharmaceuticals Ireland Unlimited Company	Abbvie	County Mayo	9343	20
MSD International GmbH (trading as MSD Ireland (Ballydine))	MSD International GmbH (t/a MSD Ireland Ballydine)	Tipperary	8811	20
Lakeland Dairies Co-operative Society Limited	Lakeland Dairies Drying Plant	Monaghan	8425	20
Lakeland Dairies Co-operative Society Limited	Killeshandra Site	Killeshandra	8395	20
Janssen Sciences Ireland UC	Janssen Sciences Ireland UC	Cork	8018	20

Swords Laboratories ULC t/a Bristol Myers Squibb Cruiserath Biologics	Bristol Myers Squibb Cruiserath Biologics	Dublin	7913	20
Medite Europe Designated Activity Company	MEDITE Europe DAC	Tipperary	7790	20
Guerbet Ireland Unlimited Company	Guerbet Ireland Unlimited Company	Dublin	7524	20
DAA Public Limited Company	Dublin Airport	County Dublin	7476	20
BASF Ireland Designated Activity Company	BASF Ireland Designated Activity Company	Cork	7065	20
Alexion Pharma International Operations Unlimited Company	Alexion College Park	Dublin	5591	20
Health Service Executive West	University Hospital Galway	Galway	5119	20
Genzyme Ireland Limited	Genzyme Ireland Limited	Waterford	5040	20
WuXi Biologics Ireland Limited	WuXi Biologics	Dundalk	4960	20
Masonite Ireland Unlimited Company	Masonite Ireland	Leitrim	4450	20
Hovione Limited	Hovione Limited	Ringaskiddy	4193	20
Breedon Brick Limited	Kingscourt Brick	Cavan	4054	32
MSD International GmbH (t/a MSD Ireland (Biotech Dublin))	MSD Ireland (Biotech Dublin)	Swords	3750	20
MSD International GmbH t/a MSD Ireland (Brinny)	MSD International GmbH t/a MSD Ireland (Brinny)	Innishannon	3438	20
MSD Intl GmbH t/a MSD Ireland (Dunboyne Biologics)	MSD Ireland (Dunboyne Biologics)	Meath	2771	20

Novartis Ringaskiddy Limited	Novartis Ringaskiddy Limited	Ringaskiddy	2656	20
Smartply Europe Designated Activity Company	Smartply Europe	Kilkenny	1600	20
Wexford Proteins Limited	Wexford Proteins Ltd	Bunclody	894	20
Waspar Limited	Waspar Limited	Dublin	235	20
Premier Periclase Limited	RHI Magnesita Drogheda Plant	Louth	0	30

APPENDIX C – ECONOMIC ANALYSIS SUPPORTING INFORMATION

C.1 APPENDIX C1. DETAILED SCENARIO DEVELOPMENT METHODOLOGY

C.1.1 1GW FIXED OFFSHORE WIND FARM

Table C-1 provides the key assumptions based on ORE Catapult's report on Fixed Bottom Wind Costs [110]. These costs were used to inform costs for the assessed 1GW fixed offshore wind farm for the purpose of this assessment. It is noted that some of these assumptions e.g. distance from shore and water depth, and potentially foundation type, would not be directly applicable to a SC-DMAP or other Irish site, but they provide a useful reference and starting point for the purpose of this assessment.

Table C-1: Key assumptions for offshore wind farm from [110]

Parameter	Data
Year of final investment decision	2019
First operation date	2022
Turbine rating	15MW
Water depth at site	30 m
Annual mean wind speed at 100 m height	10 m/s
Distance to shore, grid, port	60 km
Foundation	Monopile
Substructure manufacturing location	Europe
Currency conversion	Average annual £ to € conversion rate
Inflation	5.2% per year
Operating capacity	45%

