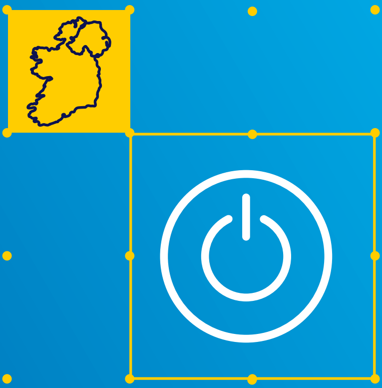
ESB NETWORKS

2030 Power System Requirements

NATIONAL NETWORK, LOCAL CONNECTIONS PROGRAMME

DOC-230921-GYN

Updated following consultation in Q4 2021



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Glossary

1 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 Volt Amperes
GVAr	Giga Volt Ampere of reactive power
GW	GigaWatts
HP	Heat Pump
kVA	kilo Volt Amperes
kVAr	kilo Volt Ampere of reactive power
kW	kilo Watts
LARES	Local Authority Renewable Energy Strategy
LCT	Low Carbon Technology
LV	Low voltage – 400 V (3 phase) 240 V (1 phase)
MEC	Maximum Export Capacity
MIC	Maximum Import Capacity
MV	Medium Voltage (10 kV and 20 kV)
MVA	Mega Volt Amperes
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

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Overview

2 OVERVIEW

The core objective of the National Network, Local Connections Programme is to bring together changes in how we are generating electricity, and how we are using it, enabling all electricity customers and communities to play an active role in climate action, by using or storing renewable electricity when it is available to them locally. This document sets out the initial scenario analysis and extensive technical power system analyses underpinning the programme rollout strategy.

In Q4 2021, we consulted on an initial high level view of the 2030 Power System Requirements, as a supporting document providing context to other documents consulted on, in advance of the publication of the full results. This document updates the consulted document based on the feedback received, and provides deeper insights accounting for the analyses completed by the end of 2021.

Positive and constructive stakeholder feedback was received on this document, with 35 items of feedback received. This feedback provided a rich insight into the perspectives of our stakeholders on this area. All feedback was carefully reviewed and feedback which fell within the scope of the programme was considered in updating the proposed 2030 Power System Requirements which has now formed this 2030 Power System Requirements delivery plan.

The key themes arising in stakeholders' feedback were:

1. **Stakeholder endorsement of the approach taken to identify the 2030 Power System Requirements, including the use of scenario analysis and collaborative data sharing;**
2. **The value of spatial visualization approaches in presenting the results, and a range of suggestions for results to be included in future analyses;**
3. **The importance of sharing this analysis, and of providing industry and stakeholders with this kind of transparent forecasting and projections.**

Where possible, we have accounted for this and the full body of feedback received, in this updated document and in our future plans for power system studies undertaken within the National Network, Local Connections Programme.

For more information on the stakeholder feedback received and how this feedback has been incorporated into the National Network, Local Connections Programme delivery plans and policy documents, please refer to the Consultation Core Response Paper available on the National Network, Local Connections Programme website.

3

Background: The Challenge

3 BACKGROUND: THE CHALLENGE

With the release of the Climate Action Plan 2019[1] and subsequent Climate Action Plan 2021, the Irish 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% of electricity to come from renewable energy sources (as per the national development plan[2] and updated Climate Action Plan[3])**

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. Traditionally, when we take account of customers' peak electricity demand happening at different times in different homes, the average peak demand per customer for a group of customers (for example in a housing estate) comes to circa 2.5kW per household. This is called After Diversity Maximum Demand or "ADMD". This figure has been reassessed periodically and has proven robust for us to use when designing networks to date.

For new local networks, however, we are now designing for a higher value. The new value of 5.5kW has been calculated to account for domestic low carbon technologies, which 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, the wires 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 an 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 generation is connected locally to Irish communities nationwide, and we expect that in future far more of this generation will come from microgeneration and mini generation in the community. Based on stakeholder input, it is 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. Supporting this generation in the community will mean creating a central role for energy communities and active energy citizens on the Irish electricity system[3].

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 while continuing to ensure a safe and secure distribution system.

