ESB NETWORKS

2030 Power System Requirements

NATIONAL NETWORK, LOCAL CONNECTIONS PROGRAMME

DOC-230921-GYN

OPENING STATEMENT

The decarbonisation of Irish society relies on fundamental changes to how energy is generated and consumed. To enable these changes at the right pace and the right price, we will rely on the electricity network, and we need to make the connection between how renewable energy is generated, and how we use or store it. Every Irish home, farm, community, and business is being called on to play a part. The National Network, Local Connections Programme has been established to work with, and for, customers to make this possible.

We are entering a period of rapid change and uncertainty. Over the coming years, technologies will change as will the energy needs of Irish homes, farms and communities. We will need to be able to adapt to meet changing needs and emerging challenges. In this document we have sought to develop a proposed plan that accounts for uncertainty and delivers that adaptability.

For example:

1. **Iterative piloting and development of processes so that we can learn what delivers the response we need to ensure we maintain a reliable network for our customers and what needs to be done differently as we prepare for a national rollout.**
2. **Target our capital investment in areas where it delivers the best value for our customers. This could be in areas where, for example, there are less flexible resources.**
3. **Extensive commitment of resources to communications and collaboration, working with partners and customers to understand their needs and how and why they change, so we can better respond and adapt to these needs.**

Over the life of this programme we will face uncertainties and risks. If we proceed too quickly, we increase the risk that customers will not be ready, or technologies will not be as mature. But if we do not proceed quickly enough, there is a risk that the solutions will not be in place when they need to be. Without taking the initial steps now, there is a risk that we and our partners could not replicate solutions that we pilot or commence a national rollout until later in the decade.

We will need to commit people and capital to deliver this programme, and we are reaching a critical decision point regarding the level of resources to commit. ESB Networks serves, and is funded by, all electricity customers. All our customers will share in the benefit, but they will also share in the costs and the risk if we act too slowly or too soon. As such, we want to give all customers an opportunity to consult.

1. **Do you think we should take a more measured pace and begin to scale closer to 2030, or commit resources needed to begin build towards a national rollout commencing in 2024 / 2025?**
2. **There are trade offs between different developments in this plan that we could prioritise. What do you think we should prioritise, and how will this affect your business.**

We need your input to determine the path forward. So please have your say!

CONTENTS

1

Have Your Say

1 NATIONAL NETWORK, LOCAL CONNECTIONS – HAVE YOUR SAY!

This document is the 2030 Power System Requirements proposal. In this document we set out:

1. **Insights from the initial analysis, in advance of completing the full body of analysis. These indicate when, where and how much flexibility will be needed over the coming years.**
2. **The approach taken, the sources of data and the partners we are working with.**
3. **How we are proposing to apply the results.**

It is critical that we implement solutions that optimally meet the wishes and needs of the customers and industry participants of Ireland. In developing these proposals, we have taken time to seek and utilise stakeholder input from round tables and focus groups, as well as to research and utilise exemplar international experiences. This has enabled us to develop the proposed approaches within this document. While we have confidence that these can meet the overall programme objectives, we are open to change and, as a result, we have prioritised this transparent and consultative approach. There were several key dimensions on which we based this document and it is important to us that we develop an understanding of your perspectives, objectives and concerns across each of those. It may be useful to consider the below questions while reading this document. Please note when responding to this document, it is not necessary to respond to each of the below questions; responding to a specific question or a general response is welcomed and appreciated.

SELECTION CRITERIA
Do you agree with our modelling approach? If not, why not? What other approach would you propose?
Do you think that these analyses should be used to inform pilot and rollout planning?

TARGET LOCATIONS
Based on the initial results, have you ideas on where we should be targeting the rollout of flexibility?

CUSTOMERS PARTICIPATION
What do you think these results mean in terms of the need for customers to participate?
What do they mean for the number of customers who could or should participate?

TYPES OF CUSTOMERS PARTICIPATING
What do you think these results mean in terms of the kinds of customer or system user who could or should participate?

FOUNDATIONAL TECHNOLOGY
Based on this information, do you think that we need to roll out foundational system management technology sooner, later or as proposed in these plans?

PILOTING AND ROLLOUTS
Based on this information, how soon do you think that we need to act?

1 NATIONAL NETWORK, LOCAL CONNECTIONS – HAVE YOUR SAY!

It is also important to us that we optimise the overall value of the programme across our stakeholders.
As such, we are inviting perspectives on additional considerations that we could fold into our approach:

LEARNING OBJECTIVES
The 2030 Power System Requirements provides a range of insights - which do you find most useful? Are there areas where you would like to see further detail?

CUSTOMER & POLICY OBJECTIVES
How best can we use these results (and the detailed results to come) to support national policy objectives?

CUSTOMER EDUCATION AND AWARENESS
How could this information be used to further support customers?

SUPPLY CHAIN
Are there opportunities for other parts of the supply chain to learn or use the information in this document?

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Glossary

2 GLOSSARY

TERM	DEFINITION
ADMD	After Diversity Maximum Demand
BER	Building Energy Rating
CSO	Central Statistics Office
DRIVE	Distribution Resource Integration and Value Estimate
DSO	Distribution System Operator
EPRI	Electric Power Research Institute
EV	Electric Vehicle
GVA	Giga VoltAmperes
GVAr	Giga Volt Ampere of reactive power
GW	GigaWatts
HP	Heat Pump
kVA	kilo VoltAmperes
kVAr	kilo Volt Ampere of reactive power
kW	kiloWatts
LARES	Local Authority Renewable Energy Strategy
LCT	Low Carbon Technology
MEC	Maximum Export Capacity
MIC	Maximum Import Capacity
MVA	Mega VoltAmperes
MVAr	Mega Volt Ampere of reactive power
MW	MegaWatts
PV	Photo Voltaic
RES	Renewable Energy Source
RESS	Renewable Electricity Support Scheme
SEAI	Sustainable Energy Authority of Ireland
WEI	Wind Energy Ireland

3

Background: The Challenge

3 BACKGROUND: THE CHALLENGE

With the release of the Climate Action Plan 2019, the Government set out ambitious targets for low carbon technologies for 2030 to aid in the reduction of greenhouse gas emissions.

1. **936,000 electric vehicles (i.e. one home in two has an electric car).**
2. **600,000 heat pumps (i.e. one home in four has electric heating).**
3. **up to 80% (as per the national development plan[1]) of electricity to come from renewable energy sources.**

These targets represent a significant change in how we use electricity at the local level in Ireland. For example, a typical domestic customer has a peak demand of 12kW. When we take account of customers availing of this peak at different times, an average peak/customer demand across a group of customers (for example in a housing estate) has been circa 2.5kW per household (this is called After Diversity Maximum Demand). While this figure has been robust in allowing us to design networks in the past, for new local networks, we are now designing for a higher value, 5.5kW, because domestic low carbon technologies have far higher loads. Standard slow charging for an electric car is 7kW alone, and a heat pump runs at a diversified load of 1.5kW, but can "boost" to 3kW or higher. However, changing our future design standards does not address the bigger challenge: how do we make sure that our existing local connections, that already reach every Irish home and business, can support an electric car at one home in two and electric heating at one home in four, as set out in our climate action targets?

Additionally, meeting a 80% renewable electricity target will mean that over the coming 10 years, we need to at least double the amount of wind and solar generation which is distributed across the Irish system, much of this connected locally to Irish communities nationwide. Based on stakeholder input, it is also expected that a significant portion (over 100,000) of our existing customers will likely seek to connect micro or mini renewable generation on their roofs. And it will mean creating a central role for energy communities and active energy citizens on the Irish electricity system[2].

Given this backdrop of the Clean Energy Package; the Climate Action Plan; and ESB Networks' Strategy, we need to develop a technical strategy to address this. The objective of the 2030 Power System Requirement studies is to identify customers' network needs as these new technologies connect, down to a local level; the potential of existing (wires) to meet these needs; in addition what new ("flexible") ways are available to meet these needs, and to do this in a way that continues to ensure a safe and secure distribution system.

[1] https://assets.gov.ie/200358/a36dd274-736c-4d04-8879-b158e8b95029.pdf

[2] Electricity Directive (EU) 2019/944 defines 'active customers' and 'citizen energy communities' whereas Renewables Directive (EU) 2018/2001 defines 'renewable self-consumers' and 'renewable energy communities.' CRU published 'Calls for Evidence on Active Consumers and Energy Communities' in August 2020. These papers consolidated the topics of 'active customers' and 'renewable self-consumers' into 'active consumers'. The topics of 'citizen energy communities' and 'renewable energy communities' were consolidated into 'energy communities.

3.1 METHODOLOGY

LOAD DATABASE

The foundation of the 2030 Power System Requirement Studies is a national network and load database. This maps the forecasted load growth and low carbon technology uptake from 2019 up to 2030. It is a detailed, bottom up model that builds upwards from over 200,000 MV/LV transformers, all the way to the high voltage (HV) system.

The database was developed based on network models and internal estimates of forecasted organic load growth, and then extended to account for industry data shared by our partners in this study.

Finally, statistical profiles for the impact of heat pumps and electric vehicles were applied to the volumes of technologies in the scenarios. These profiles reflect the fact that, for example, not all households will charge their electric vehicle at the same time or at peak load[3]. The diversity profiles used are included in Appendix One for reference.

SUSTAINABLE ENERGY AUTHORITY OF IRELAND (SEAI)

The SEAI developed and shared a range of anonymised data regarding the spatial distribution of different indicators of current or expected technology uptake, mapped to the CSO small areas. This included BER information which included information on heat sources, insulation levels and microgeneration installations for houses across the country, and microgen forecasts. Anonymised information was also shared of EV sales and home charger grants.

Access was also given to the LARES tool which helps to layer resources (wind speed & solar irradiation) along with planning requirements. This information was used to develop the various scenarios of low carbon technology uptakes.

Finally, the SEAI provided extensive advice on how these indicators and data should be used to develop a range of projected scenarios for the future uptake and spatial distribution of electric vehicles, heat pumps and microgenerators across the country.

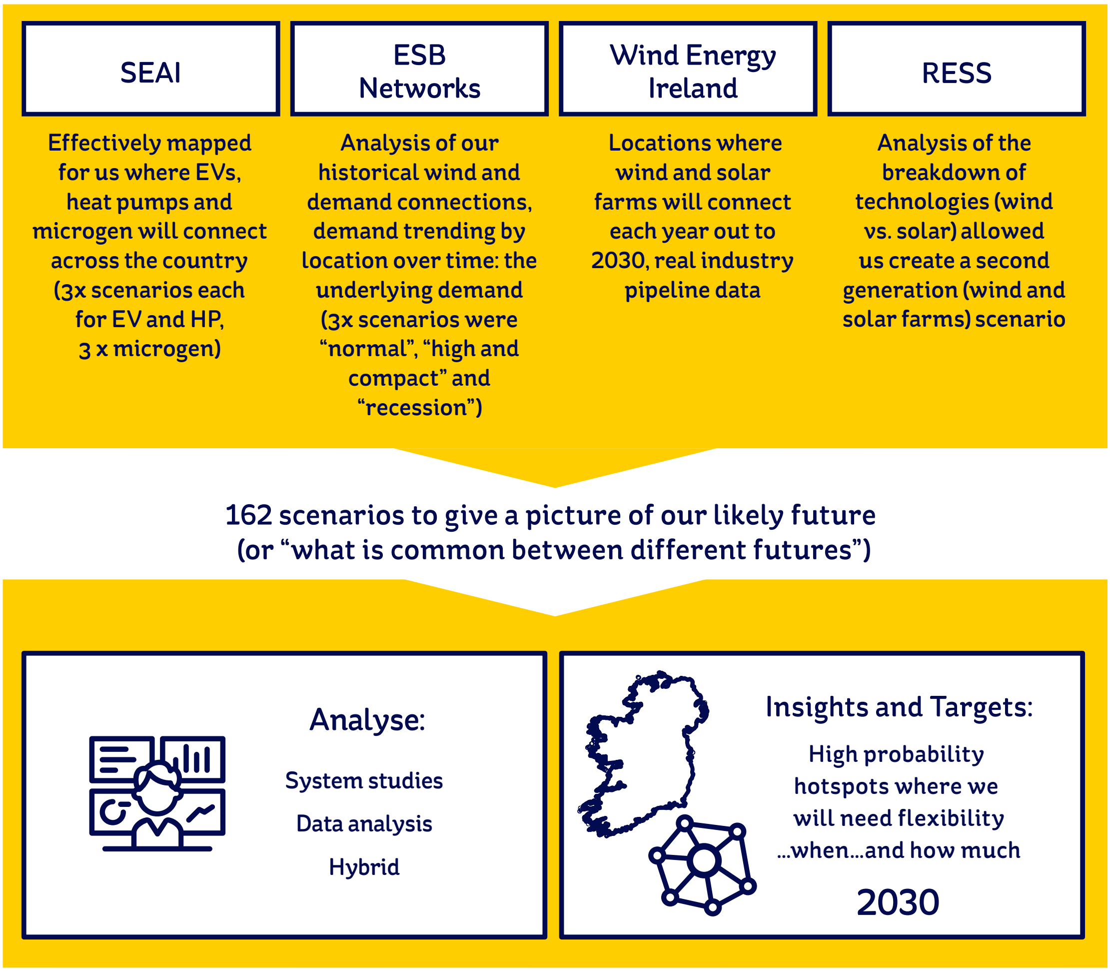
WIND ENERGY IRELAND (WEI)

WEI shared the results of their members' projects pipeline survey aggregated to 110kV node. This gave details on the amount of MW for each node and the forecasted year of connection. This data was used to help develop different scenarios of generation connections out to 2030.

The data was coupled with ESB Networks' analysis of historic renewable generator connections and applications, to develop representative distributions for the capacity of new wind and solar generations by installation. It was also coupled with the results of the RESS-1 auction, to create a second scenario for the compositions of technology in the pipeline. This data was combined with the load database as inputs to our studies.

[3]Typically system peak load occurs between 5-7pm on a weekday in Winter. However, this does not necessarily coincide with the local network peak.

3.1 METHODOLOGY



The result of this data sharing is a load database which maps new electric vehicles; heat pumps and microgeneration[4] to specific MV/LV substations across the country. The database also maps commercially connected generation to substations; 38kV/MV and 110kV/MV and at higher voltages. The adoption of a small number of scenarios for each technology, and the combination of these scenarios, allows us to create a large volume of snapshots which can be assessed, to get a clear understanding of likely, best case and worst case conditions.

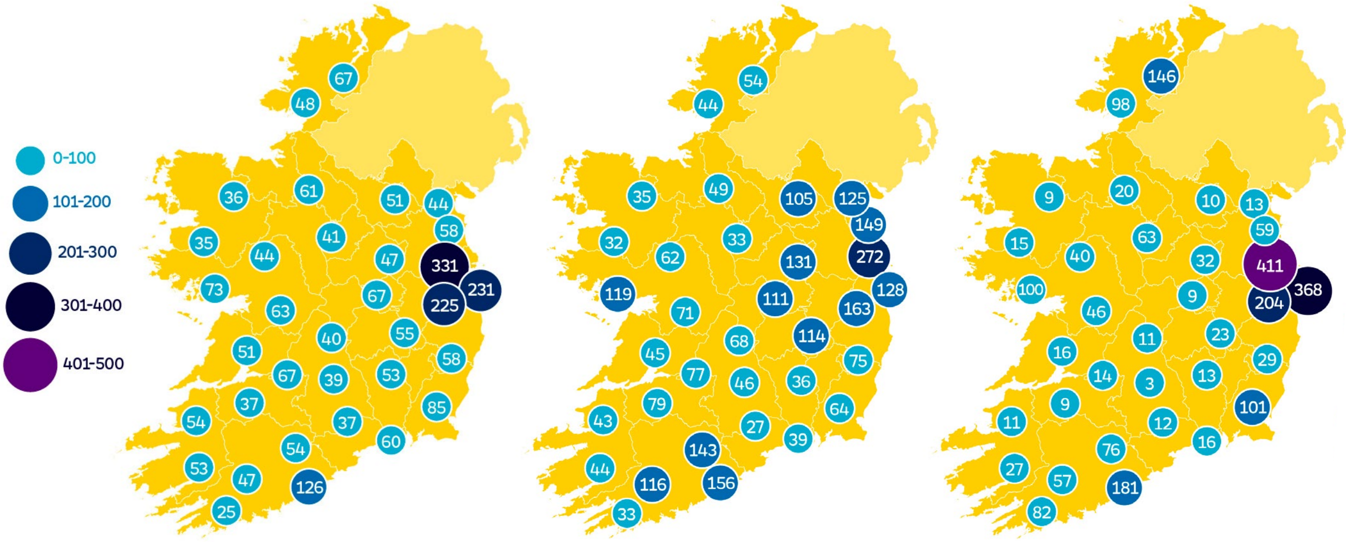
This level of detail allows for a detailed and robust assessment of the existing ability of the distribution system to support these new demands, and the technical challenges that need to be addressed to do so. This assessment is done for MV circuits, through 110kV/MV and 38kV/MV substations and onto the 38kV (and in some cases 110kV distribution, e.g. within Dublin) systems and 110kV/38kV substations. The study involves assessments on a year by year basis. The load database will also be reconfigurable on an annual basis as the load inevitably adopts a different pattern of development to that forecasted.

The various scenarios for which the database was developed are described in Appendix One and set out in graphical form on the subsequent pages.

[4] Assumed to be rooftop PV.