Estimations for DEVEX, CAPEX, and OPEX associated with the 1GW offshore wind farm are created based on these assumptions, with expenditure derived from ORE Catapult's report on Fixed Bottom Wind Costs [110]. The expenditure estimations in this report are based on 10MW (rather than 15MW) turbines. Other than this difference, other assumptions are similar to the ones used in that assessment. Adjustment to expenditure estimations were made by GDG based on both supplier engagement and project experience for 15MW turbines, and more recent costs, where information was available. Most cost estimates are struck at 2019 prices. However, some more recent estimations were available. All prices have been converted to 2023 prices using GDP deflator information ascertained from the Irish National Accounts, provided by CSO. All prices were estimated in Pound Sterling. The average annual exchange rate [162] has been used to convert Pounds Sterling to Euros. Currency conversion was completed before inflating prices to 2023 levels. The average annual exchange rate during the year that prices were struck was used.

Table C-2 shows the expenditure categories along with the price (adjusted for year and currency) and the assumptions[17] used to create the expenditure estimate.

Table C-2: Estimated expenditure (offshore wind farm)

Expenditure categories	Prices (€M)	Assumptions
	Development and PM	
Development activities and consenting services	70	No additional adjustments
Environmental surveys	6	No additional adjustments
Resource and metocean assessment	6	No additional adjustments
Geological and hydrographical surveys	6	No additional adjustments
Engineering and consultancy	6	No additional adjustments
Other	75	No additional adjustments
Total	168	
	Capital	
Turbines	1,641	Updated to ORE Catapult FLOW 2021
Array cable	51	Adjusted based on GDG supplier engagement
Export cable	114	Adjusted based on GDG supplier engagement
Cable accessories	7	Adjusted based on GDG supplier engagement for 15MW
Turbine foundations[18]	639	Adjusted based on GDG project experience for 15MW
Offshore substation	168	No additional adjustments
Onshore substation	42	No additional adjustments
Operation base	4	No additional adjustments
Total	2,665	
	Installation	
Foundation installation	188	Adjusted based on GDG project experience for 15MW
Offshore substation installation	91	Adjusted based on GDG project experience for 15MW
Onshore substation construction	35	No additional adjustments
Onshore export cable installation	70	No additional adjustments
Offshore cable installation	125	Adjusted based on GDG project experience – reduced cable connection with higher MW WTGs
Turbine installation	103	Adjusted based on GDG project experience for 15MW
Offshore logistics	5	No additional adjustments

[17] All figures are adjusted for wind farm size, GDP deflators, and currency; this is not listed in the assumptions column.
[18] Average between MP or JCK, 30-40m WD.

Other	205	Adjusted based on GDG project experience for 15MW
Total	822	
Operations, maintenance, and service (per annum)		
Operations[19]	4	No additional adjustments
Other[20]	31	No additional adjustments
Turbine maintenance and service	46	No additional adjustments
Balance of plant, maintenance, and service	25	No additional adjustments
Total	106	

The capacity rate of the offshore wind farm is assumed to be 45%[21]; this implies 3.9 million MWh of electricity production per annum. Current electricity prices are €163 per kWh, this is used as the basis for this assessment. This implies that the revenue of the offshore wind farm is expected to be €643M in current prices. Due to a current lack to data, this cannot be deflated to 2023 prices.

C.1.2 150MW ONSHORE WIND FARM

Expenditure estimates for the 150MW onshore wind farm are built up using per MW estimates for the development of a large-scale wind farm in Europe [113]. These cost estimates include capital, installation, and operation. Estimates were provided for 2018 in Euros, these figures were inflated to 2023 prices using GDP deflator information. The development expenditure associated with the onshore wind farm was calculated using estimates for an offshore wind farm [163]. Expenditure was scaled based on the size of the development and inflated to 2023 prices. It is also assumed that the capacity rate of the wind farm is 35%. Table C-3 shows the estimated DEVEX, CAPEX, and OPEX of the 150MW onshore wind farm in 2023 prices.