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[1] d042e174c1654c6ca14f39242fb07d22.pdf (assets.gov.ie)

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

[3] A revised Climate Action Plan has since been released (November 2021) and can be found at this link: https://assets.gov.ie/203558/f06a924b-4773-4829-ba59-b0feec978e40.pdf

3 BACKGROUND: THE CHALLENGE

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) distribution 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 heat pumps' and electric vehicles' electricity demand 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.

For those seeking to replicate and/or extend our analysis:

1. **The diversity profiles used are included in Appendix 1 for reference.**
2. **The volumes and distribution of electric vehicle and heat pump loads are as per the approach set out in Appendix 1 and as summarised in figures 3.1 – 3.2**

Sustainable Energy Authority Of Ireland (Seai) - Microgeneration And Low Carbon Technologies

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 on 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.

For those seeking to replicate and/or extend our analysis:

1. **The application of the data provided is set out in Appendix 1 and the results are as summarised in figures 3.1 – 3.6**
2. **Information on the LARES methodology is available at Methodology-for-Local-Authority-Renewable-Energy-Strategies.pdf (seai.ie)**

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[4] 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 BACKGROUND: THE CHALLENGE

3.1 METHODOLOGY continued

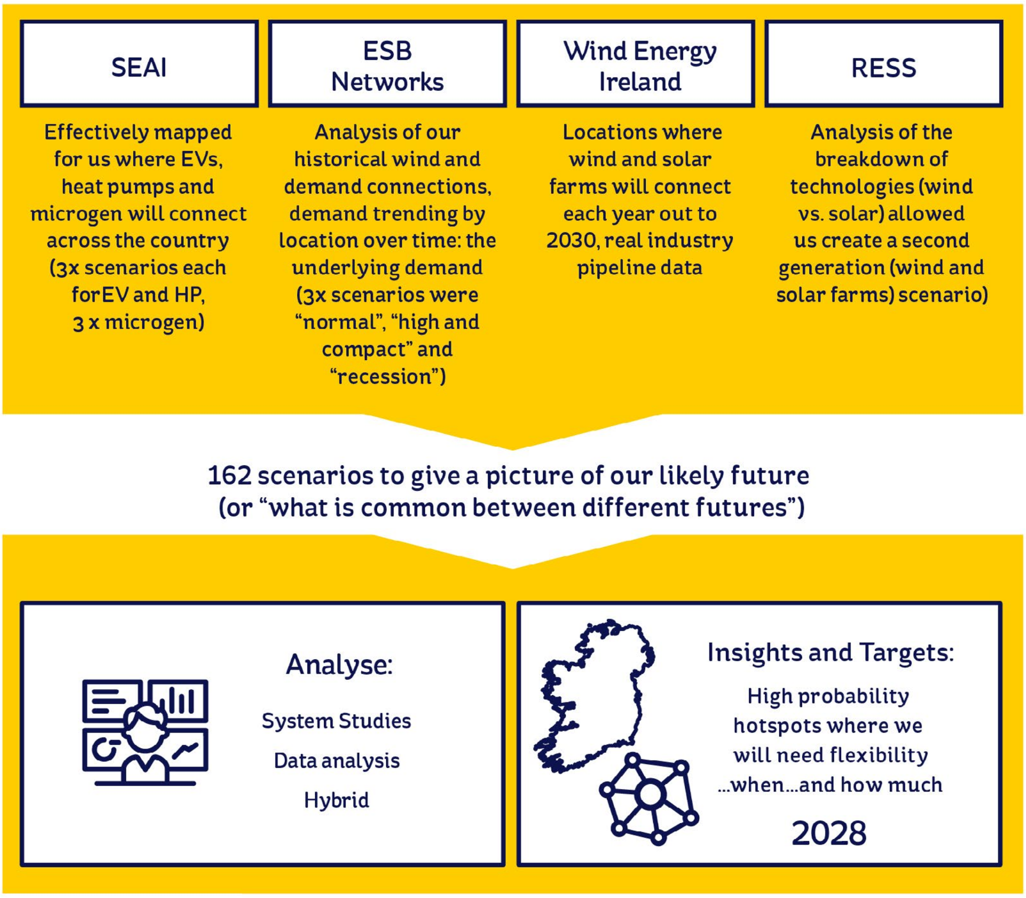
Wind Energy Ireland (WEI)

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.