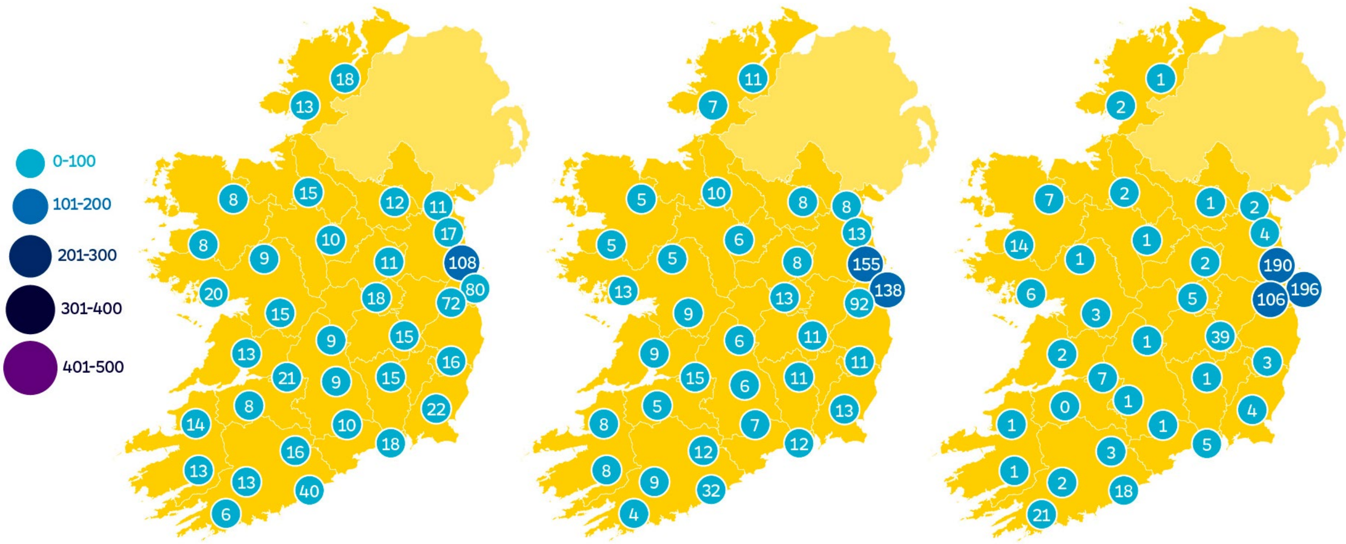
3.1 METHODOLOGY

Electric Vehicles (MW)



2030 SCENARIO 1 2030 SCENARIO 2 2030 SCENARIO 3

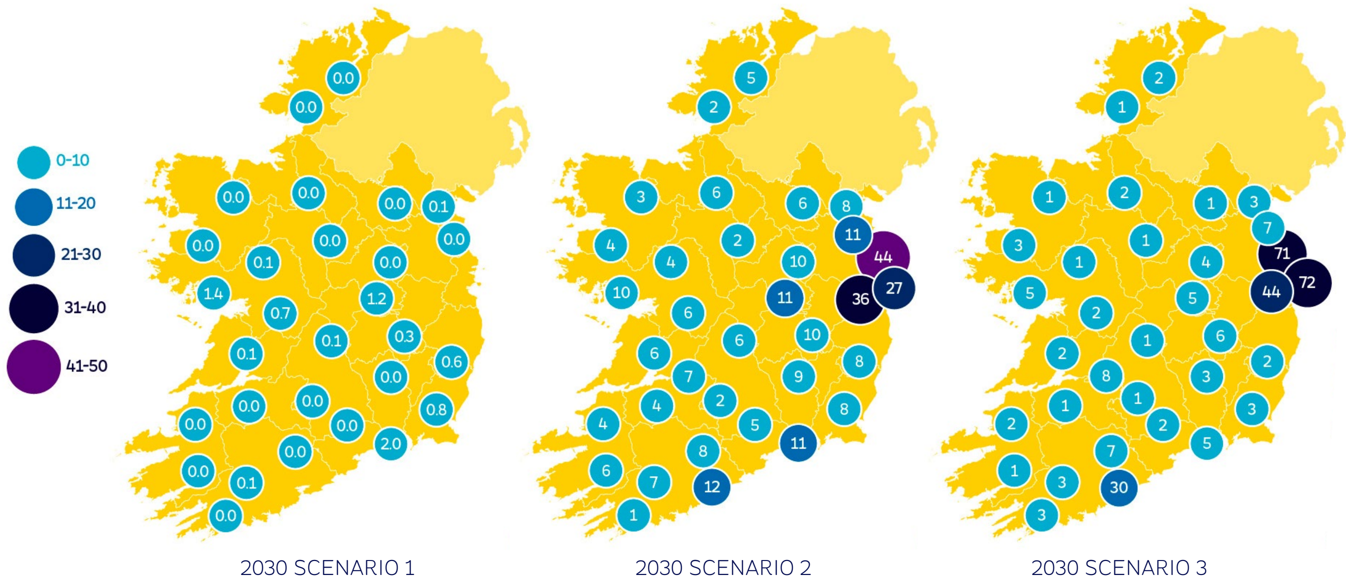
Heat Pumps (MW)



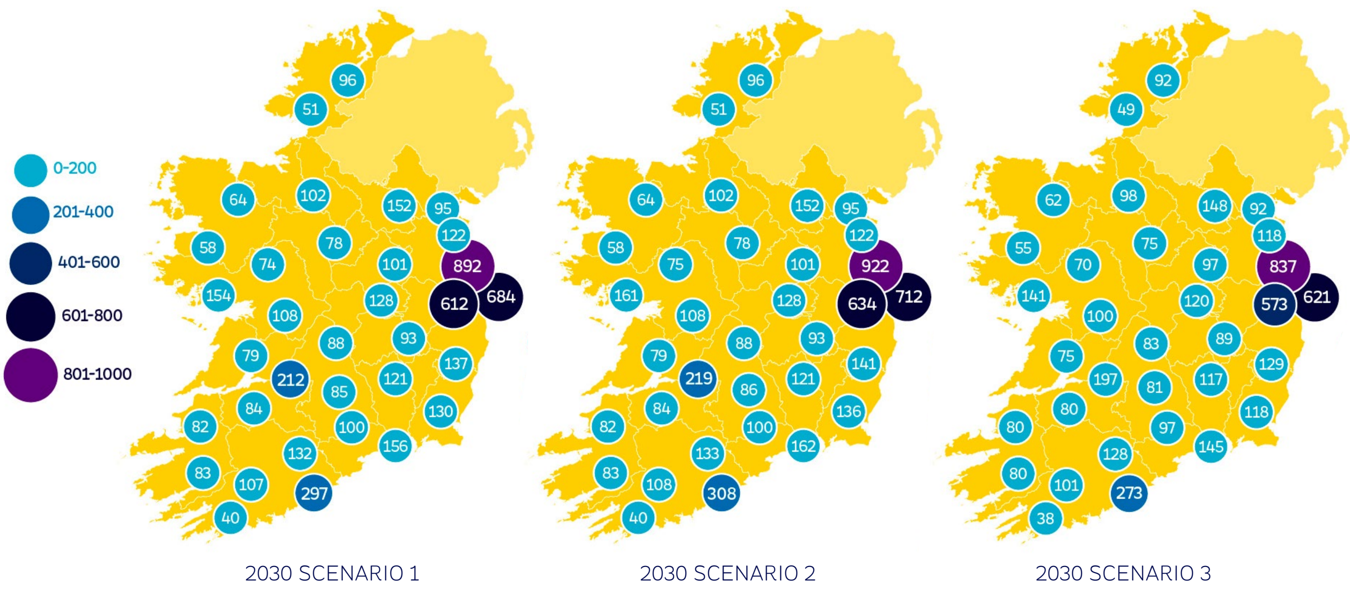
2030 SCENARIO 1 2030 SCENARIO 2 2030 SCENARIO 3

3.1 METHODOLOGY

Micro Generation (MW)

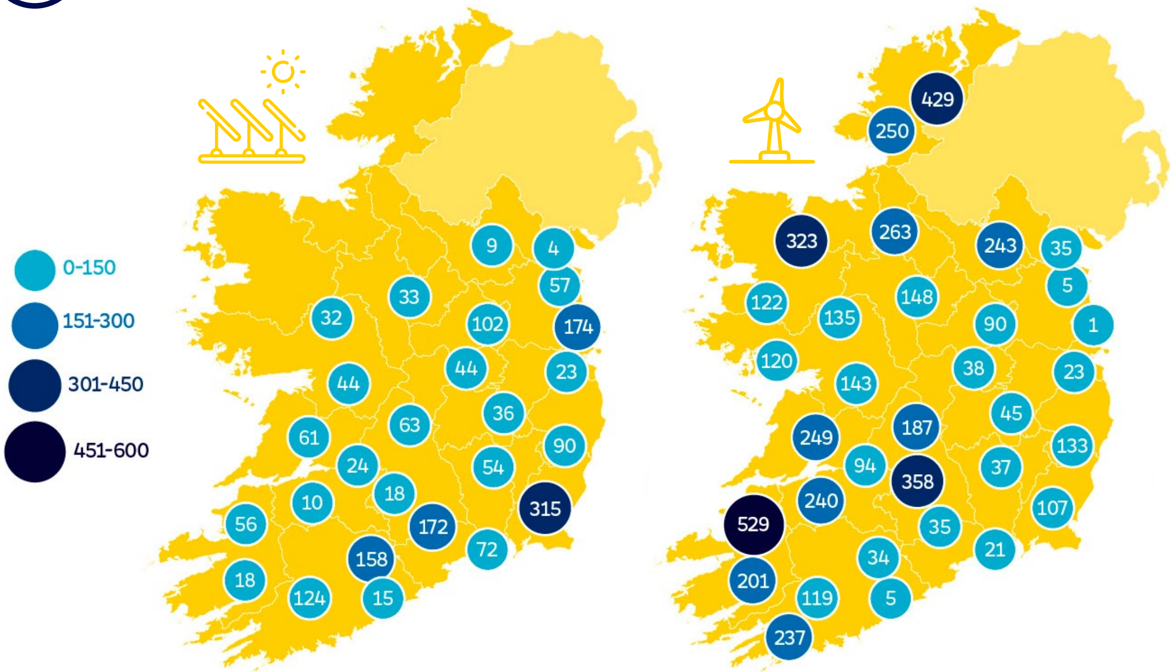


Underlying Demand (MW)



3.1 METHODOLOGY

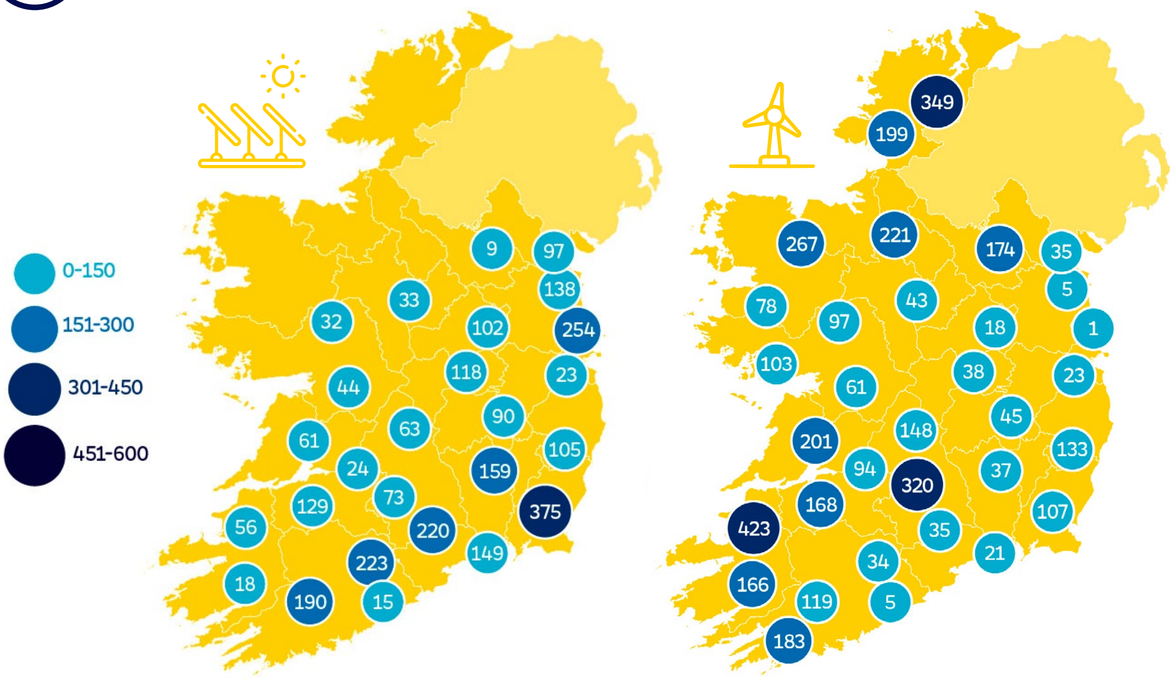
Larger Generation Scenario 1 (MW)



2030 SOLAR ONLY SCENARIO 1

2030 WIND ONLY SCENARIO 1

Larger Generation Scenario 2 (MW)



2030 SOLAR ONLY SCENARIO 2

2030 WIND ONLY SCENARIO 2

3.1 METHODOLOGY

LOAD FLOW STUDIES

The main source of detailed information for the 2030 Power System Requirements is a suite of load flow studies for the distribution system - at MV, 38kV and 110kV (where relevant). The output of these studies is identification of issues to be addressed due to thermal and voltage constraints on the network. These studies are underway developing a snapshot of capacity at all voltage levels across the forthcoming decade, and are expected to be established by end 2021. We will publish the 2030 Power System Requirements at that time.

- Demand Studies are being undertaken at peak loading, under normal and standby feeding arrangements. This provides information on available capacity both with the new low carbon technology (LCT)[5] load and without (i.e. with organic growth only). Studies look at the mix of scenarios which gives the highest level of load in a given area. The studies also look at the time-varying profile of load (over 8,760 hours of the year in 30 minute intervals) to assess the possible duration of constraints and identify time frames for load shifting.
- Generation Studies are assessing the impact and needs of generation, again under normal and standby feeding arrangements at minimum loading, for both generation scenarios (high wind and high solar).

DATA ANALYSIS

In addition to the load flow studies being undertaken, the load database is also being assessed by data scientists working for ESB Networks. Using data science techniques, it has been possible to develop a high level picture of the available capacity on the distribution system; albeit currently this assessment is focussed on thermal constraints only. Much of the information presented later in this document is based on the data analytics work undertaken to date.

INTERNATIONAL INPUT

EPRI, in the United States, have also been commissioned to undertake MV studies in a rural part of Ireland using their DRIVE tool. This tool uses a combination of load flow studies and data analytics to establish the 'hosting capacity' on an MV circuit. By comparing this figure with the expected load on a circuit (based on the load database), it is possible to determine if the circuit capacity is sufficient for the load which may develop. Once final results are available, ESB will consider the usefulness of this tool compared to other methods for long term needs.

[5]Low carbon technologies include electric vehicles and heat pumps and are also taken to include plant such as rooftop solar.

4

Dealing with Demand

4 DEALING WITH DEMAND

As noted above, the Climate Action Plan sets targets to reduce Ireland's carbon footprint through the electrification of heat and transport, powering this transformation largely through renewable electricity.

4.1 DEMAND DEVELOPMENT

There will be a rapid increase from the low existing (2020) levels of electric vehicles, heat pumps and microgeneration installations to the expected 2030 levels listed below:

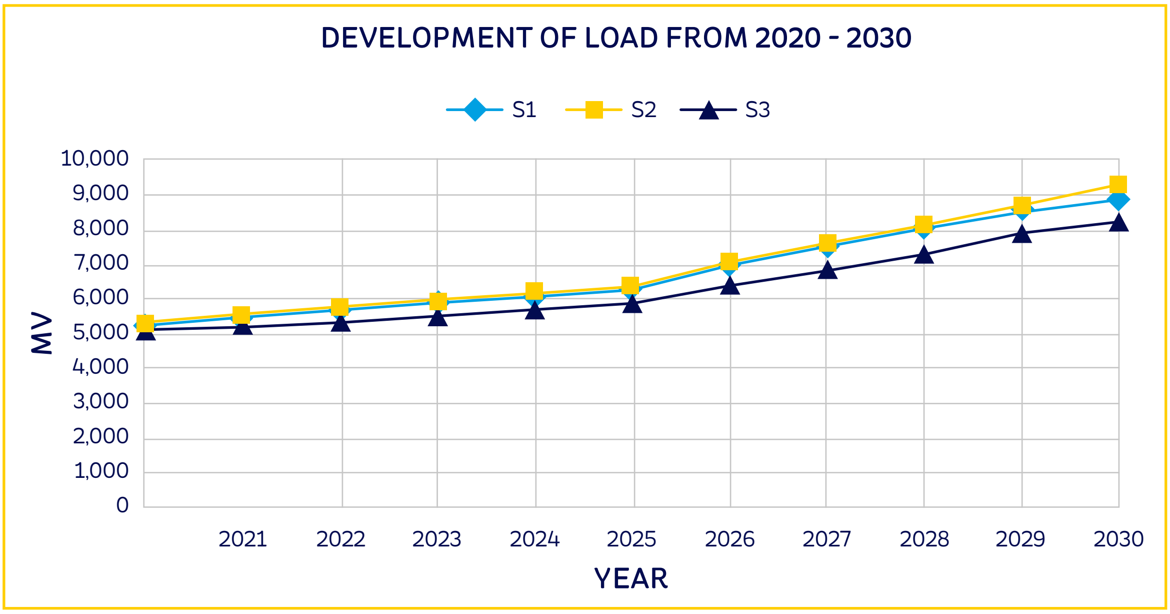
1. **936,000 electric vehicles.**
2. **600,000 heat pumps.**
3. **120,000 microgeneration installations.**

As can been seen in Figure 1, the peak load on the distribution system is forecasted to increase dramatically over the next 10 years, especially in the years after 2025. This is due in large part to the introduction of low carbon technology load – such as electric vehicles and heat pumps – at c. 36% of peak load by 2030.