Table C-3: Estimated expenditure (onshore wind farm)

Expenditure categories	Price (€M)
Development and PM	
Environmental impact assessments	2
Development activities and other consenting services	11
Environmental surveys	2
Resource and metocean assessment	1
Geological and surveys	2
Engineering and consultancy	2
Project management	9
Total	29
Capital and installation	

[19] Excludes Insurance
[20] Includes insurance, environmental studies, and compensation payments
[21] Capacity factor for offshore wind in the ORESS Terms and Conditions

Wind generator	114
Internal electrical installations	10
Electrical substation and power lines	29
Engineering design and construction	12
Additional expenses	3
Total	168
Operations and maintenance	
Head office	4
Maintenance	4
Total	8

The capacity rate of the onshore wind farm is assumed to be 35%[22]. This implies 460 thousand MWh of electricity production per annum. Current electricity prices are €163 per kWh, this is used as the basis for this assessment. This implies that the revenue of the wind farm is expected to be €43M in current prices. Due to a current lack to data, this cannot be deflated to 2023 prices.

C.1.3 150MW SOLAR FARM

Expenditure estimates for the 150MW solar farm use cost estimates for the development of a solar farm in UK. The UK is used as a basis due to market similarities and geographical proximity. Estimates for the DEVEX and CAPEX for a solar farm in the UK are provided in 2019 prices in USD [114]. These figures are converted to Euros using the average exchange rate in 2019 and then inflated to 2023 prices. These estimates are broadly consistent with other examples of solar farm developments in Ireland [164]. Operating costs are assumed to be 1% of CAPEX [165]. This assumption aligns closely with other estimates for operating costs [166]. This includes the cleaning of panels, damage inspections, and monitoring of electricity production.

Table C-4 provides estimated DEVEX, CAPEX, and OPEX of the 150MW solar farm in 2023 prices.

Table C-4: Estimated expenditure (solar farm)

Expenditure categories	Price (€M)
Development	
Head office	12
Systems design	3
Permitting	18
Total	33
Capital and installation	
Modules	68
Inverters	10
Mechanical installation	18
Electrical installation	14

[22] Capacity factor for onshore wind in RESS Terms and Conditions

Inspection	2
Racking and mounting	9
Cabling / wiring	19
Safety and security	2
Monitoring and control	1
Total	144
Operations and maintenance	
Operations and maintenance	2
Total	2

The capacity rate of the solar farm is assumed to be 11%[23]. This implies 151 thousand MWh of electricity production per annum. Current electricity prices are €163 per kWh, this is used as the basis for this assessment. This implies that the revenue of the solar farm is expected to be €25M in current prices. Due to a current lack to data, this cannot be deflated to 2023 prices.

C.1.4 500MW DATA CENTRE

It is assumed that the data centre will have a 500MW capacity. Estimates vary, but Mordor Intelligence notes that as of 2024, Ireland has a total data centre capacity of 771MW, occupying a total floor space of 457,082 sqm [167]; this implies that the power capacity density is 1.7KW per sqm. Case study of data centres in Ireland align with this estimate [168]. However, it should be noted that power density capacity can vary between data centres and power capacity density is improving as technology does [169]. For the 500MW data centre in this scenario, the power capacity ratio implies a total floor space of 296,422 sqm. On-site employment can be estimated using employment densities provided by the UK Government Homes and Communities Agency [170]. Employment densities (and output) can vary drastically, from 180 sqm per employee in a colocation data centre to 1,400 sqm per employee in a wholesale data centre. There are currently no indications as to who the potential users of a data centre in a GEP would be. As such, for the purposes of assessment, it is assumed that the data centre will include hyperscale colocation and wholesale elements. The current spilt in Ireland is 78% hyperscale, 8% wholesale, and 11% colocation [171]. For this reason, a "mixed" employment density of 400 sqm per employee is used to represent the range of different potential data centres. This gives a total on-site employment of 741 users.

Labour market data provided by CSO gives the total 2020 employment in the industries represented by CPA code 58-60, 62-63 (that which contains data centres and related activities) as 113,275. The total output of this sector according to the CSO Supply and Use tables is €166,808M in 2020 prices. This implies an output ratio of €1,642,705 per employee after inflating to 2023 prices. Thus, the estimated output of this 500MW data centre under these assumptions is €1,217M.

To estimate the construction costs of the data centre, industry benchmarks were used. The average data centre construction cost in Ireland is 8.9 USD per W of capacity in 2023 [172]. It should be noted that this has risen to 9.4 USD per W of capacity in 2024; supply chain limitations, inflationary trends, and labour shortages have been driving up costs [173]. However, since 2023 is used as the base year in this report, the 2023 figure has been used. After converting this to Euros using the average USD to Euro conversion rate, this implies that a 500MW data centre would cost €4,098M to construct. This

[23] Capacity factor in RESS Terms and Conditions

figure also lies within the low-high range of data centre construction costs reported by Savills. This can be broken down into discrete expenditure streams based on a Europe-wide breakdown of construction costs [172] (which is comparable to breakdown costs in the USA [174]). Table C-5 shows the percentage breakdown of construction costs.

Table C-5: Data centre construction costs breakdown (Europe)

Cost component	Percentage breakdown (low case)
Powered shell	17%
Electrical systems	45%
HVAC, mechanical, cooling	20%
Fire suppression	2%
Building fit-out	16%

Table C-6 shows the breakdown of construction costs for the 500MW data centre under the assumptions outlined.

Table C-6: Estimated expenditure (data centre)

Expenditure categories	Price (€M)
Powered shell	688
Electrical systems	1,836
HVAC, mechanical, cooling	820
Fire suppression	98
Building fit-out	656
Total	4,098

C.1.5 100MW PHARMACEUTICAL MANUFACTURING FACILITY

It is assumed that the pharmaceutical manufacturing facility will have a 100MW capacity. Assuming an energy capacity utilisation factor of 30%, there will be a total energy usage of 262,800 MWh per annum. The Office for National Statistics (ONS) publishes data on industry reallocated energy use per Great British Pound (GBP) of GVA [175], with specific data available for the pharmaceutical industry. This metric is then modified to remove the energy lost in transformation and distribution. In the UK, this is around 7% to 8% of generated electricity [176] [177], however, 10% is used in the calculation to take a conservative position. This modified metric is used to calculate GVA (in GBP). The UK supply and use tables published by the ONS [178] are then used to establish output, which is then converted to Euros and inflated to 2023 prices. Through the impact modelling, direct employment is established. The resulting calculation gives an estimate output, for a 100MW pharmaceutical manufacturing facility under these assumptions, of €3,698M and employment (in FTEs) of 1392. The USA Government publishes data on floorspace and employment by industry [179] [180]. This is used to establish an employee density metric[24]. The employee density metric was used to calculate total estimated floorspace of the facility as 99,415 sqm.

Construction industry benchmarks were used to estimate the construction costs of the pharmaceutical facility. It should be noted that this includes the construction of the structure only and not the capital equipment. It has been assumed that the vast majority of capital equipment will be imported and thus the associated economic impacts in Ireland will be limited. Construction costs for laboratories have been used as the most suitable benchmark for the pharmaceutical facility. Construction costs per sqm can range up to £3,960 [181]. Thus, a building of this size would cost £470M (including external works at 15% of the total cost and contingency at 15% of the total cost). Converting this to Euros using average annual exchange rates gives a value of €610M.

C.1.6 20MW HYDROGEN FACILITY

The green hydrogen facility is assumed to have a capacity of 20MW. The key assumptions describing the 20MW green hydrogen facility are presented in Table C-7. It is noted that this is relatively small in scale, but given the nascent nature of the industry in Ireland and worldwide, this was seen as an appropriate scale for this assessment.