The graph below[6] shows the forecasted development of load to 2030 for 3 different scenarios. These scenarios combine different scenarios for each of the LCT technologies and are described as follows (reference Appendix 1 also):

1. **Scenario 1 (S1) EV1, HP1, WP1**
2. **Scenario 2 (S2) EV2, HP2, WP2**
3. **Scenario 3 (S3) EV3, HP3, WP3**

FIGURE 1 **LOAD GROWTH 2020 - 2030**



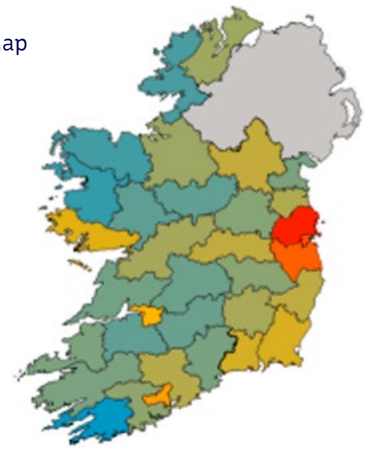
[6]Load developed based on peak loading on MV circuits. This is corrected to reflect peak system load, but on occasion, the timing of load on circuits is not co-incident. As a result, this load may not be quite aligned with overall system peak loads.

4 DEALING WITH DEMAND

TABLE 1 SCENARIO1 LOAD GROWTH

SCENARIO 1 EV1, HP1, WP1	**UNMANAGED PEAK LOADING** (GW)		
	2020	**2025**	**2030**
Total Load at peak	5.3 GW	6.3 GW	8.8 GW
Base Load (before LCT)	5 GW	5.3 GW	5.6 GW
Average % of load due to EVs	3%	9%	28%
Average % of load due to HPs	2%	6%	8%

2030
Year Displayed on Map



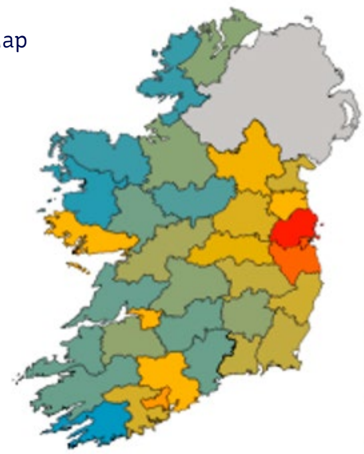
Key Reference
0 GW
0.3 GW
1.5 GW

FIGURE 2
2030 PEAK LOAD DISTRIBUTION ACROSS THE COUNTRY - SCENARIO 1

TABLE 2 SCENARIO2 LOAD GROWTH

SCENARIO 2 EV2, HP2, WP2	**UNMANAGED PEAK LOADING** (GW)		
	2020	**2025**	**2030**
Total Load at peak	5.3 GW	6.4 GW	9.2 GW
Base Load (before LCT)	5 GW	5.4 GW	5.7 GW
Average % of load due to EVs	3%	9%	31%
Average % of load due to HPs	2%	6%	7%

2030
Year Displayed on Map



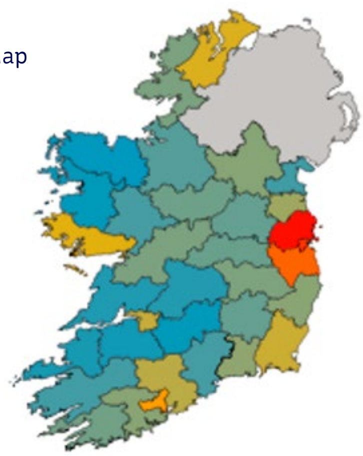
Key Reference
0 GW
0.3 GW
1.5 GW

FIGURE 3
2030 PEAK LOAD DISTRIBUTION ACROSS THE COUNTRY - SCENARIO 2

TABLE 3 SCENARIO3 LOAD GROWTH

SCENARIO 3 EV3, HP3, WP3	**UNMANAGED PEAK LOADING** (GW)		
	2020	**2025**	**2030**
Total Load at peak	5.1 GW	5.9 GW	8.2 GW
Base Load (before LCT)	4.9 GW	5 GW	5.3 GW
Average % of load due to EVs	2%	9%	28%
Average % of load due to HPs	1%	6%	8%

2030
Year Displayed on Map



Key Reference
0 GW
0.3 GW
1.5 GW

FIGURE 4
2030 PEAK LOAD DISTRIBUTION ACROSS THE COUNTRY - SCENARIO 2

4 DEALING WITH DEMAND

TABLE 4 **AVERAGE GROWTH OVER THE 3 SCENARIOS**

AVERAGE S1, S2, S3	**UNMANAGED PEAK LOADING** (GW)		
	2020	**2025**	**2030**
Total Load at peak	5.2 GW	6.2 GW	8.8 GW
Base Load (before LCT)	5 GW	5.2 GW	5.5 GW
Average % of load due to EVs	3%	9%	29%
Average % of load due to HPs	2%	7%	8%

4.2 MITIGATION

While the demand growth outlined above looks (and indeed is) significant, the picture is not as challenging as it may appear on first glance.

Firstly, let's take electric vehicles. The figures above assume that customers look to charge their electric vehicles at peak time. While it is certainly possible that this could happen, it is also feasible that this load would be more flexible and given the correct market and technical signals, could be encouraged to charge at times which are much more favourable to the network conditions. Furthermore, this load – if charging at times when renewable generation is high – would greatly decrease the need to reduce local generation. Given the nature of the load, it is new and behavioural patterns have not yet formed, it is very feasible to believe that this shift can be obtained.

In a similar fashion, the contribution of heat pump load to peak demand could be reduced, once again with the correct market and technical signals, if customers reduced the temperature requirement from their heat pumps for even a short while.

Organic load growth is aligned to historical figures. As customers engage more actively in energy efficiency, this growth may not materialise[7]. More significantly, however, for active customers, energy efficiency combined with a better awareness of when to use their energy (informed by DSO dashboards and information, and facilitated by market and technical signals) will have a more significant impact and allow customers to save money while assisting with the Climate Action Plan.

In addition to the potential to reduce the impact of electric vehicle charging and heat pumps on peak load, the increase of microgeneration (the impact of which is not considered in Tables 1-4 above) will undoubtedly assist in feeding some of the new demand.

[7]Growth in commercial load in urban centres, however, continues to be strong which may counteract any reduction in more residential or small commercial growth.

4 DEALING WITH DEMAND

4.3 EXAMPLE OF HOW WE WILL USE THIS INFORMATION

The sections above set out the level of load we expect to arise within the coming decade; the high level conclusions we have reached with regard to addressing these; and the role that we see flexible services playing.

Figures 5-8 below give an example of the manner in which we will use the data generated by detailed studies:

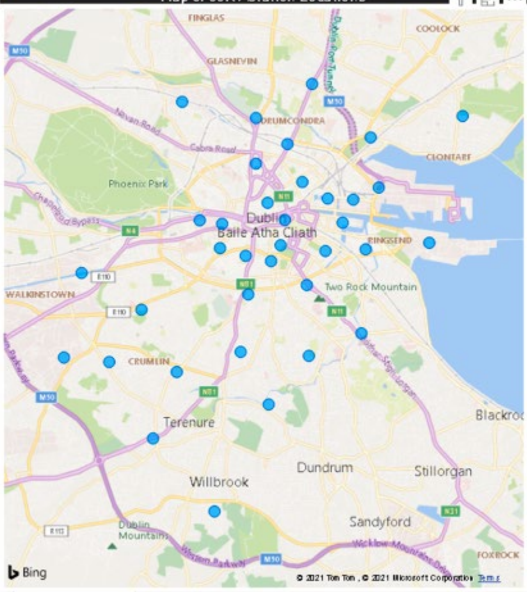
1. **To focus on where flexible services can be used; and often in a very local context where possible constraints are on lower voltage networks.**
2. **To share the data with customers and energy industry participants in order that they can plan to provide these services.**
3. **To establish how gradually the load will build up; evidence to date suggests that we have time to develop our response to this if we lay the groundwork now.**
4. **To identify where flexible solutions are optimum and where capital infrastructure will provide a better solution.**

4 DEALING WITH DEMAND

FIGURE 5 **POWER SYSTEM STUDIES FOR NORMAL FEEDING AND CONTINGENCY FEEDING**

Power System Studies for Normal Feeding and Contingency Feeding

Map of 38KV Station Locations



Substation	Baseload for Normal	Baseload+LCT for Normal	Baseload for Contingency	Baseload+LCT for Contingency
BALLYBODEN	0.00	19.09	3.73	19.09
BALLYMOUNT	0.00	0.00	3.61	3.70
BEDFORD ROW	1.56	8.77	7.90	9.31
CABRA	9.04	33.77	10.32	38.58
CAMDEN ROW	0.00	9.49	3.58	9.49
CLONTARF	0.00	23.47	3.12	23.47
CRUMLIN	0.83	9.23	4.26	20.82
DODDER ROAD	0.00	8.31	4.33	13.25
DONNYBROOK	0.00	4.28	0.50	7.07
DRUMCONDRA	0.00	12.00	2.18	16.48
EAST WALL ROAD	0.00	0.00	0.25	0.68
FAIRVIEW	0.00	24.08	3.17	24.08
GARVILLE AVENUE	0.00	15.85	1.96	15.85
GLASNEVIN	0.00	9.94	8.90	20.96
GLOUCESTER PLACE	0.00	21.15	4.25	21.15
GREENHILLS	0.00	12.68	4.32	14.03
HAROLDS CROSS	0.00	14.38	2.91	26.13
HEUSTON SQUARE	1.34	8.20	2.79	16.57
INCHICORE CENTRAL	1.51	21.27	4.91	25.11
KIMMAGE	0.00	26.11	6.56	27.74
KINGSBRIDGE	0.00	6.72	2.46	15.22
LEESON STREET	1.20	19.07	5.97	19.07
MARROWBONE LANE	0.00	9.50	0.94	13.86
MERRION SQUARE	0.00	0.00	1.54	3.29
MILLTOWN (DR)	0.00	25.74	3.55	25.74
MISERY HILL	0.00	0.88	2.05	3.71

Year: 2030

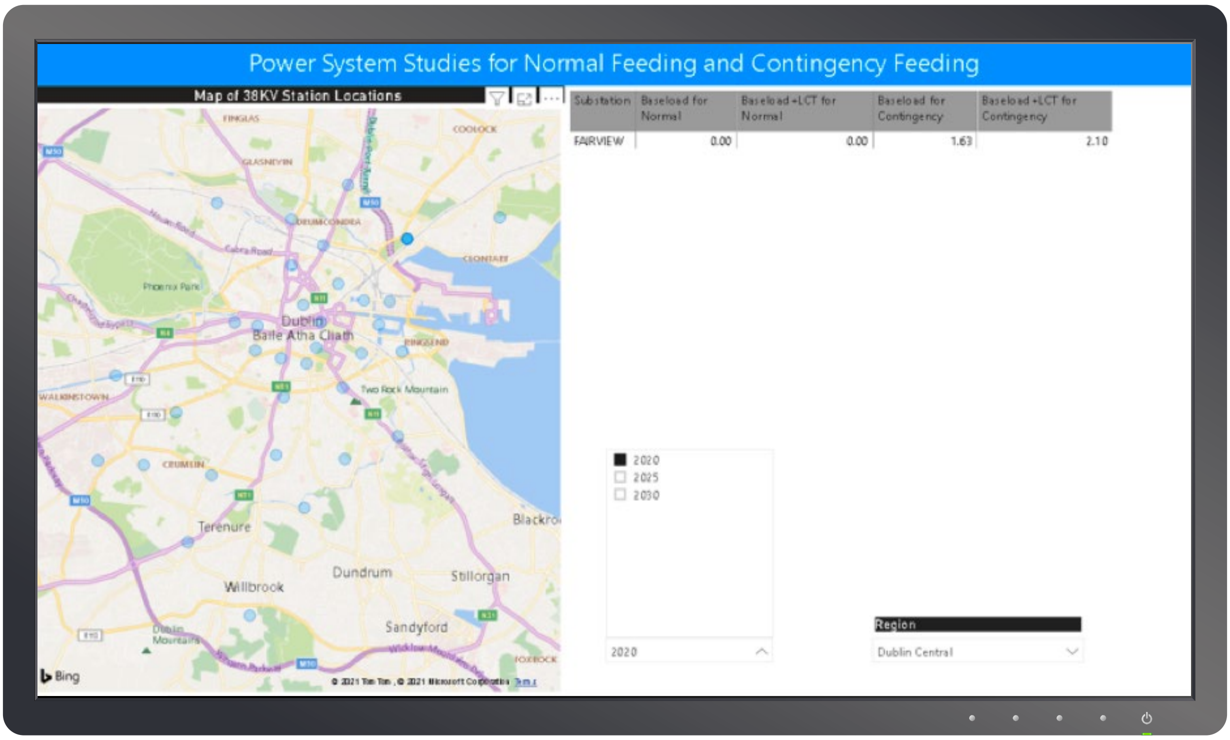
Region: Dublin Central

The numbers in the table above set out capacity shortfalls based on unmanaged load growth, if no additional infrastructure were built, at various stations in the Dublin area. The detail is as predicted for 2030, and the table identifies the flexible services that would be required (in MW) (columns from left to right) :

1. **Under normal feeding arrangements, with no electric vehicles or heat pumps in the area.**
2. **Under normal feeding arrangements, with electric vehicles and heat pumps distributed across the area based on a geospatial projection in line with 2030 targets.**
3. **Under standby feeding arrangements, with no electric vehicles or heat pumps in the area.**
4. **Under standby feeding arrangements, with electric vehicles and heat pumps distributed across the area based on a geospatial projection in line with 2030 targets.**

4 DEALING WITH DEMAND

FIGURE 6 **POWER SYSTEM STUDIES FOR NORMAL FEEDING AND CONTINGENCY FEEDING**

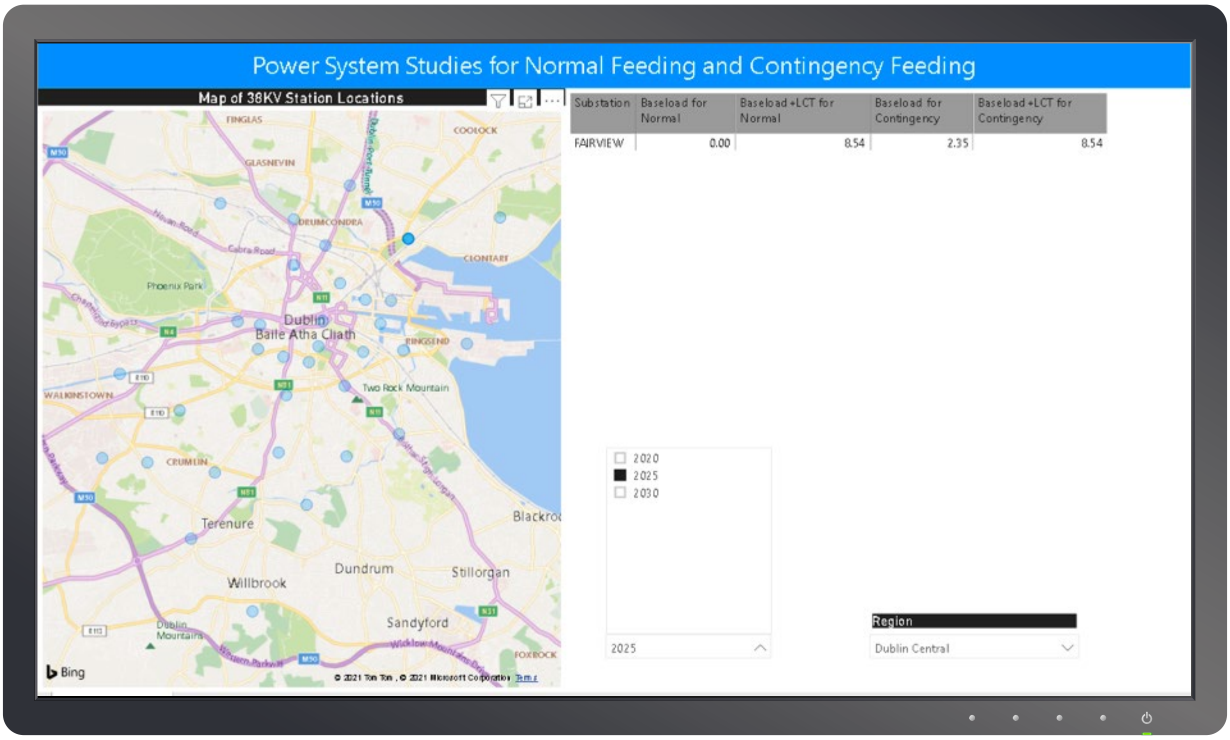


The screenshot above focuses on Fairview 38kV station in Dublin. This is an urban location where the provision of new electricity infrastructure has the potential to be disruptive to those working and living in the area. Many of the roads are more narrow as this is an older part of the city, making network upgrades particularly disruptive.

In 2020, the figures above identified the potential to introduce some flexible services (circa 2MW) under certain standby feeding arrangements. The table above identifies that this is the case even without the impact on the load due to electric vehicles and heat pumps (referred to as “LCT” below).