Table C-7: Key assumptions for green hydrogen facility

Parameter	Data
Hydrogen electrolyser plant CAPEX (€/kW)	1970
Installed power (MW)	20
Economic lifetime (years)	25
Theoretical energy consumption (kW/h/kg)	39.4
Electrolyser efficiency (%)	70.00%
Actual energy consumption (kWh/kg)	56.3
Stack durability (Operational lifetime) (hr)	60000
Stack degradation (% per 1000h)	0.19%
Stack replacement cost (% CAPEX)	15.00%
Other OPEX (% CAPEX)	2.00%
Renewable energy connection	Direct
Operating hours (hr/year)	4383
Average electricity costs (€/MWh)	86.05
Grid fees (€/MWh)	0
Electricity taxes (€/MWh)	0
Cost of capital (%)	6%

[24] Note that data from the USA was used because there was no suitable data available for Ireland and the USA was considered the most suitable alternative.

Expenditure estimates for CAPEX (including DEVEX) and OPEX are created from these assumptions. Analysis shows that there are approximately 45 on-site direct jobs created for a 100MW hydrogen facility [182]. This would create 9 direct jobs in a 20MW facility. Assuming €50,000 in labour costs per employee, that would be a total direct employee compensation of €450,000. Table C-8 shows the CAPEX and OPEX for the 20MW green hydrogen facility in 2023 prices.

Table C-8: Estimated expenditure (green hydrogen facility)

Expenditure category	Price (€M)
CAPEX	
Electrolyser stack – labour, energy	0
Electrolyser stack – materials	3
Electrolyser stack – other	5
BoP – power supply unit	6
BoP – other	6
Engineering, procurement, construction, and installation	18
Total	39
OPEX	
Electricity	8
Stake replacement	0
Labour costs	0
Other	0
Total	9

Under the assumptions outlined above, the levelised cost of hydrogen would be €6.92 per kg of hydrogen. Due to the lack of available robust data on the hydrogen market, this has been used as the basis for the sale price of the hydrogen. This would imply an annual revenue of €10M.

C.2 APPENDIX C2. CPA CODE ASSIGNMENT

Table C-9: 1 GW Offshore wind farm CPA Codes

Expenditure category	CPA Code
Development and PM	
Development activities and consenting services	74-75
Environmental surveys	74-75
Resource and metocean assessment	74-75
Geological and hydrographical surveys	74-75
Engineering and consultancy	71
Other	70
Capital	
Turbines	28
Array cable	27
Export cable	27
Cable accessories	27
Turbine foundations[25]	25
Offshore substation	27
Onshore substation	27
Operation base	41-43
Installation	
Foundation installation	41-43
Offshore substation installation	41-43
Onshore substation construction	41-43
Onshore export cable installation	41-43
Offshore cable installation	41-43
Turbine installation	41-43
Offshore logistics	50
Other	41-43
Operations, maintenance, and service (per annum)	
Operations[26]	33
Other[27]	70
Turbine maintenance and service	33
Balance of plant, maintenance, and service	33

[25] Average between MP or JCK, 30-40m WD.

[26] Excludes insurance.
[27] Insurance, environmental studies, and compensation payments.

Table C-10: 150MW Onshore wind farm CPA Codes

Expenditure category	CPA Code
Development and PM	
Environmental impact assessments	74-75
Development activities and other consenting services	74-75
Environmental surveys	74-75
Resource and metocean assessment	74-75
Geological and surveys	74-75
Engineering and consultancy	71
Project management	70
Capital and installation	
Wind generator	28
Internal electrical installations	33
Electrical substation and power lines	27
Construction	41-43
Additional expenses	41-43
Operations and maintenance	
Head office	70
Maintenance	33

Table C-11: 150MW Solar farm CPA Codes

Expenditure category	CPA Code
Development	
Head office	70
Systems design	71
Permitting	74-75
Capital and installation	
Modules	27
Inverters	27
Mechanical installation	41-43
Electrical installation	41-43
Inspection	41-43
Racking and mounting	25
Cabling / wiring	27
Safety and security	80-82
Monitoring and control	80-82
Operations and maintenance	
Operations and maintenance	33

Table C-12: 500MW Data centre CPA Codes

Expenditure category	CPA Code
Capital and construction	
Powered shell	41-43
Electrical systems	27
HVAC, mechanical, cooling	27
Fire suppression	27
Building fit-out	41-43
Operations	
Operations	58-60, 62-63

Table C-13: 100MW pharmaceutical manufacturing facility CPA Codes

Expenditure category	CPA Code
Construction	41-42
Operations	21, 26

Table C-14: 20MW green hydrogen facility CPA Codes

Expenditure category	CPA Code
CAPEX	
Electrolyser stack – labour, energy	33
Electrolyser stack – materials	27
Electrolyser stack – other	27
BoP – power supply unit	27
BoP – other	25
Engineering, procurement, construction, and installation	41-43
OPEX	
Stake replacement	27
Other	36

C.3 APPENDIX C3. NATIONAL EXPENDITURE FACTORS

Table C-15: 1 GW offshore wind farm

Expenditure category	National expenditure factor (%)
Development and PM	
Development activities and consenting services	66
Environmental surveys	66
Resource and metocean assessment	66
Geological and hydrographical surveys	66
Engineering and consultancy	66
Other	66
Capital	
Turbines	0
Array cable	1
Export cable	1
Cable accessories	1
Turbine foundations[28]	1
Offshore substation	1
Onshore substation	1
Operation base	100
Installation	
Foundation installation	10
Offshore substation installation	10
Onshore substation construction	10
Onshore export cable installation	10
Offshore cable installation	10
Turbine installation	10
Offshore logistics	10
Other	10
Operations, maintenance, and service (per annum)	
Operations[29]	51
Other[30]	51
Turbine maintenance and service	51
Balance of plant, maintenance, and service	51

[28] Average between MP or JCK, 30-40m WD
[29] Excludes Insurance
[30] Insurance, environmental studies, and compensation payments.

Table C-16: 150MW onshore wind farm

Expenditure category	National expenditure factor (%)
Development and PM	
Environmental impact assessments	66
Development activities and other consenting services	66
Environmental surveys	66
Resource and metocean assessment	66
Geological and surveys	66
Engineering and consultancy	66
Project management	66
Capital and installation	
Wind generator	0
Internal electrical installations	50
Electrical substation and power lines	0
Construction	50
Additional expenses	50
Operations and maintenance	
Head office	100
Maintenance	100

Table C-17: 150MW solar farm

Expenditure category	National expenditure factor (%)
Development	
Head office	50
Systems design	50
Permitting	50
Capital and installation	
Modules	0
Inverters	0
Mechanical installation	90
Electrical installation	90
Inspection	100
Racking and mounting	0
Cabling / wiring	0
Safety and security	100
Monitoring and control	100
Operations and maintenance	
Operations and maintenance	90

Table C-18: 500MW data centre

Expenditure category	National expenditure factor (%)
Capital and construction	
Powered shell	100
Electrical systems	0
HVAC, mechanical, cooling	10
Fire suppression	10
Building fit-out	75
Operations	
Operations	100

Table C-19: 100MW pharmaceutical manufacturing facility

Expenditure category	National expenditure factor (%)
Construction	100
Operations	100

Table C-20: 20MW green hydrogen facility

Expenditure category	National expenditure factor (%)
CAPEX	
Electrolyser stack – labour, energy	100
Electrolyser stack - materials	0
Electrolyser stack – other	10
BoP – power supply unit	0
BoP - other	10
Engineering, procurement, construction, and installation	50
OPEX	
Stake replacement	10
Other	100

C.4 APPENDIX C4. DETAILED IMPACT MODELLING METHODOLOGY

C.4.1 METHODOLOGY: DEVELOPMENT AND CONSTRUCTION

All prices and impacts are shown in 2023 prices. To calculate the direct and indirect impacts, the metrics provided in the CSO Input-Output tables are used.

The DEVEX and CAPEX described in the three scenarios are organised by category and assigned the most appropriate CPA code. Relevant Type I metrics are then applied to the expenditure categories; these metrics provide estimates for imports, product taxes (less subsidies), employee compensation, net operating surplus, consumption of fixed capital, and taxes (less subsidies) on production.