4 DEALING WITH DEMAND

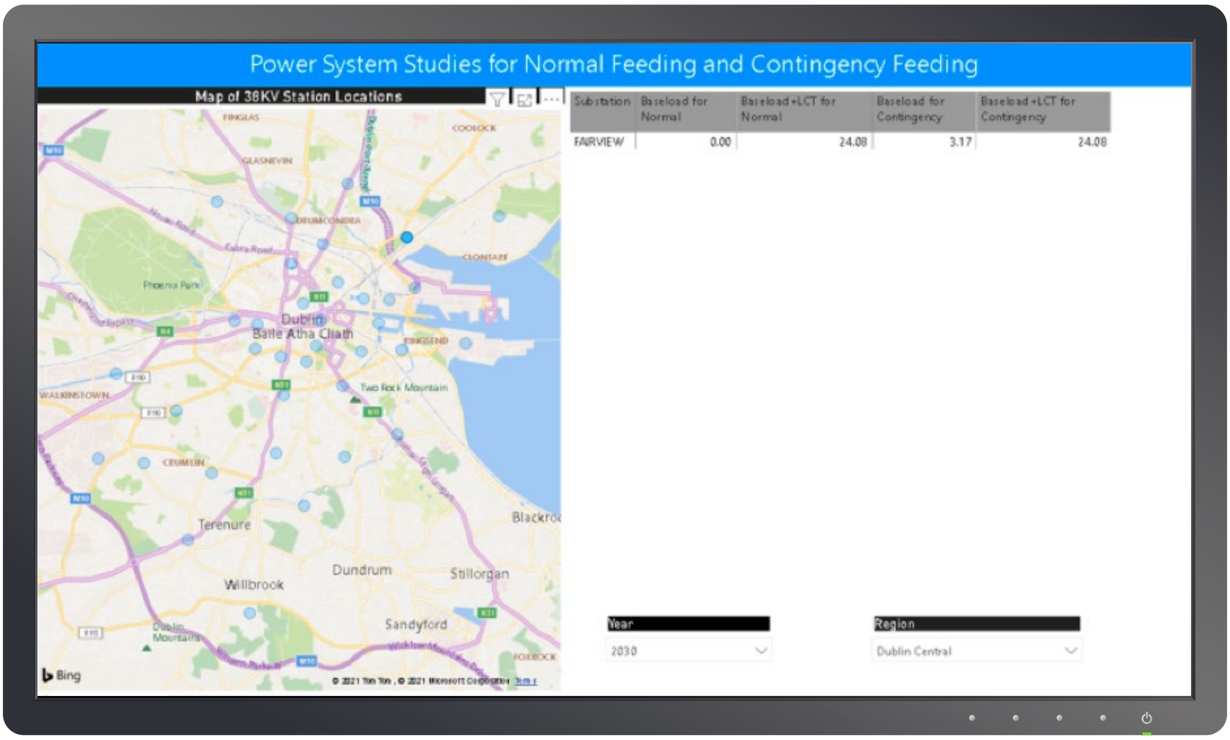
FIGURE 7 **POWER SYSTEM STUDIES FOR NORMAL FEEDING AND CONTINGENCY FEEDING**



In 2025, largely based on the increased presence of LCT load – we may have more need for flexible services (circa 8MW) under both normal and standby feeding arrangements. However as the bulk of this need appears to be associated with the LCT load (which as per earlier sections we expect to be more flexible), such services may well be readily available. This information does, however, highlight the need to consider alternatives to flexible services especially where the take up of LCT in the area is as currently predicted.

4 DEALING WITH DEMAND

FIGURE 8 **POWER SYSTEM STUDIES FOR NORMAL FEEDING AND CONTINGENCY FEEDING**



In 2030 – shown above – the figure of circa 24MW is the volume of demand reduction which would be required based on predicted load growth in the area, including as a result of the take up of LCT, and as set out above, on the assumption that LCT is unmanaged and that no additional infrastructure has been provided in the area in the interim.

Notwithstanding the above, at this level of demand, this information is indicative of a need to consider additional electricity infrastructure in the area.

5

The Generation Challenge

5 THE GENERATION CHALLENGE

As of April 2021, there was c. 2.5GW of wind generation connected[8] to the distribution system and c. 2.1GW of wind generation connected to the transmission system in Ireland. By 2030, in order to meet the target of up to 80% or more generation from renewable sources, it is estimated that an additional 10GW of generation will need to be connected. Current estimates are that this will be split 50/50[9] between distribution and transmission connections[10]. In practice on the system, this will mean that c. 30% of the time or more, we will be operating on 100% renewable sources.

The load database forecasts the growth of generation from 2020 to 2030 as follows (scenarios 1,2 and 3 refer to the microgeneration/summer valley[11] combined scenarios (PV1 and SV1 PV2 and SV2, and PV3 and SV3) and are as described in Appendix 1):

TABLE 5 **MICRO-GENERATION SCENARIO 1**

MICRO-GENERATION SCENARIO 1	GENERATION CONNECTED (MW/GW) 2020 AND BEYOND		
Existing generation	2.5GW		
	2020	2025	2030
Impact of Micro-generation	5MW	36MW	74MW
Commercial generation - scenario 1 – wind	2.2GW	3GW	5GW
Commercial generation - scenario 1 - solar	0GW	1.3GW	1.8GW
Commercial generation - scenario 2 - wind	2.2GW	2.9GW	3.9 GW
Commercial generation - scenario 2 - solar	0GW	1.3GW	2.8GW

TABLE 6 **MICRO-GENERATION SCENARIO 2**

MICRO-GENERATION SCENARIO 2	GENERATION CONNECTED (MW/GW) 2020 AND BEYOND		
Existing generation	2.5GW		
	2020	2025	2030
Impact of Micro-generation	25MW	200MW	300MW
Commercial generation - scenario 1 – wind	2.2GW	3GW	5GW
Commercial generation - scenario 1 - solar	0GW	1.3GW	1.8GW
Commercial generation - scenario 2 - wind	2.2GW	2.9GW	3.9 GW
Commercial generation - scenario 2 - solar	0GW	1.3GW	2.8GW

[8] With an additional 1.17GW contracted but not yet connected. This contracted capacity forms part of the 2030 forecast.

[9] Based on historical information.

[10] The bulk of the connections to the Transmission System are expected to be offshore wind.

[11] Summer Valley load is when the load in an area is at it's lowest level. Low load is the most onerous condition for connection of generation..

5 THE GENERATION CHALLENGE

TABLE 7 **MICRO-GENERATION SCENARIO 3**

MICRO-GENERATION SCENARIO 3	**GENERATION CONNECTED (MW/GW)** 2020 AND BEYOND		
Existing generation	2.5GW		
	2020	**2025**	**2030**
Impact of Micro-generation	20 MW	200MW	300MW
Commercial generation - scenario 1 – wind	2.2GW	3GW	5GW
Commercial generation - scenario 1 - solar	0GW	1.3GW	1.8GW
Commercial generation - scenario 2 - wind	2.2GW	2.9GW	3.9 GW
Commercial generation - scenario 2 - solar	0GW	1.3GW	2.8GW

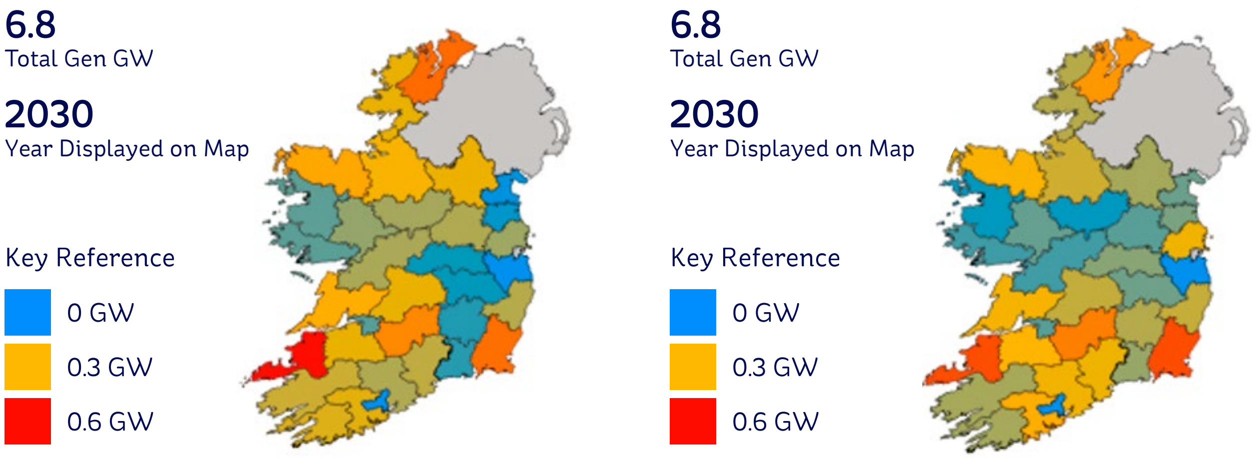


FIGURE 9 **LEFT HAND SIDE - LARGE SCALE GENERATION SCENARIO 1 ; RIGHT HAND SIDE SCENARIO 2**

5 THE GENERATION CHALLENGE

5.1 INTERACTION BETWEEN LOCAL GENERATION AND LARGER GENERATION

The sections above set out figures for microgeneration, primarily rooftop solar in urban areas, and larger commercial scale generation (both solar and wind and some other technologies but on a much smaller scale). In order to achieve our Climate Action Plan targets, it will be increasingly important to manage, and aim to match, load and generation at a local level. This in turn will minimise the generation being turned down. This is especially the case for generation connecting to the distribution system, as the bulk of this generation is renewable.

An example of where this may arise is on a sunny afternoon in an area with a predominantly residential/small commercial load and where there is a lot of rooftop solar. This could be representative of many suburbs in the future particularly as many new homes have rooftop solar installed in line with Part L of the Irish building regulations[12]. In such a scenario, we may have more generation connected to the local network then we have load to use it - unless some customers in the area have flexible load which can be turned up to use that generation. The diagram below indicates that countrywide, there is a small % of MV feeders where microgeneration is expected to exceed summer valley load.

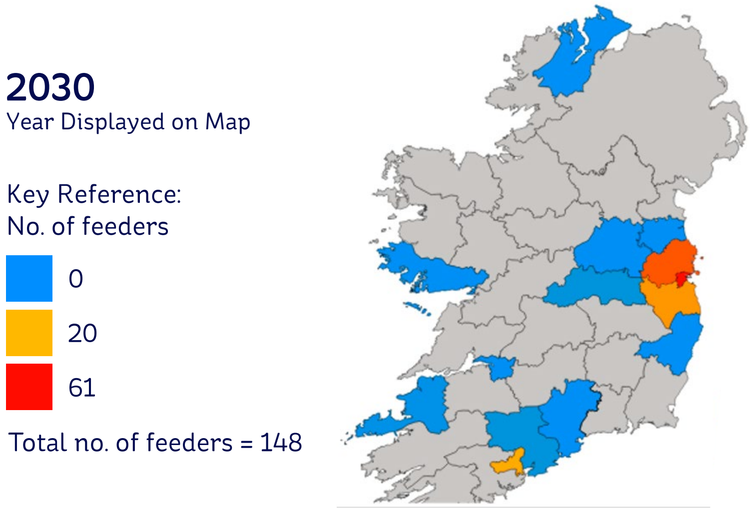


FIGURE 10 **MV FEEDERS WITH PV LOAD GREATER THAN SUMMER VALLEY**

[12] gov.ie - Building Regulations (www.gov.ie)

5 THE GENERATION CHALLENGE

5.2 FIRM VERSUS FLEXIBLE

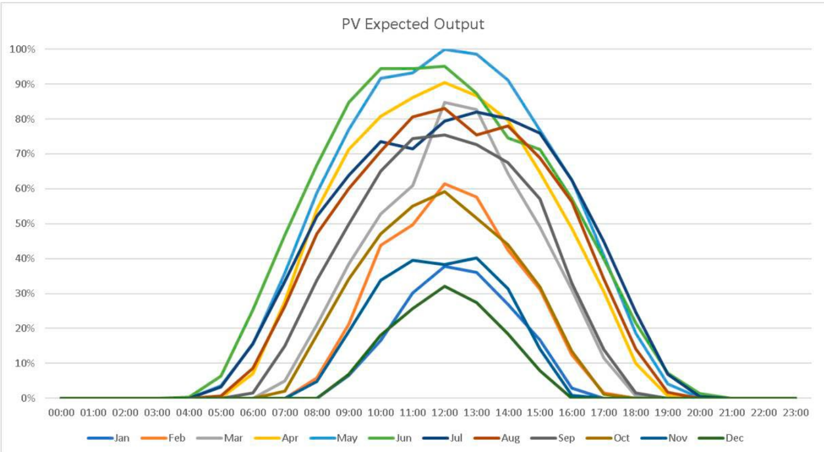
Traditionally, generation connecting to the distribution system has been connected on a firm basis i.e. the connection designed has been such as to allow the generator to export their full Maximum Export Capacity (MEC) when the network is in normal or standby feeding[13] arrangement. As the level of generation has grown across the country, this has often led to connections which require substantial and costly reinforcements of the existing system (e.g. a new collector station). These take a long time to deliver and potentially require significant outages on existing plant.

These outages can have a (temporary) impact on the reliability of supply in the area and can also mean that existing renewable generation is unavailable.

Whether connections to the distribution system should be offered on a more flexible basis has been an ongoing consideration. The first step into this area has already taken place in ECP2 where some non-firm offers[14] will be issued under certain circumstances[15]. However, there are a number of reasons why it is timely to consider a more extensive review of this policy.

1. **Availability of the tools to manage such connections.**
2. **Ongoing industry interest.**
3. **More solar applying for connections. The introduction of a different technology gives rise to two areas of consideration:**
   a. High wind and high sun tend not to co-incide and therefore solar and wind will not frequently be coincidentally exporting at their full MEC.
   b. As per the sample graph below, the solar peak does not tend to be aligned with Summer valley load[16] (which represents the worst case for generation).
4. **The extensive deep works which would otherwise be required to deliver on the CAP targets.**

FIGURE 11 **PV EXPECTED OUTPUT**



[13] Standby feeding arrangements typically mean that an item of plant is not in service - for example due to fault or planned maintenance.

[14] Circa 5-10 of 76 offers.

[15] Non-firm second transformer access is available for High Voltage/Medium Voltage (HV/MV) transformer capacity from the second HV station transformer, utilising a hard-intertripping / special protection scheme arrangement within the HV station. The paper detailing the initial non-firm offering is at the link Non-Firm Access Connections for Distribution Connected Distributed Generators (esbnetworks.ie)

[16] It should be noted, however, that mid-morning load on a local network can be low – especially in a residential area.

6

Applying These Insights

6 APPLYING THESE INSIGHTS

6.1 INFORMING THE DEVELOPMENT OF A MARKET FOR DISTRIBUTION SERVICES

The purpose of the work being undertaken in the 2030 Power System Requirements is to identify the system needs and to analyse a variety of solutions to meet those needs. These include both new and existing solutions.

As can be seen from previous sections, and for a number of reasons, the exact locations where new load will develop, and the actual scale of the development is uncertain. Any decision, therefore, to invest in long-term capital infrastructure has the potential for stranded assets. In addition, capital infrastructure takes time to develop and frequently impacts on the availability of existing infrastructure during the build, due to the outages required. On the contrary, the new low carbon technologies which we are aiming to facilitate can be connected very quickly and often with very limited infrastructure; it is the volume of them that is giving rise to the challenge and also the opportunity.

For the above reasons, a market for services, MW or MVAr[17] up or down, is essential to support the development of the system in a cost effective and timely manner.

The proposed market design and the description of flexible services, which are likely to be required, are set out in detail in Phased Flexibility Market Development Plan in particular in Section 3.3 of same. As a general point, however, the type of service required – in terms of size of load to be flexible and how quickly a change in load profile will be required – will depend on the local network conditions and load in the area at the time.

[17] MW up and down services are predominantly to address thermal constraints. While MVAr services are to address voltage constraints.

6 APPLYING THESE INSIGHTS

6.2 CAPITAL INFRASTRUCTURE VERSUS MARKET SERVICES

As stated previously, load development is uncertain. A decision to invest in capital infrastructure is risky. However, the analysis undertaken to date in this study aligns with the Price Review 5 outcome, which indicates that significant capital infrastructure will still be required. This is the case even with a strong flexibility market achieved for distribution services.

With a strong flexibility market, however, the development of capital infrastructure can be more focussed on areas where there is already a strong load and potential for congestion, especially under normal feeding arrangements. The initial approach to how decisions will be made has been set out in the 'Guide - Non-Wires Alternatives to Network Development' published in May 2021[18]. This work forms a good foundation on which to build the process and policy which will be supported by the market.

Flexible services, as an alternative to capital infrastructure are best used in areas:

1. **Where there are active customers who are keen to get involved and optimise their energy costs. Ultimately, we need all customers – from a domestic customer with an immersion heater to a larger industrial customer – to have the opportunity to offer flexible services**
2. **Where load has not yet developed and is not yet certain.**
3. **Where congestion is primarily due to non-standard feeding arrangements which may only arise infrequently.**
4. **Where the local area profile is 'peaky' and therefore shifting load to another part of the daily load profile has the potential to optimise use of the local asset.**

However in parts of the network, capital investment will still be required. In such instances, flexible services will have a role in:

1. **Allowing new loads and new generation connect prior to required deep infrastructure being in place.**
2. **Provide system operators with additional tools which will facilitate outages required to deliver identified and required capital infrastructure.**

[18] Non-Wires Alternatives to Network Development (esbnetworks.ie)

6 APPLYING THESE INSIGHTS

6.2 CAPITAL INFRASTRUCTURE VERSUS MARKET SERVICES continued

Most significantly, however, the availability of a flexible services market will allow the customer to:

1. **Get the best use from any LCT assets.**
2. **Get rewarded for working with the DSO to manage their load to optimise the use of existing infrastructure and renewable energy (both locally and nationally).**
3. **Optimise their own energy costs while assisting in the deliverables under the Climate Action Plan.**

So it is clear that in identifying the requirements of the power system to deal with the current challenge, a combination of infrastructure build and market services is optimum.