GVA is calculated as the sum of employee compensation, net operating surplus, consumption of fixed capital, and taxes (less subsidies) on production. 'Household earnings' is employee compensation less taxes on employment and other employment costs. The ratio of household earnings to employment costs by sector was calculated using labour market data provided by CSO, which was used to calculate household earnings impacts.

Employment (in terms of FTEs) has been calculated by dividing the employee compensation by the estimated employee costs per FTE. The employee costs per FTE was calculated by Glic using labour market data by CPA code provided by CSO.

Additionality is then considered to calculate the net direct and indirect impacts.

C.4.2 ADDITIONALITY

In accordance with the additionality assessment, a national expenditure factor has been assessed for all DEVEX and CAPEX categories. The national expenditure factors for each expenditure category are listed in Appendix C3. National Expenditure Factors.

National expenditure factors for the DEVEX and CAPEX associated with the offshore and onshore wind farms and the offshore and onshore substations are based on a report published by BVG titled South coast Designated Maritime Area Plan: Regional economic impact of offshore wind development [183] including general assessments of national content for offshore wind farms and associated onshore infrastructure.

There is not the same level of secondary research available on the national content for solar farms. As such, the vast majority of capital equipment has been assessed to come from sources from outside Ireland, with only elements of installation and development expenditure expected to occur within Ireland. Following this rationale, it is assessed that:

- DEVEX will have medium national content
- Modules will have zero national content
- Inverters will have zero national content
- Mechanical installation will have very high national content
- Electrical installation will have very high national content
- Inspection will have full national content

- Racking and mounting will have zero national content
- Cabling / wiring will have zero national content
- Safety and security will have full national content
- Monitoring and control will have full national content.

The construction and development of the data centre will likely require import of equipment required to be installed within the centre. National content is assessed to be low.

The CAPEX associated with the pharmaceutical manufacturing facility can be spilt into two parts, the construction activities associated with the building and the equipment installed within the facility. The construction and installation activities are assessed to have a high national content as relevant skills are available within the country.

It is assessed that the vast majority of equipment and technology will be imported and as such there is limited national content. Due to the variety of activities that can occur within a pharmaceutical manufacturing facility, estimating equipment costs is difficult without further information on the types of activities that may occur. As such, the expenditure on equipment is not considered within this assessment; on this basis there is zero national content.

The CAPEX and DEVEX associated with the hydrogen production facility are split into the electrolyser stack; balance of plant; and engineering, procurement, construction and installation (EPC&I).

The electrolyser stack is further spilt into labour/energy, materials, and other. It is assessed that:

- Labour/energy will have full national content
- Materials will have zero national content
- Other will have very low national content.

The balance of plant is spilt into the power supply unit and other. It is assessed that:

- The power supply unit will have zero national content
- Other will have very low national content
- EPC&I will have medium national content.

C.4.3 METHODOLOGY: OPERATIONS

All prices and impacts are calculated in 2023 prices. To calculate the direct and indirect impacts, the metrics provided in the CSO Input-Output tables and Glic economic modelling are used.

To assess the indirect impacts associated with the operation of the 1GW fixed offshore wind farm and associated substations, the 150MW onshore wind farm and associate substations, the 150MW solar farm, and green hydrogen production facility, the OPEX described in the three scenarios are organised by category and assigned their most appropriate CPA code[31]. Type I metrics[32] are then applied to the

[31] See appendix C2 for CPA code assignment.
[32] Type I metrics are inclusive of direct and indirect effects, however, in this instance, the multiplier is applied to supply chain expenditure and so relative to the energy generation facilities, represent only the indirect effects.

expenditure categories according to their CPA code. As with the construction impacts, GVA, household earnings, and employment are calculated.

Direct GVA is calculated by subtracting the total expenditure on goods and services (OPEX) from the total output in basic prices. Total output in basic prices is estimated by multiplying the total output capacity in MW by the capacity load and the basic price of electricity per MW. The basic price of electricity per MW is assumed for the purposes of this assessment is the average band IG business electricity prices [184].