To illustrate this, the tables below give a picture of load versus capacity over the whole country. The first table, gives a picture of the additional transformer capacity that would be required to deal with the expected growth in demand, if this demand was unmanaged and no flexible services were available.

The second table sets out a high level indication of the maximum flexibility that would be needed over the coming decade countrywide if no additional station capacity was provided.

The tables are based on:

1. **Analysis undertaken to date.**
2. **Consideration of station transformer capacity only.**

TABLE 8

Overall Analysis	Overloaded Stations			Additional Capacity Required	
	Number			Number	
	Without LCT	With Additional Flexible Load		Without LCT	With Additional Flexible Load
110kV/MV station (see assumption 2 below)	0	7	New stations	0	4
110kV/38kV	2	41		1	21
38kV/MV > = 10MVA capacity (new 110kV station)	4	96		1	32
38kV/MV < 10MVA capacity (38kV station uprate)	21	128	Station Uprates	21	128

TABLE 9 **HIGH LEVEL INDICATION OF THE MAXIMUM FLEXIBILITY THAT WOULD BE NEEDED IF NO ADDITIONAL STATION CAPACITY WAS PROVIDED**

Overall Analysis	MW demand reduction	
	No LCT	With additional flexible load
110kV/MV station	3	132
110kV/38kV	64	2001
38kV/MV	75	1291

6 APPLYING THESE INSIGHTS

6.3 CAN GENERATION AND LOAD BE MORE CLOSELY ALIGNED?

Improved alignment of generation and load has the dual benefit of:

1. **Optimising our use of renewable generation resources; local renewables being consumed locally.**
2. **Supplying our demand of low carbon load while minimising the need for new infrastructure.**

From the data analysis undertaken to date, there is certainly potential for improved alignment of local demand with local generation. As noted previously, there are household loads in particular where the time of using electricity does not need to match the time of the service need. These include :

- **The immersion heater**: Ideal for heating off peak.
- **The electric vehicle**: Very large load even without a home charger installed. As these cars become more mainstream (rather than a 2nd 'about town' vehicle), they will be plugged in more often and for longer.
- **To some extent heat pumps**[19]: Where the demand can be turned down for periods of time with minimal impact on comfort levels.

Add to the above residential solar and battery installations, and the scope for managing and matching load with generation increases.

The pictures and numbers in Figure 12 and Figure 13 below illustrate this concept, albeit in theory - based on the assumption that all generation is available to feed all of the load (and all of the load is available to use the renewable generation).

In Figure 12, we look at summer valley load – which is the worst case for new generation. If we ignore the new low carbon technology load (LH Graph), there is a very significant excess of generation connected to the distribution system which cannot be used to feed the load on same (excess of generation over summer valley load is more than 6GW). Much of this generation can and will be exported onto the transmission system, but much will also need to be constrained.

However the RH Graph shows a much better picture. If the new electric vehicles and heat pumps are available to be supplied by generation, there is a significant increase in summer valley load and, as a result, there will be a lot less generation exported to the transmission system. More importantly, a lot less of this renewable generation, which is core to the Climate Action Plan, will need to be curtailed or constrained.

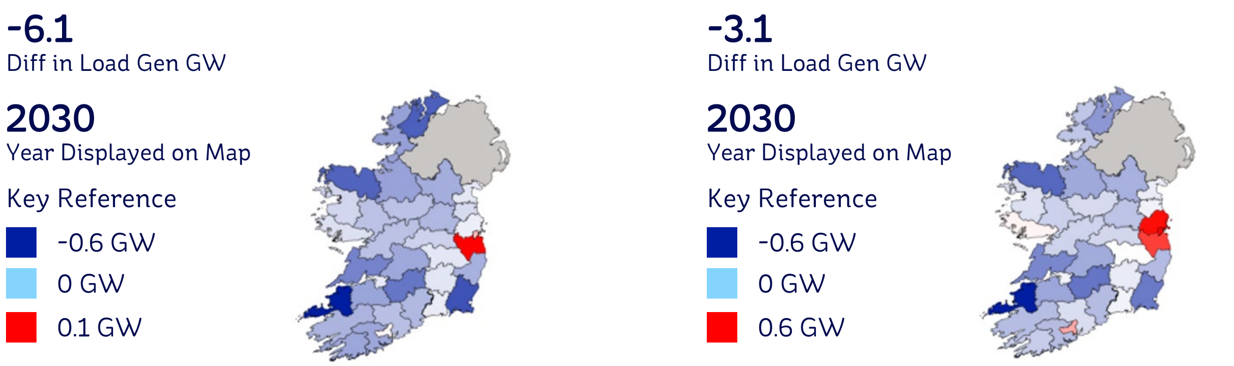


FIGURE 12
LEFT HAND SIDE -GENERATION -LOAD AT SUMMER VALLEY (NO LCT). RIGHT HAND SIDE -GENERATION -LOAD AT SUMMER VALLEY (INCLUDING LCT).

[19] A key requirement for an efficiently operating heat pump is a good level of insulation which minimises heat loss

6 APPLYING THESE INSIGHTS

6.3 CAN GENERATION AND LOAD BE MORE CLOSELY ALIGNED? continued

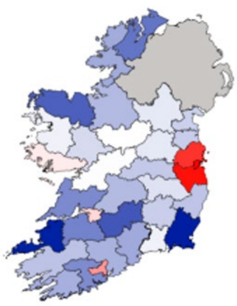
Figure 13 looks at winter peak with the emphasis here on the locally produced generation supplying the local load. As can be seen, matching local load and generation gives a much more manageable level of load in terms of what will now need to be supported by the national distribution infrastructure. In this case, on the Left Hand Side of the graph, at peak load (no LCT), circa 2.5GW of local generation will be exported onto the Transmission System or constrained i.e. the local load is comfortably supplied by local generation. However, when we add the LCT load (Right Hand Side of the graph), we have only 1.5GW of load which will need to be serviced by more traditional generation (connected to the Transmission System).

-2.6
Diff in Load Gen GW

2030
Year Displayed on Map

Key Reference

- -0.5 GW
- 0 GW
- 0.5 GW



1.5
Diff in Load Gen GW

2030
Year Displayed on Map

Key Reference

- -0.4 GW
- 0 GW
- 0.9 GW

FIGURE 13
LEFT HAND SIDE IS GENERATION -LOAD AT WINTER PEAK (NO LCT). RIGHT HAND SIDE IS GENERATION -LOAD AT WINTER PEAK (INCLUDING LCT)

While the above graphs are high level, they do indicate that the scale of generation and load planned is such that we do have the opportunity to optimise our load and generation to make our system as carbon neutral as possible. But we cannot control the weather – so we need to control the demand (or where feasible store the renewable energy.)

As a further example of what can be achieved in this area, and bringing the analysis to a more granular level, we have assessed the level of load which would need to be available as flexible load on the distribution system to optimise the use of locally connected generation. The table below indicates:

1. **The level of load needed taking account of restrictions on medium voltage networks[20] and at at 38kV stations[21] (columns 1 and 2).**
2. **The level of flexible load (assumed to be electric vehicle load) which may be available at each station – taking account of the ability of the medium network to accommodate same (column 3)**

[20] These are the networks which form the bulk of the distribution system countrywide and are typically operated at 10kV and 20kV.

[21] These form the bulk of the stations on the distribution system. Any town in the country will typically have a 38kV station close by.

6 APPLYING THESE INSIGHTS

6.3 CAN GENERATION AND LOAD BE MORE CLOSELY ALIGNED? continued

TABLE 10 **TURN ON LOAD**

	Turn on Load Needed by 2030 (MW)		Turn on Load available to meet this need
	Generation Scenario 1 - High Wind	Generation Scenario 2 - High Solar	Both generation scenarios
Winter - Scenario 1	464	435	145
Winter - Scenario 2	470	438	170
Winter - Scenario 3	504	468	164
Summer Valley - Scenario 1	739	656	145
Summer Valley - Scenario 2	734	652	170
Summer Valley - Scenario 3	748	663	164

Reference descriptions in section 4.1

So what does this mean? Using domestic customers as an example, the volumes set out in the first 2 columns of the table could be met in part by new demands including electric vehicles, immersion heaters and other "storage-like" loads. By switching these demands on when renewable generation in the area is at a high level, better use would be made of this clean energy in a manner which represents little or no inconvenience to customers.

The 3rd column represents the flexible load – primarily electric vehicles – predicted to be available at each of the locations where turn on load is needed, indicating that some generation may need to be exported to higher voltages and that some infrastructure build may be required to facilitate this. However this will only be the case if we were to facilitate all generation exporting at full MEC all of the time. Realistically as the amount of generation grows and there is an increasing mix of wind, solar and storage, the level of load available, as per column 3, is likely to be adequate for a significant portion of the time.

This will rely on active customers who want to make good use of their low carbon technology, and requires those customers to have the right technology to do so. For more information on the technology standards that will be needed, please refer to the National Networks, Local Connections Programme Data Exchange & Signals Guidance Proposal.

6 APPLYING THESE INSIGHTS

6.4 WHO WE NEED TO WORK WITH?

As set out in detail in the consultation framework document, the delivery of the National Network, Local Connections Programme involves a comprehensive list of stakeholders and participants. In terms of the Power System Requirements workstream in particular, the picture below gives a strong sense of who we need to work with to ensure that:

1. **The picture of our system is as accurate as possible (inputs from SEAI, WEI amongst others – reference section 2)**
2. **Other parties can use the information provided to action the requirements**

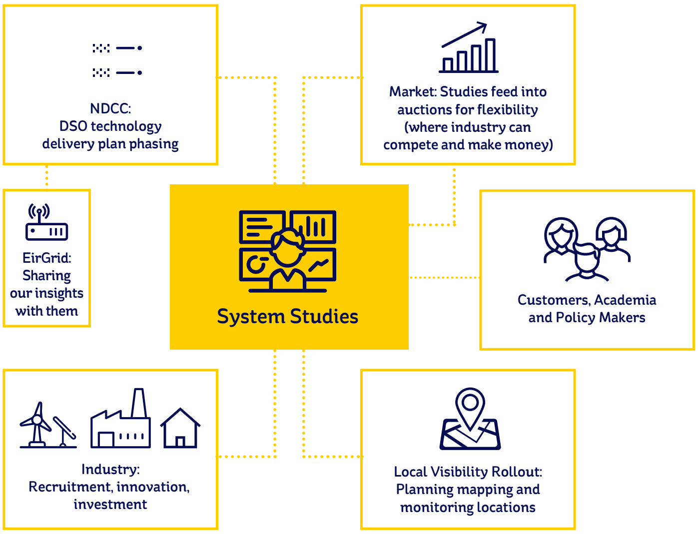
   a. Identify what is needed from the market, and also get feedback from the market.

   b. Engage with EirGrid to ensure that we optimise market services and infrastructure build across the entire electricity system.

   c. Inform industry and customers of services needed so that they can plan and prepare for the future.

   d. Within our direct team, ensure that the areas undertaking operations can engage with us on process, as well as technology, changes to make this happen ensuring that we transition in as seamless a way as possible.

   e. Also within the programme team directly, the mapping and visibility roll out plans to ensure they are initially rolled out in the areas of greatest need.



Additionally, for further information for other stakeholders we need to work with:

1. **For customers or those working directly with customers, technology manufacturers, wholesalers, retailers and installers, please see the National Network, Local Connections Programme Data Exchange & Signals Guidance.**
2. **For suppliers, aggregators and generators interested in market opportunities to address the needs set out in this document, please see the National Network, Local Connections Programme Phased Flexibility Market Plan.**

6 APPLYING THESE INSIGHTS

6.5 OPTIONS CONSIDERED

Some alternative options to undertaking work aimed at identifying the needs for the 2030 power system, in particular the challenge of electrification of heat and transport, are listed below:

1. **Meeting the need by building out infrastructure based on load growth estimates. This would potentially be more expensive and also will take more time. In addition, given the nature of the change we are aiming to facilitate and the lack of historical data, the challenge in developing accurate load growth estimates would be significant.**
2. **Waiting until the load develops. This could lead to scenarios where, for example, customers purchasing new electric vehicles are advised of restrictions in the supply in their area which make the transition less attractive and ultimately undermines customer confidence and the Climate Action Plan.**
3. **Allowing load to develop and customers connect without any advance plans which may lead to reduced reliability.**
4. **Establishing a market without giving customers an indication as to the types and quantities of products and services which are required, and other key customer information.**

6 APPLYING THESE INSIGHTS

6.6 RISK ASSESSMENT

The table below sets out some of the key risks considered to date, the impact of same and/or how we plan to mitigate against them. We would welcome input on what other risks we should be mitigating against and also how significant are the risks already listed.

	RISK	IMPACTS/MITIGATION
1	Uptake of LCT accelerates and these figures are too conservative	Different scenarios being considered so less likely that this risk will arise. Load refresh on an annual basis. Ongoing interaction with stakeholders such as SEAI and WEI for early 'heads up'. Flexible services can respond more quickly.
2	Risk that uptake stalls and these figures are too aggressive	Annual load refresh (as for 1.) Stakeholder feedback (as for 1.) Issue short-term flexible contracts to minimise costs where there is no need to draw down on flexible services.
3	Risk that we delay flexibility market and are not able to meet the pace of uptake (cannot build fast enough)	Investment in operations system will facilitate increased automation and more active management of the existing loads.
4	Risk that we buy too much flexibility too soon, and we don't need it	Short term cost increase is possible. However, estimates can be corrected for subsequent years. Overall investment cost less than if capital infrastructure project was progressed.
5	Risk that we have the volumes right but the locations wrong	Short term cost increase possible in area where we predicted increased load/generation which didn't arise. However estimates can be corrected for subsequent years. For areas where increased load/generation arose and was not predicted, investment in operations system will facilitate increased automation and more active management of the existing loads. Overall investment cost less than if capital infrastructure project was progressed.
6	Risk that something else comes along and electrification of heat and transport no longer the issue	Short term cost increase possible in area where we predicted increased load/generation which didn't arise. However estimates can be corrected for subsequent years. Overall investment cost less than if capital infrastructure project was progressed.
7	Risk that renewable generation shifts offshore / very large scale only and no longer distributed	Flexible services at distribution will still provide a benefit to reduce constraints of generation. However, additional infrastructure build at distribution will be required to deliver the 'demand up' to match the transmission connected generation.
8	Risk that customers with low carbon technologies do not participate in the market	Proactive engagement with all customers to ensure they are aware of opportunities; Monitor the response to pilots and engage with customers to see what is driving behaviour; investment in operations system to ensure we can better manage existing loads to allow time for capital infrastructure development.

7

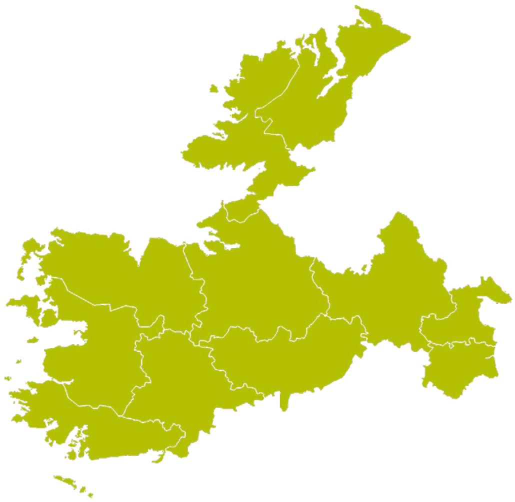
Area by Area Analysis

7 AREA BY AREA ANALYSIS - NORTH REGION

Based on the data analysis work undertaken to date, we have an overall view as to how load and generation are likely to develop in various different parts of the country. This is detailed below based on 4 different areas: North, Central, South and Dublin.

7.1 NORTH REGION

The North region encompasses the north west of Ireland along with the border regions. The network here is predominantly rural with long feeders of 10kV and 20kV networks, the longest covering c. 87km of 3 phase network. The number of urban and rural customers is roughly evenly split, slightly in favour of rural customers. Whereas the number of urban vs rural MV/LV substations is dominated by rural MV/LV substations (c. 90%).



The tables below set out some detail identifying the areas within the region where we expect the highest uptake of low carbon technologies (electric vehicles; heat pumps and microgeneration) – first row; and the lowest uptake – second row. For example in scenario 1 by 2030 Galway is expected to have over 26,000 electric vehicles.

TABLE 11 **HIGHEST AND LOWEST LCT NUMBERS IN NORTH REGION**

Area	2020 LCT			2030 LCT		
Scenario 1 EV1, HP1, WP1	**EVs**	**HPs**	**PV**	**EVs**	**HPs**	**PV**
Highest in terms of EV numbers	Drogheda 688	Letterkenny 1,597	Galway 29	Galway 26,264	Galway 16,533	Galway 560
Lowest in terms of EV numbers	Castlebar 254	Castlebar 727	Sligo 0	Castlebar 11,093	Castlebar 6,525	Sligo 0

TABLE 12 **HIGHEST AND LOWEST LCT NUMBERS IN NORTH REGION**

Area	2020 LCT			2030 LCT		
Scenario 2 EV2, HP2, WP2	**EVs**	**HPs**	**PV**	**EVs**	**HPs**	**PV**
Highest in terms of EV numbers	Drogheda 2,237	Drogheda 1,353	Drogheda 366	Drogheda 55,342	Drogheda 11,024	Drogheda 4,566
Lowest in terms of EV numbers	Longford 119	Tuam 287	Longford 45	Longford 7,680	Castlebar 3,803	Longford 691

TABLE 13 **HIGHEST AND LOWEST LCT NUMBERS IN NORTH REGION**

Area	2020 LCT			2030 LCT		
Scenario 3 EV3, HP3, WP3	**EVs**	**HPs**	**PV**	**EVs**	**HPs**	**PV**
Highest in terms of EV numbers	Galway 1,558	Drogheda 338	Drogheda 183	Letterkenny 43,837	Castlebar 12,928	Drogheda 2,890
Lowest in terms of EV numbers	Castlebar 1	Longford 0	Longford 10	Cavan 2,166	Tuam 603	Tuam 290

7 AREA BY AREA ANALYSIS - NORTH REGION

DEMAND

Section 2.1 shows the national peak demand as forecasted to be between 8.2GW and 9.2GW. As shown in Table 14, Table 15 and Table 16 (below) for the various scenarios, the load in the north region makes up c. 20% of the national load in 2030.

The percentage of the Northern region 2030 peak demand due to low carbon technologies – such as EVs and heat pumps – is c.41%. This is above the national average of c. 36%.

TABLE 14 **SCENARIO 1 NORTH REGION LOAD GROWTH**

Scenario 1 EV1, HP1, WP1	Unmanaged Peak Loading (MW)		
	2020	**2025**	**2030**
Total Load at peak	1,010 MW	1,201 MW	1,745 MW
Base Load (before LCT)	955 MW	999 MW	1,046 MW
Average % of load due to EVs	3%	9%	32%
Average % of load due to HPs	2%	7%	8%

TABLE 15 **SCENARIO 2 NORTH REGION LOAD GROWTH**

Scenario 2 EV2, HP2, WP2	Unmanaged Peak Loading (MW)		
	2020	**2025**	**2030**
Total Load at peak	1,020 MW	1,224 MW	1,951 MW
Base Load (before LCT)	956 MW	1,002 MW	1,053 MW
Average % of load due to EVs	5%	13%	41%
Average % of load due to HPs	1%	5%	5%

TABLE 16 **SCENARIO 3 NORTH REGION LOAD GROWTH**

Scenario 3 EV3, HP3, WP3	Unmanaged Peak Loading (MW)		
	2020	**2025**	**2030**
Total Load at peak	960 MW	1,102 MW	1,612 MW
Base Load (before LCT)	941 MW	956 MW	1,000 MW
Average % of load due to EVs	2%	12%	35%
Average % of load due to HPs	0.1%	1%	2%

7 AREA BY AREA ANALYSIS - NORTH REGION

GENERATION

The northern region is a high wind location, such that a large amount of the future wind generation from a national perspective is forecasted to be located in this region. In Scenario 1 for commercial generation (high wind), by 2030, the northern region is forecast to have 40% of the total wind for the country.

The northern region also includes the Drogheda and Dundalk regions, which, being in the east of the country, are classed as potential solar areas.

If we look at high solar, scenario 2 for commercial, the northern region may have up to 10% of the total solar.

TABLE 17 **SCENARIO 1 NORTH REGION MICROGENERATION FORECAST**

Scenario 1 Microgeneration	Generation connected		
	2020	**2025**	**2030**
Existing generation			
Impact of PVs	0.1 MW	0.1 MW	0.2 MW
Commercial generation - scenario 1 - wind	737 MW	1,041 MW	2,071 MW
Commercial generation - scenario 1 - solar	-	114 MW	135 MW
Commercial generation - scenario 2 - wind	737 MW	1,029 MW	1,569 MW
Commercial generation - scenario 2 - solar	-	114 MW	309 MW

TABLE 18 **SCENARIO 2 NORTH REGION MICROGENERATION FORECAST**

Scenario 2 Microgeneration	Generation connected		
	2020	**2025**	**2030**
Existing generation			
Impact of PVs	5 MW	7 MW	5 MW
Commercial generation - scenario 1 - wind	737 MW	1,041 MW	2,071 MW
Commercial generation - scenario 1 - solar	-	114 MW	135 MW
Commercial generation - scenario 2 - wind	737 MW	1,029 MW	1,569 MW
Commercial generation - scenario 2 - solar	-	114 MW	309 MW

7 AREA BY AREA ANALYSIS - NORTH REGION

GENERATION continued

TABLE 19 **SCENARIO 3 NORTH REGION MICROGENERATION FORECAST**

Scenario 3 Microgeneration	Generation connected		
	2020	2025	2030
Existing generation			
Impact of PVs	1 MW	3 MW	2 MW
Commercial generation - scenario 1 - wind	737 MW	1,041 MW	2,071 MW
Commercial generation - scenario 1 - solar	-	114 MW	135 MW
Commercial generation - scenario 2 - wind	737 MW	1,029 MW	1,569 MW
Commercial generation - scenario 2 - solar	-	114 MW	309 MW

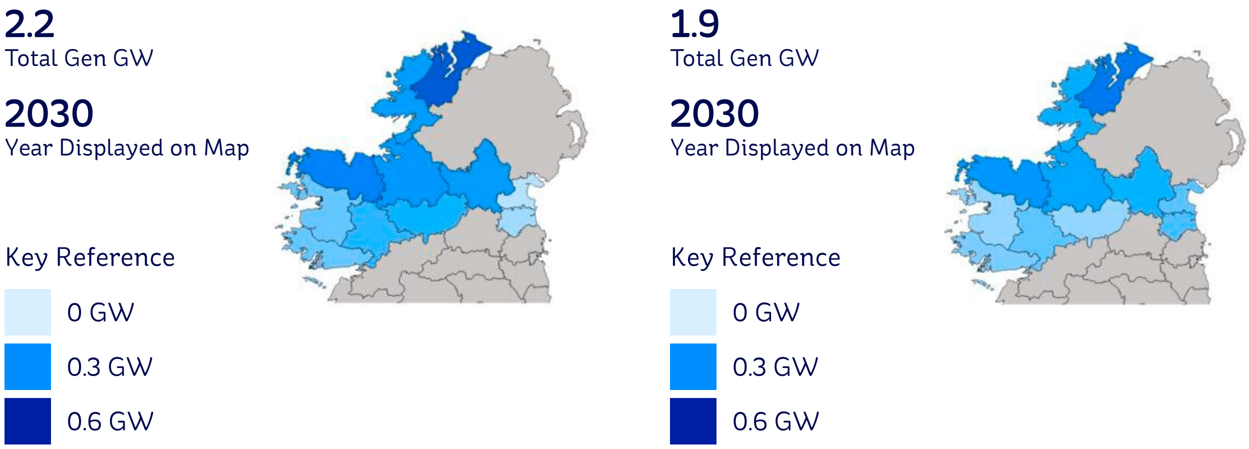
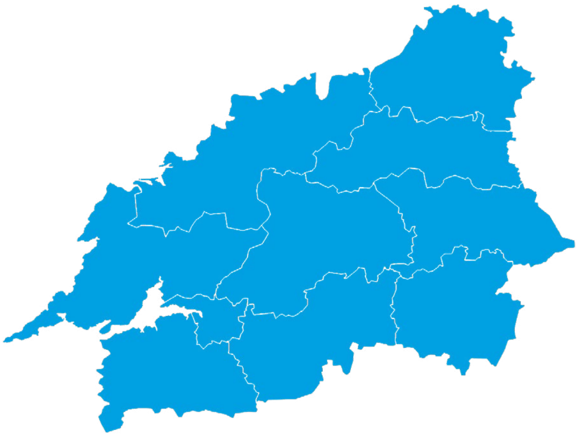


FIGURE 14 **LEFT HAND SIDE - LARGE SCALE GENERATION SCENARIO 1– HIGH WIND; RIGHT HAND SIDE SCENARIO 2– HIGH SOLAR**

7 AREA BY AREA ANALYSIS - CENTRAL REGION

7.2 CENTRAL REGION



The central region encompasses the mid-west of Ireland along with midlands areas. The network here is predominantly rural with long feeders of 10kV and 20kV networks, the longest covering c. 75km of 3 phase network. The number of urban and rural customers is evenly split. Whereas the number of urban vs rural MV/LV substations is dominated by rural MV/LV substations (c. 90%).

The tables below set out some detail identifying the areas within the region where we expect the highest uptake of low carbon technologies (electric vehicles; heat pumps and microgeneration) – first row; and the lowest uptake – second row. For example in scenario 1 by 2030, Limerick is expected to have over 27,000 electric vehicles.

TABLE 20 **HIGHEST AND LOWEST LCT NUMBERS IN CENTRAL REGION**

Area	2020 LCT			2030 LCT		
Scenario 1 EV1, HP1, WP1	**EVs**	**HPs**	**PV**	**EVs**	**HPs**	**PV**
Highest in terms of EV numbers	Limerick 855	Limerick 1,735	Limerick 106	Limerick 27,472	Limerick 18,100	Limerick 1,386
Lowest in terms of EV numbers	Newcastlewest 253	Newcastlewest 708	Thurles 0	Newcastlewest 11,550	Newcastlewest 6,600	Thurles 0

TABLE 21 **HIGHEST AND LOWEST LCT NUMBERS IN CENTRAL REGION**

Area	2020 LCT			2030 LCT		
Scenario 2 EV2, HP2, WP2	**EVs**	**HPs**	**PV**	**EVs**	**HPs**	**PV**
Highest in terms of EV numbers	Tullamore 1,421	Tullamore 1,568	Tullamore 336	Tullamore 38,295	Limerick 12,907	Tullamore 4,468
Lowest in terms of EV numbers	Kilkenny 252	Newcastlewest 273	Thurles 52	Kilkenny 10,084	Newcastlewest 3,726	Thurles 931

TABLE 22 **HIGHEST AND LOWEST LCT NUMBERS IN CENTRAL REGION**

Area	2020 LCT			2030 LCT		
Scenario 3 EV3, HP3, WP3	**EVs**	**HPs**	**PV**	**EVs**	**HPs**	**PV**
Highest in terms of EV numbers	Portloaise 829	Tullamore 188	Limerick 178	Athlone 13,314	Portloaise 35,113	Limerick 3,077
Lowest in terms of EV numbers	Thurles 0	Newcastlewest 5	Newcastlewest 11	Thurles 657	Newcastlewest 272	Newcastlewest 364

7 AREA BY AREA ANALYSIS - CENTRAL REGION

DEMAND

As shown in Section 2.1, the national peak demand in 2030 is forecasted to be between 8.2GW and 9.2GW. Table 23, Table 24 and Table 25 below forecast the load in the central region making up between 15% and 21% (on average 19%) of the national load. The percentage of the Central Region 2030 peak demand associated with low carbon technologies, such as electric vehicles and heat pumps, at c.33%, is below the national average of c .36%.

TABLE 23 **SCENARIO 1 CENTRAL REGION LOAD GROWTH**

Scenario 1 EV1, HP1, WP1	Unmanaged Peak Loading (MW)		
	2020	**2025**	**2030**
Total Load at peak	1,035 MW	1,233 MW	1,752 MW
Base Load (before LCT)	983 MW	1,038 MW	1,097 MW
Average % of load due to EVs	3%	9%	30%
Average % of load due to HPs	2%	7%	8%

TABLE 24 **SCENARIO 2 CENTRAL REGION LOAD GROWTH**

Scenario 2 EV2, HP2, WP2	Unmanaged Peak Loading (MW)		
	2020	**2025**	**2030**
Total Load at peak	1,044 MW	1,254 MW	1,976 MW
Base Load (before LCT)	984 MW	1,043 MW	1,107 MW
Average % of load due to EVs	4%	12%	39%
Average % of load due to HPs	1%	5%	5%

TABLE 25 **SCENARIO 3 CENTRAL REGION LOAD GROWTH**

Scenario 3 EV3, HP3, WP3	Unmanaged Peak Loading (MW)		
	2020	**2025**	**2030**
Total Load at peak	979 MW	1,029 MW	1,275 MW
Base Load (before LCT)	966 MW	985 MW	1,039 MW
Average % of load due to EVs	1%	3%	14%
Average % of load due to HPs	0.1%	1%	5%

7 AREA BY AREA ANALYSIS - CENTRAL REGION

GENERATION

The central region is generally a flat region making it suitable for both wind and solar installations. As shown in Table 26, Table 27 and Table 28, in 2030, the central region is forecasted to have a balance of wind and solar connections roughly 60/40. The central region is forecasted to have c. 29% of the national wind MW and c. 25% to 30% of the solar MW.

TABLE 26 **SCENARIO 1 CENTRAL REGION MICROGENERATION FORECAST**

Scenario 1 Microgeneration	Generation connected		
	2020	2025	2030
Existing generation			
Impact of PVs	0.4 MW	0.5 MW	0.6 MW
Commercial generation - scenario 1 - wind	618 MW	870 MW	1,481 MW
Commercial generation - scenario 1 - solar	-	386 MW	455 MW
Commercial generation - scenario 2 - wind	618 MW	859 MW	1,130 MW
Commercial generation - scenario 2 - solar	-	386 MW	862 MW

TABLE 27 **SCENARIO 2 CENTRAL REGION MICROGENERATION FORECAST**

Scenario 2 Microgeneration	Generation connected		
	2020	2025	2030
Existing generation			
Impact of PVs	5 MW	8 MW	7 MW
Commercial generation - scenario 1 - wind	618 MW	870 MW	1,481 MW
Commercial generation - scenario 1 - solar	-	386 MW	455 MW
Commercial generation - scenario 2 - wind	618 MW	859 MW	1,130 MW
Commercial generation - scenario 2 - solar	-	386 MW	862 MW

7 AREA BY AREA ANALYSIS - CENTRAL REGION

GENERATION CONTINUED

TABLE 28 **SCENARIO 3 CENTRAL REGION MICROGENERATION FORECAST**

Scenario 3 Microgeneration	Generation connected		
	2020	2025	2030
Existing generation			
Impact of PVs	2 MW	4 MW	3 MW
Commercial generation - scenario 1 - wind	618 MW	870 MW	1,481 MW
Commercial generation - scenario 1 - solar	-	386 MW	455 MW
Commercial generation - scenario 2 - wind	618 MW	859 MW	1,130 MW
Commercial generation - scenario 2 - solar	-	386 MW	862 MW

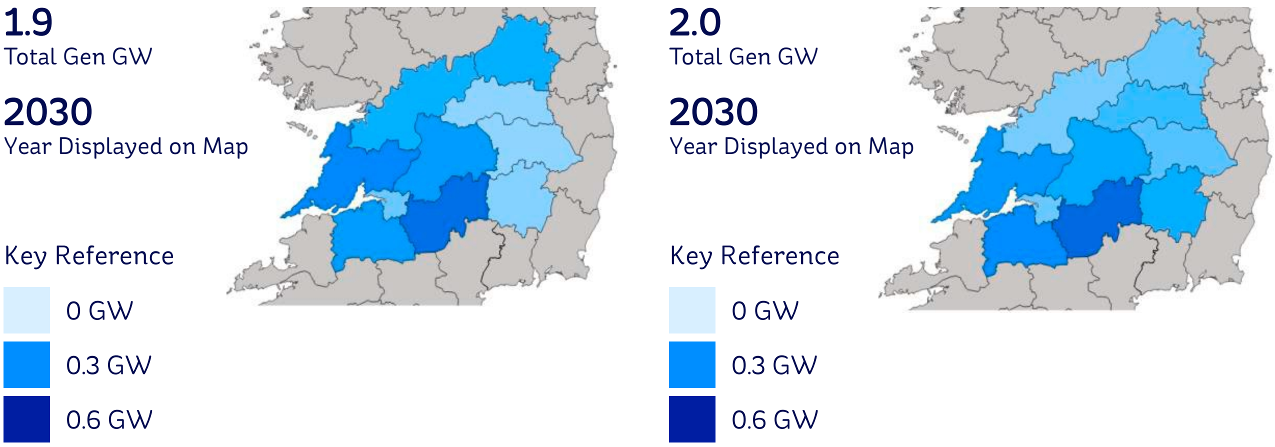
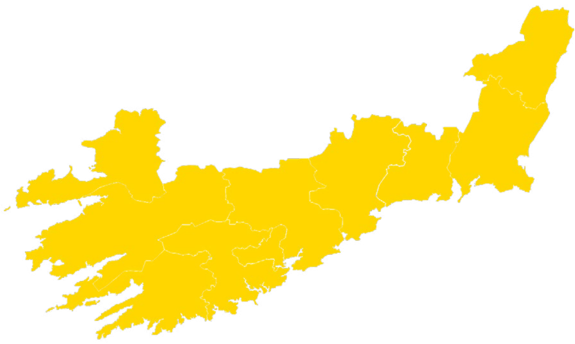


FIGURE 15
LEFT HAND SIDE GENERATION MW IN 2030 FOR CENTRAL REGION (SCENARIO 1) – HIGH WIND; RIGHT HAND SIDE SCENARIO 2

7 AREA BY AREA ANALYSIS - SOUTH REGION

7.3 SOUTH REGION

The southern region encompasses the south west and south east of Ireland. The network here is predominantly rural with long feeders of 10kV and 20kV networks, the longest covering c. 77km of 3 phase network. The number of urban customers is higher in this region, probably due to the greater Cork area. Whereas the number of urban vs rural MV/LV substations is dominated by rural MV/LV substations (c. 90%).



The tables below set out some detail identifying the areas within the region where we expect the highest uptake of low carbon technologies (electric vehicles; heat pumps and microgeneration) – first row; and the lowest uptake – second row. For example in scenario 1 by 2030, Cork City is expected to have almost 54,000 electric vehicles.