It should be noted that for the hydrogen production facility specifically, the cost of electricity is not included in the calculation for indirect impacts. This is to avoid double counting, since the electricity will come from other developments within the GEPs.

It is assumed that all employment is included in OPEX and there will be no direct employment or employee compensation. Thus, there are also no direct household earnings.

To assess the impacts associated with the data centre and pharmaceutical manufacturing facility the type I multipliers are applied to the estimated output in basic prices of the data centre and pharmaceutical manufacturing facility to obtain the direct and indirect impacts. GVA, household earnings, and employment is calculated in the same way as with the construction methodology.

Detailed expenditure analysis and an independent assessment of direct and indirect impacts is not possible at this stage as specific information is not available.

Electricity for these developments will come generation activities within the GEPs. Supply chain expenditure on electricity and those associated impacts are already built into the type I multipliers.

To avoid double counting the indirect impacts, the expenditure on electricity is estimated by multiplying the total power capacity in MW by the power utilisation rate and the basic price of electricity per MW. This is then multiplied by the appropriate type I multiplier to ascertain the impacts associated with expenditure and subtracted from the total impacts.

It should be noted that this assessment does not consider whether the tenant is willing to pay the costs of the electricity produced at the site and what the cost to subsidise might be.

Additionality is then considered in order to calculate the net direct and indirect impacts.

C.4.4 ADDITIONALITY

All prices and impacts are calculated in 2023 prices. To calculate the direct and indirect impacts, the metrics provided in the CSO Input-Output tables and Glic economic modelling are used.

To assess the indirect impacts associated with the operation of the 1GW fixed offshore wind farm and associated substations, the 150MW onshore wind farm and associate substations, the 150MW solar farm, and green hydrogen production facility, the OPEX described in the three scenarios are organised by category and assigned their most appropriate CPA code[33]. Type I metrics[34] are then applied to the expenditure categories according to their CPA code. As with the construction impacts, GVA, household earnings, and employment are calculated.

Direct GVA is calculated by subtracting the total expenditure on goods and services (OPEX) from the total output in basic prices. Total output in basic prices is estimated by multiplying the total output capacity in MW by the capacity load and the basic price of electricity per MW. The basic price of electricity per MW is assumed for the purposes of this assessment is the average band IG business electricity prices [184].

It should be noted that for the hydrogen production facility specifically, the cost of electricity is not included in the calculation for indirect impacts. This is to avoid double counting, since the electricity will come from other developments within the GEPs.

It is assumed that all employment is included in OPEX and there will be no direct employment or employee compensation. Thus, there are also no direct household earnings.

To assess the impacts associated with the data centre and pharmaceutical manufacturing facility the type I multipliers are applied to the estimated output in basic prices of the data centre and pharmaceutical manufacturing facility to obtain the direct and indirect impacts. GVA, household earnings, and employment is calculated in the same way as with the construction methodology.

Detailed expenditure analysis and an independent assessment of direct and indirect impacts is not possible at this stage as specific information is not available.

Electricity for these developments will come generation activities within the GEPs. Supply chain expenditure on electricity and those associated impacts are already built into the type I multipliers.

To avoid double counting the indirect impacts, the expenditure on electricity is estimated by multiplying the total power capacity in MW by the power utilisation rate and the basic price of electricity per MW. This is then multiplied by the appropriate type I multiplier to ascertain the impacts associated with expenditure and subtracted from the total impacts.

It should be noted that this assessment does not consider whether the tenant is willing to pay the costs of the electricity produced at the site and what the cost to subsidise might be.

Additionality is then considered in order to calculate the net direct and indirect impacts.

[33] See appendix C2 for CPA code assignment.
[34] Type I metrics are inclusive of direct and indirect effects, however, in this instance, the multiplier is applied to supply chain expenditure and so relative to the energy generation facilities, represent only the indirect effects.

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