TABLE 29 **HIGHEST AND LOWEST LCT NUMBERS IN SOUTH REGION**

Area	2020 LCT			2030 LCT		
Scenario 1 EV1, HP1, WP1	**EVs**	**HPs**	**PV**	**EVs**	**HPs**	**PV**
Highest in terms of EV numbers	Cork City 1,764	Cork City 3,390	Cork City 227	Cork City 53,924	Cork City 35,489	Cork City 3,159
Lowest in terms of EV numbers	Dunmanway 208	Dunmanway 521	Traleee 0	Dunmanway 7,886	Dunmanway 4,730	Tralee 0

TABLE 30 **HIGHEST AND LOWEST LCT NUMBERS IN SOUTH REGION**

Area	2020 LCT			2030 LCT		
Scenario 2 EV2, HP2, WP2	**EVs**	**HPs**	**PV**	**EVs**	**HPs**	**PV**
Highest in terms of EV numbers	Cork City 2,337	Cork City 2,064	Cork City 456	Cork City 66,403	Cork City 27,488	Cork City 4,738
Lowest in terms of EV numbers	Dunmanway 28	Dunmanway 262	Dunmanway 28	Dunmanway 7,387	Dunmanway 2,855	Dunmanway 263

TABLE 31 **HIGHEST AND LOWEST LCT NUMBERS IN SOUTH REGION**

Area	2020 LCT			2030 LCT		
Scenario 3 EV3, HP3, WP3	**EVs**	**HPs**	**PV**	**EVs**	**HPs**	**PV**
Highest in terms of EV numbers	Cork City 3,308	Cork City 442	Cork City 839	Cork City 83,829	Dunmanway 18,647	Cork City 11,836
Lowest in terms of EV numbers	Tralee 0	Tralee 11	Killarney 24	Tralee 2,787	Tralee 491	Killarney 482

7 AREA BY AREA ANALYSIS - SOUTH REGION

DEMAND

As shown in Section 2.1 the national peak demand is forecasted to be between 8.2GW and 9.2GW. As shown in Table 32, Table 33 and Table 34 below, under each of the scenarios the forecast load in Southern Region 2030 in the southern region makes up c. 23% of the national load. The percentage of the 2030 peak demand coming from low carbon technologies – such as electric vehicles and heat pumps – at c.37%, is in line with the national average of c. 36%

TABLE 32 **SCENARIO 1 SOUTH REGION LOAD GROWTH**

Scenario 1 EV1, HP1, WP1	Unmanaged Peak Loading (MW)		
	2020	**2025**	**2030**
Total Load at peak	1,197 MW	1,436 MW	2,031 MW
Base Load (before LCT)	1,134 MW	1,196 MW	1,265 MW
Average % of load due to EVs	3%	9%	29%
Average % of load due to HPs	2%	7%	8%

TABLE 33 **SCENARIO 2 SOUTH REGION LOAD GROWTH**

Scenario 2 EV2, HP2, WP2	Unmanaged Peak Loading (MW)		
	2020	**2025**	**2030**
Total Load at peak	1,194 MW	1,422 MW	2,149 MW
Base Load (before LCT)	1,136 MW	1,210 MW	1,293 MW
Average % of load due to EVs	3%	10%	34%
Average % of load due to HPs	1%	5%	5%

TABLE 34 **SCENARIO 3 SOUTH REGION LOAD GROWTH**

Scenario 3 EV3, HP3, WP3	Unmanaged Peak Loading (MW)		
	2020	**2025**	**2030**
Total Load at peak	1,141 MW	1,253 MW	1,840 MW
Base Load (before LCT)	1,112 MW	1,127 MW	1,188 MW
Average % of load due to EVs	2%	8%	32%
Average % of load due to HPs	0.1%	2%	3%

7 AREA BY AREA ANALYSIS - SOUTH REGION

GENERATION

The south west is a high wind area with the south east being a high sun area. With these two parameters, the southern region has a high level of generation, with c. 30% of the national wind MW and c. 50 % of the national solar MW by 2030.

TABLE 35 **SCENARIO 1 SOUTH REGION MICROGENERATION FORECAST**

Scenario 1 Microgeneration	Generation connected		
	2020	2025	2030
Existing generation			
Impact of PVs	1 MW	1 MW	1 MW
Commercial generation - scenario 1 - wind	831 MW	1,033 MW	1,394 MW
Commercial generation - scenario 1 - solar	0.05 MW	646 MW	1,019 MW
Commercial generation - scenario 2 - wind	831 MW	1,012 MW	1,199 MW
Commercial generation - scenario 2 - solar	0.05 MW	636 MW	1,350 MW

TABLE 36 **SCENARIO 2 SOUTH REGION MICROGENERATION FORECAST**

Scenario 2 Microgeneration	Generation connected		
	2020	2025	2030
Existing generation			
Impact of PVs	5 MW	8 MW	6 MW
Commercial generation - scenario 1 - wind	831 MW	870 MW	1,394 MW
Commercial generation - scenario 1 - solar	0.05 MW	646 MW	1,019 MW
Commercial generation - scenario 2 - wind	831 MW	1,012 MW	1,199 MW
Commercial generation - scenario 2 - solar	0.05 MW	636 MW	1,350 MW

7 AREA BY AREA ANALYSIS - SOUTH REGION

GENERATION continued

TABLE 37 **SCENARIO 3 SOUTH REGION MICROGENERATION FORECAST**

Scenario 3 Microgeneration	Generation connected		
	2020	2025	2030
Existing generation			
Impact of PVs	4 MW	7 MW	5 MW
Commercial generation - scenario 1 - wind	831 MW	1,033 MW	1,394 MW
Commercial generation - scenario 1 - solar	0.05 MW	646 MW	1,019 MW
Commercial generation - scenario 2 - wind	831 MW	1,012 MW	1,199 MW
Commercial generation - scenario 2 - solar	0.05 MW	636 MW	1,350 MW

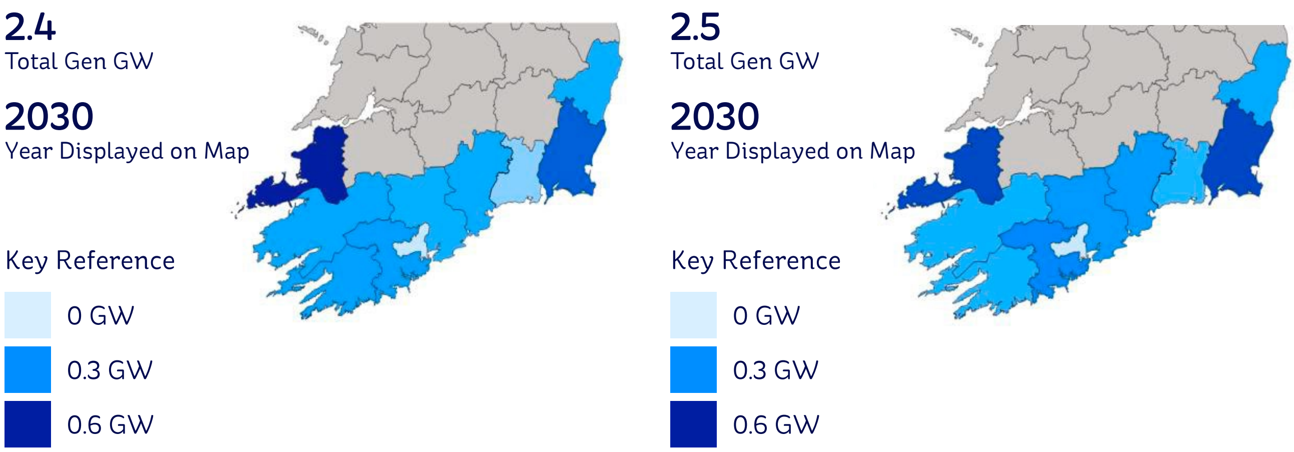


FIGURE 16
LEFT HAND SIDE GENERATION MW IN 2030 FOR SOUTH REGION (SCENARIO 1) – HIGH WIND; RIGHT HAND SIDE SCENARIO 2

7 AREA BY AREA ANALYSIS - DUBLIN REGION

7.4 DUBLIN REGION

The Dublin region encompasses the greater Dublin area, North, Central and South. The network here is predominantly urban, the longest MV feeder covering c. 55km of 3 phase network. The number of urban customers is c. 95% of the customer numbers. With the number of MV/LV substations dominated by urban MV/LV substations (c. 58%).

The tables below set out some detail identifying the areas within the region where we expect the highest uptake of low carbon technologies (electric vehicles; heat pumps and microgeneration) – first row; and the lowest uptake – second row. For example in scenario 1 by 2030, Dublin North is expected to have over 142,000 electric vehicles.

TABLE 38 **HIGHEST AND LOWEST LCT NUMBERS IN DUBLIN REGION**

Area	2020 LCT			2030 LCT		
Scenario 1 EV1, HP1, WP1	**EVs**	**HPs**	**PV**	**EVs**	**HPs**	**PV**
Highest in terms of EV numbers	Dublin North 4,810	Dublin North 9,130	Dublin Central 748	Dublin North 142,584	Dublin North 95,782	Dublin Central 9,803
Lowest in terms of EV numbers	Dublin South 3,192	Dublin South 6,093	Dublin South 342	Dublin South 95,827	Dublin South 63,895	Dublin South 4,888

TABLE 39 **HIGHEST AND LOWEST LCT NUMBERS IN DUBLIN REGION**

Area	2020 LCT			2030 LCT		
Scenario 2 EV2, HP2, WP2	**EVs**	**HPs**	**PV**	**EVs**	**HPs**	**PV**
Highest in terms of EV numbers	Dublin North 3,595	Dublin North 16,029	Dublin North 1,681	Dublin North 111,054	Dublin North 139,269	Dublin North 17,593
Lowest in terms of EV numbers	Dublin Central 1,756	Dublin South 8,954	Dublin Central 1,048	Dublin Central 54,445	Dublin South 82,309	Dublin Central 10,743

TABLE 40 **HIGHEST AND LOWEST LCT NUMBERS IN DUBLIN REGION**

Area	2020 LCT			2030 LCT		
Scenario 3 EV3, HP3, WP3	**EVs**	**HPs**	**PV**	**EVs**	**HPs**	**PV**
Highest in terms of EV numbers	Dublin North 7,009	Dublin Central 22,953	Dublin Central 2,097	Dublin Central 190,163	Dublin Central 184,154	Dublin Central 28,650
Lowest in terms of EV numbers	Dublin South 2,654	Dublin South 11,057	Dublin South 1,181	Dublin South 93,738	Dublin South 97,198	Dublin South 17,637

7 AREA BY AREA ANALYSIS - DUBLIN REGION

DEMAND

As shown in Section 2.1, the national peak demand is forecasted to be between 8.2GW and 9.2GW. As shown in Table 41, Table 42 and Table 43 below, the load in the Dublin region makes up c. 38% of the national load. The percentage of the Dublin Region 2030 peak demand coming from low carbon technologies, such as electric vehicles and heat pumps, at c. 35%, is in line with the national average of c. 36%.

TABLE 41 **SCENARIO 1 DUBLIN REGION LOAD GROWTH**

Scenario 1 EV1, HP1, WP1	Unmanaged Peak Loading (MW)		
	2020	2025	2030
Total Load at peak	2,028 MW	2,423 MW	3,237 MW
Base Load (before LCT)	1,932 MW	2,054 MW	2,188 MW
Average % of load due to EVs	3%	9%	24%
Average % of load due to HPs	2%	6%	8%

TABLE 42 **SCENARIO 2 DUBLIN REGION LOAD GROWTH**

Scenario 2 EV2, HP2, WP2	Unmanaged Peak Loading (MW)		
	2020	2025	2030
Total Load at peak	2,030 MW	2,463 MW	3,215 MW
Base Load (before LCT)	1,941 MW	2,094 MW	2,268 MW
Average % of load due to EVs	2%	9%	17%
Average % of load due to HPs	2%	5%	12%

TABLE 43 **SCENARIO 3 DUBLIN REGION LOAD GROWTH**

Scenario 3 EV3, HP3, WP3	Unmanaged Peak Loading (MW)		
	2020	2025	2030
Total Load at peak	2,020 MW	2,493 MW	3,505 MW
Base Load (before LCT)	1,890 MW	1,912 MW	2,031 MW
Average % of load due to EVs	3%	10%	28%
Average % of load due to HPs	3%	14%	14%

7 AREA BY AREA ANALYSIS - DUBLIN REGION

GENERATION

The Dublin regions are classed as solar regions due to their location on the east coast. As a result of this, there is little wind forecasted for this region. Solar installations in the area are forecasted to be c. 10 % of the national solar MW. There is no large scale generation forecast for Dublin Central.

TABLE 44 **SCENARIO 1 DUBLIN REGION MICROGENERATION FORECAST**

Scenario 1 Microgeneration	Generation connected		
	2020	2025	2030
Existing generation			
Impact of PVs	4 MW	5 MW	6 MW
Commercial generation - scenario 1 - wind	1 MW	1 MW	1 MW
Commercial generation - scenario 1 - solar	-	162 MW	197 MW
Commercial generation - scenario 2 - wind	1 MW	1 MW	1 MW
Commercial generation - scenario 2 - solar	-	162 MW	277 MW

TABLE 45 **SCENARIO 2 DUBLIN REGION MICROGENERATION FORECAST**

Scenario 2 Microgeneration	Generation connected		
	2020	2025	2030
Existing generation			
Impact of PVs	10 MW	12 MW	8 MW
Commercial generation - scenario 1 - wind	1 MW	1 MW	1 MW
Commercial generation - scenario 1 - solar	-	162 MW	197 MW
Commercial generation - scenario 2 - wind	1 MW	1 MW	1 MW
Commercial generation - scenario 2 - solar	-	162 MW	277 MW

7 AREA BY AREA ANALYSIS - DUBLIN REGION

GENERATION continued

TABLE 46 **SCENARIO 3 DUBLIN REGION MICROGENERATION FORECAST**

Scenario 3 Microgeneration	Generation connected		
	2020	2025	2030
Existing generation			
Impact of PVs	13 MW	22 MW	18 MW
Commercial generation - scenario 1 - wind	1 MW	1 MW	1 MW
Commercial generation - scenario 1 - solar	-	162 MW	197 MW
Commercial generation - scenario 2 - wind	1 MW	1 MW	1 MW
Commercial generation - scenario 2 - solar	-	162 MW	277 MW

0.2
Total Gen GW

2030
Year Displayed on Map

Key Reference
- 0 GW
- 0.3 GW
- 0.6 GW

0.3
Total Gen GW

2030
Year Displayed on Map

Key Reference
- 0 GW
- 0.3 GW
- 0.6 GW

FIGURE 17
LEFT HAND SIDE GENERATION MW IN 2030 FOR DUBLIN REGION (SCENARIO 1) – HIGH WIND; RIGHT HAND SIDE SCENARIO 2

8

Conclusion

8 CONCLUSION

The introduction of circa 1M electric vehicles and 600,000 heat pumps across the country will have a significant impact on the electricity load, in particular in residential areas. While work is well underway in developing a picture of the available capacity across the country (depending on the expected local uptake), additional work is required to ensure as complete a picture as possible is available, and that we keep that picture up to date. This will include:

1. Completion of demand load flow studies at MV and 38kV and 110kV countrywide.
2. Detailed load flow studies assessing the impact of the additional generation (5GW) on the 38kV and 110kV system have yet to be completed.
3. Scoping and commencing studies to assess short circuit levels countrywide and where (or if) services could be used to alleviate any problems identified in terms of the short circuit level being too high, or too low.
4. Undertaking studies to assess the impact of distribution connected parties providing services to the transmission system and ensuring that the provision of these services can be facilitated in general.
5. Using the output of these studies to inform the need for flexible services – where, when and how much – across the country and also to identify where capital infrastructure development should be prioritised.
6. Setting up processes, similar to those in place for organic load growth, to ensure that our picture of where the new LCT growth is occurring is kept up to date in a timely fashion.
7. Publication of opportunities for flexible services in local communities or occasionally further afield.
8. Identifying and removing any blockers to participation.
9. Identifying any scenarios where a mandatory response may be required.

8 CONCLUSION

In the more immediate future and as set out in detail in the paper detailing piloting plans, we are planning to procure flexible services in 2022 in a number of locations. The locations being considered are:

LOCATION	RANGE OF MW REDUCTION WHICH MAY BE PROCURED
Watling St, Dublin City Centre	Up to 8MW
Corduff, Co. Dublin	Circa 20MW
Wexford – specifically areas around Carriglawn; Clonard, Mulgannon	Circa 2MW
Trim, Co. Meath	Circa 5MW
Wexford - Clonroche area	Circa 3MW
Blake/Edenderry areas, Co. Offaly	Circa 3MW
Wexford/Carlow area specifically Tullow; Baltinglass; Shillelagh	Circa 4MW
McDermott St, Dublin City	Circa 12MW

While the services being requested in the initial pilot are demand down, subsequent pilots (2023 and beyond) will also call for demand up – to facilitate renewable generation – and other services such as kVAr up and down. These will be subject of calls to tender in 2022 and beyond.

9

Appendices

9 APPENDIX 1 - DEVELOPMENT OF 2030 SCENARIOS

GENERATION

1. IWEA provided detailed pipeline data from a survey of wind and solar developers.
2. SEAI provided access to environmental / planning sensitivity maps.
3. SEAI provided microgen. input data (forecast and historical data).
4. ESB Networks team coupled this with statistical analysis of historical connections & applications, and other data relating to natural resources and industry trends.

DEMAND

1. SEAI provided EV and heat pump grant data, BER maps, other research relating to demand and energy efficiency, and validating their use in projections.
2. ESB Networks scenarios were validated by SEAI, and aligned with SEAI energy modelling.
3. ESB Networks team coupled this with planning team underlying demand analysis, local authority and industry engagement insights from PR5.

SYSTEM SERVICES

1. EirGrid will provide technical scarcities data, and advising on locational vs. location agnostic requirements.
2. ESB Networks team will couple this with analysis / characterisation of the local impact of a providers' availability and delivery of service.

9 APPENDIX 1 - DEVELOPMENT OF 2030 SCENARIOS

ELECTRIC VEHICLES (936,000)

The challenge is to sensibly “allocate” EV uptake. We can randomly assign EVs applying a binomial distribution, which will allocate higher numbers of vehicles to locations with higher customer volumes.

Scenario 1 – PR5 submission + CAP trended to 2030:

1. 43% of EVs allocated to new housing.
2. 37% allocated to existing urban customers.
3. 19% allocated to existing rural customers.

Scenario 2:

1. 20% of EVs allocated to new housing.
2. 52% allocated to customers in commuter belt.
3. 27% split between urban & rural.

Scenario 3:

1. 60% uptake in areas with existing home charge points.
2. 30% commuter belt.
3. 10% across all existing customers.

9 APPENDIX 1 - DEVELOPMENT OF 2030 SCENARIOS

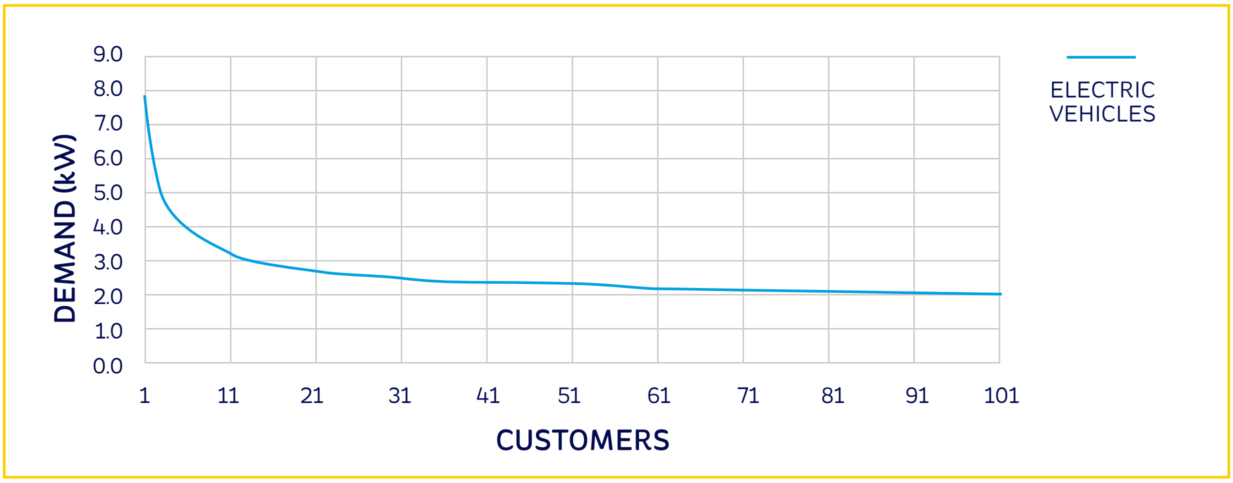
SEAI INPUTS

BER Database has some locational information, tying this with MV/LV sub locations can give a local picture:

1. **Sharing EV grant uptake & EV home charge point installs to help highlight areas where uptake is higher.**
2. **BER database to help determine households that may install charge points (i.e., have driveway, etc.)**

The graph below indicates the diversity which is applied to the load due to home charging points. This reflects the fact that not all customers will charge their EV at the same time in a given area.

FIGURE 18 **WINTER MAXIMUM DIVERSITY EQUATIONS**



9 APPENDIX 1 - DEVELOPMENT OF 2030 SCENARIOS

HEAT PUMPS (600,000)

As with EVs, for heat pumps (HP) we need assumptions to couple with our detailed geographical / connectivity models, to "allocate" electrical heating to existing and future homes. Heat pumps in new homes can be modelled as lumped new loads on the medium or high voltage system, but retrofit heat pumps need to be allocated to existing connected homes on the model.

Scenario 1 – PR5 submission + CAP trended to 2030:

1. 66% of HPs allocated to new housing.
2. 22% allocated to existing urban customers.
3. 11% allocated to existing rural customers.

Scenario 2 – CAP Uptake:

1. Up to 33% allocated to new houses.
2. 66% allocated to Houses with HLI of 2 or less.

Scenario 3 – Use BER data to focus on HLI of 2 or less:

1. All new houses assumed to have heat pumps installed.
2. 10% allocated to Houses with HLI of 2 or less.

SEAI INPUTS

BER Database has some locational information, tying this with MV/LV sub locations can give a local picture:

1. Houses with HLI of 2 or less heat pump ready function of existing.
2. Houses built in last 15 years.
3. New housing - HP installations increasing year on year.

The graph below indicates the diversity of heat pump load in a given area. While heat pumps will have a more constant load than EVs, the diversity reflects the fact that the boost to the load will vary across the day.

FIGURE 19 WINTER MAXIMUM DIVERSITY EQUATIONS

9 APPENDIX 1 - DEVELOPMENT OF 2030 SCENARIOS

MICROGEN (PV)

As with EVs and for heat pumps (HP), we need assumptions to couple with our detailed geographical / connectivity models, to "allocate" microgeneration to existing and future homes.

User BER roof area to determine suitable roofs.

Scenario 1:

1. 33% of new houses to have PV.
2. Installed size 2kW.

Scenario 2:

1. Allocations based on SEAI figures.
2. Allocation in "high" roof area areas.
3. Install size based on roof area 2-4kW.

Scenario 3:

1. Allocations based on SEAI figures.
2. Allocation in areas of existing high installs.
3. Install size based on location 2-4kW.

9 APPENDIX 1 - DEVELOPMENT OF 2030 SCENARIOS

SEAI INPUTS:

Current forecast PV installations in table below Average c. 2kW.

BER database:

1. **Shows average installation between 1-4kW can be assigned based on locational data.**
2. **Shows average roof area per kW to be c. 36m².**

YEAR	NEW HOMES	EXISTING HOMES	NO. OF INSTALLATIONS	ANNUAL KW RETROFIT	TOTAL INSTALLED KW
2020	6,500	2,600	9,100	6,500	13,650
2021	9,000	3,120	21,220	7,800	31,350
2022	12,000	3,744	36,964	9,360	53,910
2023	10,500	4,493	51,957	11,232	76,692
2024	9,000	5,391	66,348	13,478	100,070
2025	9,000	5,661	81,009	14,152	124,123
2026	1,000	5,944	87,953	14,860	140,083
2027	1,500	6,241	95,694	15,603	157,336
2028	2,000	6,553	104,247	16,383	175,919
2029	2,500	6,881	113,628	17,202	195,871
2030	3,000	7,225	123,853	18,062	217,233

9 APPENDIX 1 - DEVELOPMENT OF 2030 SCENARIOS

GENERATION:

Scenario 1 – 80% wind 20% solar (IWEA Pipeline).

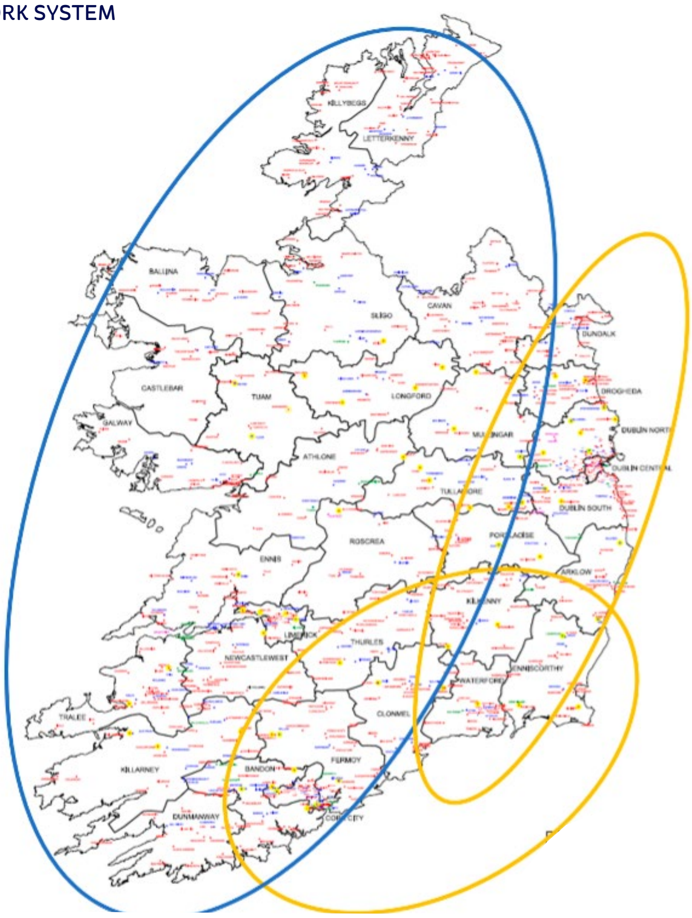
Scenario 2 - 40% wind 60% solar (RESS Auction).

Generation numbers driven by CAP:

1. 500MW to be connected per year on distribution system.
2. IWEA pipeline study to help inform on likely locations for connections.
3. SEAI planning database & LARES tool to help inform on likely locations for connections.
4. Blue circle (on below figure) predominantly wind connections.
5. Orange circle (on below figure) predominantly solar connections.
6. Normal distribution of capacities around an average wind connection ≈ 10MW.
7. Normal distribution of capacities around an average solar connection ≈ 4MW.

FIGURE 20 **HIGH VOLTAGE NETWORK SYSTEM**

Key Reference
WIND AREAS
SOLAR AREAS



9 APPENDIX 1 - DEVELOPMENT OF 2030 SCENARIOS

UNDERLYING DEMAND

Growth rates built up based on:

1. Historic trending of "organic" load growth.
2. Spot load application based on Industrial Development Agency (IDA), local authority and other stakeholder insights.
3. National Development Plan housing volumes.
4. NDP strategy of "compact, sustainable development", consultation with regional assemblies, and volumes of new homes.
5. Peak demand reduction of 8.8% in domestic premises arising of smart metering.

Scenario 1 – PR5 submission trended to 2030:

1. High Growth rates tied to NDP areas 2%.
2. Low Growth locations1%.

Scenario 2:

1. High Growth 2.5%.
2. Med Growth 2%.
3. Low Growth 1%.

Scenario 3- recession to 22:

1. Negative growth 20-21.
2. Return to positive growth 22.
3. Return to PR5 growth 23.

9 APPENDIX 2 – LOAD FLOW METHODOLOGY

The distribution system delivers electricity to 2.3 million customers in Ireland, operating at 110kV in the Dublin area, and at 38kV, 20kV, 10kV and low voltage (LV) nationwide. In serving Ireland's large rural population, the network length per capita is four times the European average and overhead lines outnumber underground cables 6:1. The distribution system also includes a large number of substations that step between the different voltages of the distribution system.

To understand the impact of load and generation on our system, load flow studies are undertaken, and the outcome documented. The sections below set out some information in relation to how these studies were undertaken

LOAD FLOW STUDY METHODOLOGY.

The load flow studies are conducted within the PSS Sincal software which is a software package used by industry. The studies aim to assess the loading and voltage profile of the entire distribution network from the MV voltage level (20kV and 10 kV) up to 38 kV and 110 kV. Given the significant quantity of network to be assessed the analysis is divided up by voltage level and further by network area.

MV Network Studies

The analysis is initially focused on the MV voltage level. In this analysis the load points are modelled at the MV/LV transformer locations. Separate loads are modelled at each load point to represent the following load elements:

1. **WP Underlying demand**
2. **Summer night valley underlying demand**
3. **Electric Vehicle load**
4. **Heat Pump load**
5. **Microgeneration**

The modelling of the loads in this manner allows for the investigation of multiple scenarios, such as that of the underlying demand in the absence of the forecast LCT such as EVs or heat pumps, or the maximum load scenario which would be composed of the underlying demand connected at the same time as the EV and heat pump load. The analysis of the MV networks will identify

1. **Sections of network which become overloaded.**
2. **The time/year that the overload first occurs.**
3. **The extent of the overload.**

9 APPENDIX 2 – LOAD FLOW METHODOLOGY

Additionally, the analysis will identify feeders which encounter voltages outside of the limits specified within the Distribution System Security and Planning Standards (as shown in Table 47)

For the purpose of the 2030 studies, all new renewable commercial generation is modelled as being connected to the 38 kV network. As a result, the MV studies are primarily focused on demand scenarios. However, an additional analysis is completed considering the summer valley load in parallel with the forecast microgeneration penetration in each MV network area. Load flow simulations are carried out assuming both normal feeding and the worst-case contingency feeding. The worst-case contingency is where an entire MV feeder is fed from a single 38kV (or 110kV/MV) substation. This is modelled by way of closing a normally open point and opening of the breaker in one of the two substations which supply the feeder under normal feeding.

38kV station transformer capacity

The loading of the 38kV / MV and 110kV/MV transformers is calculated by means of assessment in Microsoft EXCEL.

110kV and 38kV System loading

To carry out the assessment of the 110 kV and 38 kV system loading, the loads that are modelled at MV are summed up to the relevant 38 kV substation level. The analysis of the 110 kV and 38 kV system is done both under a maximum demand scenario and a maximum generation scenario. As was the case with the MV analysis the demand scenario simulation looks to forecast feeders and transformers that might become overloaded in the future, and the time that the overload might first occur.

The generation analysis - which is conducted based on the assumption that 5 GW of new renewable generation will be connected to the distribution networks by 2030 - seeks to identify occasions where circuits or transformers become overloaded, or voltage standards are breached, because of generators exporting at their maximum export capacity. As was the case in the MV analysis the analysis of the 110 kV and 38 kV networks is completed under both normal and the worst-case N-1 analysis, where the loss of a single 110/38 kV transformer or a single 38 kV circuit is investigated.

TABLE 47 **PERMITTED VOLTAGE DROPS**[22]

Description	Sending Set Point Vs	Maximum Network Voltage Drop	
		Normal	Contingency
HV – 110 kV	See Footnote Below		
HV – 38 kV	41.6 kV	10.5% = 4.3 kV to 37.3 kV	14.5% = 6 kV to 35.6 kV
MV – 20 kV	21.4 kV	5% = 1.1 kV to 20.3 kV	10% = 2.1 kV to 19.3 kV
MV – 10 kV	10.7 kV4	5% = 0.5 kV to 10.2 kV	10% = 1.1 kV to 9.6 kV

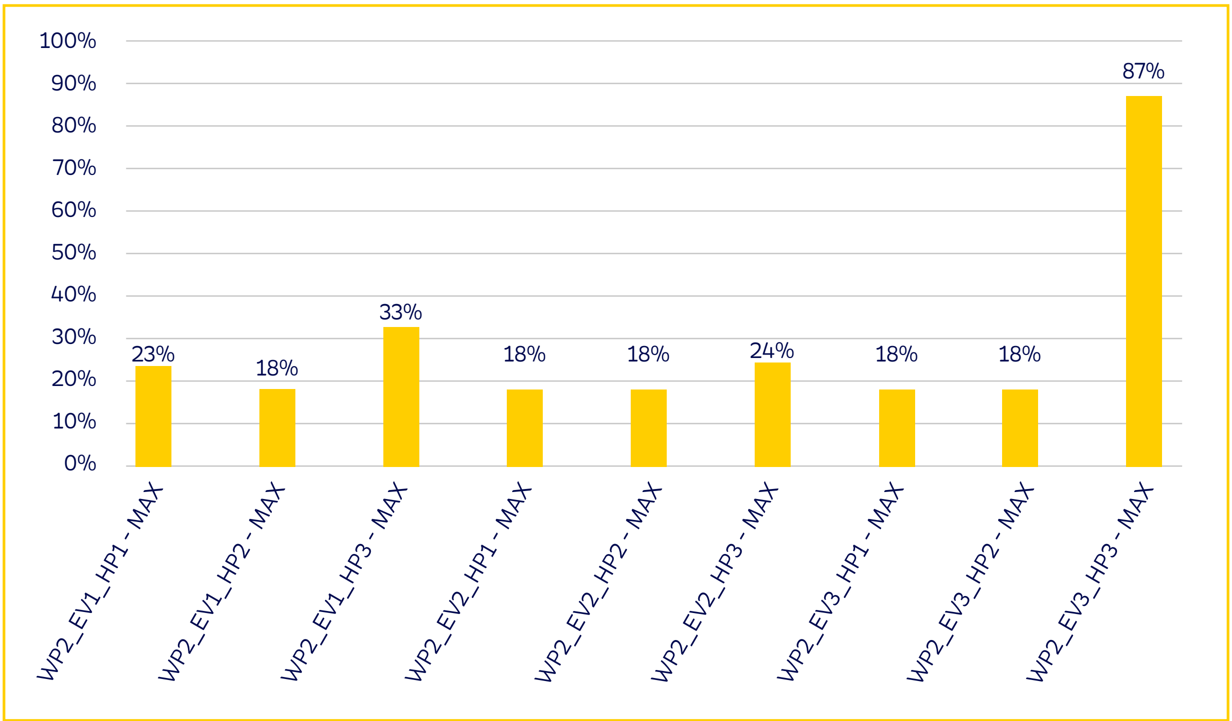
[22] Main source voltages on the 110kV networks are generally controlled by TSO. Permitted voltage drops on distribution 110kV networks should be determined on a case by case basis; however volt drop assessments shall maintain the receiving voltage on all distribution 110kV and lower voltage (38kV and MV) busbars within normal voltage ranges and take account of the operating voltage range on the TSO interfacing 110kV busbar.

9 APPENDIX 2 – LOAD FLOW METHODOLOGY

SCENARIO SELECTION:

Prior to conducting the analysis of any MV network area an assessment is first carried out to identify the worst-case scenario to be studied in relation to the low carbon technology that is forecast for that area. This is done by completing an excel analysis of the load data to identify the scenarios in relation to EVs, heat pumps and PVs which give rise to the highest predicted loading (in 2030), on the most feeders within a specific MV network area. Figure 21 is a sample of a graph produced by the excel analysis when identifying the worst-case scenario in a particular network area[23]

FIGURE 21 **SCENARIO IDENTIFICATION GRAPH**



[23] Please note that – on occasion – scenarios gave identical results. As a consequence, we would not expect the % to add to 100%.