For those seeking to replicate and/or extend our analysis:

- **The application of the data provided is set out in Appendix 1 and the results are as summarised in figures 3.5 – 3.6**



SEAI	ESB Networks	Wind Energy Ireland	RESS
Effectively mapped for us where EVs, heat pumps and microgen will connect across the country (3x scenarios each forEV and HP, 3 x microgen)	Analysis of our historical wind and demand connections, demand trending by location over time: the underlying demand (3x scenarios were "normal", "high and compact" and "recession")	Locations where wind and solar farms will connect each year out to 2030, real industry pipeline data	Analysis of the breakdown of technologies (wind vs. solar) allowed us create a second generation (wind and solar farms) scenario)

162 scenarios to give a picture of our likely future (or "what is common between different futures")

Analyse:

System Studies

Data analysis

Hybrid

Insights and Targets:

High probability hotspots where we will need flexibility ...when...and how much

2028

3 BACKGROUND: THE CHALLENGE

3.1 METHODOLOGY continued

The result of this data sharing is a load database which maps new electric vehicles; heat pumps and microgeneration to specific MV/LV substations across the country. The database also maps commercial scale generation to substations; at 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 ability of today's distribution system to support these new demands, and the technical challenges that need to be addressed to do so. This assessment was done for:

1. **MV circuits (based on modelling from the MV/LV substation upwards), through to 110kV/ MV and 38kV/ MV substations.**
2. **38kV circuits (and in some cases 110kV distribution, e.g. within Dublin) and 110kV/38kV substations.**

The study involves running powerflow and other analytical assessments on a year-by-year basis. The load database is reconfigurable on an annual basis, to allow us account for inevitable variations in the pattern of development from that forecasted.

The various scenarios currently modelled in the database are described in Appendix 1 and set out in graphical form in figure 3.1 – figure 3.6.

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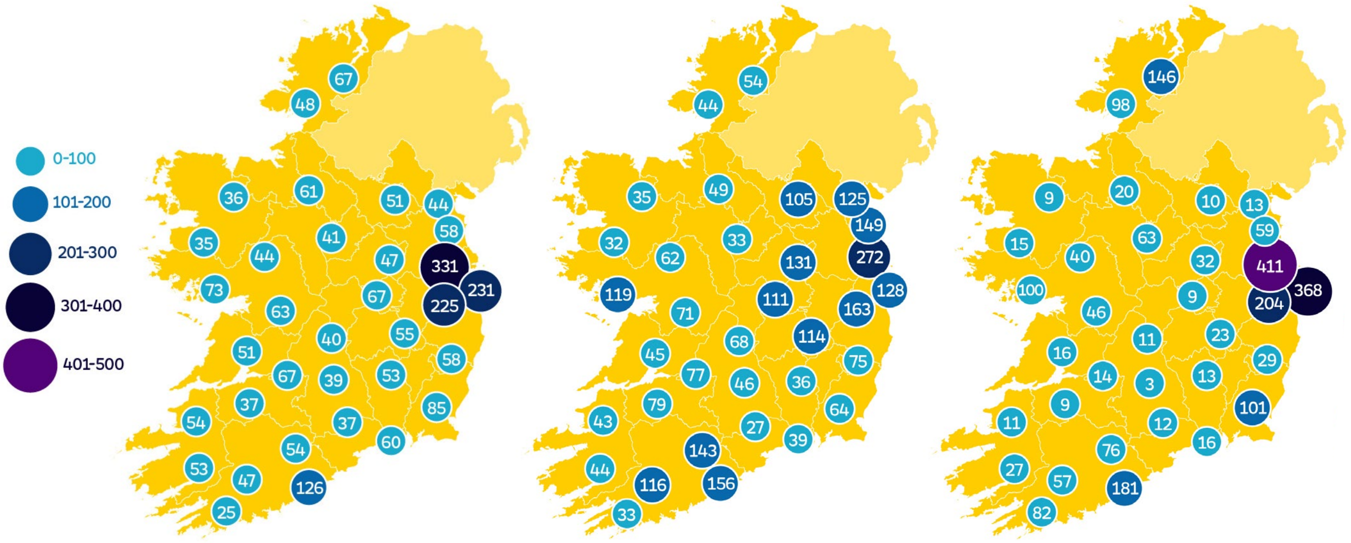
[5] Assumed to be rooftop PV.

3 BACKGROUND: THE CHALLENGE

Electric Vehicles (MW)

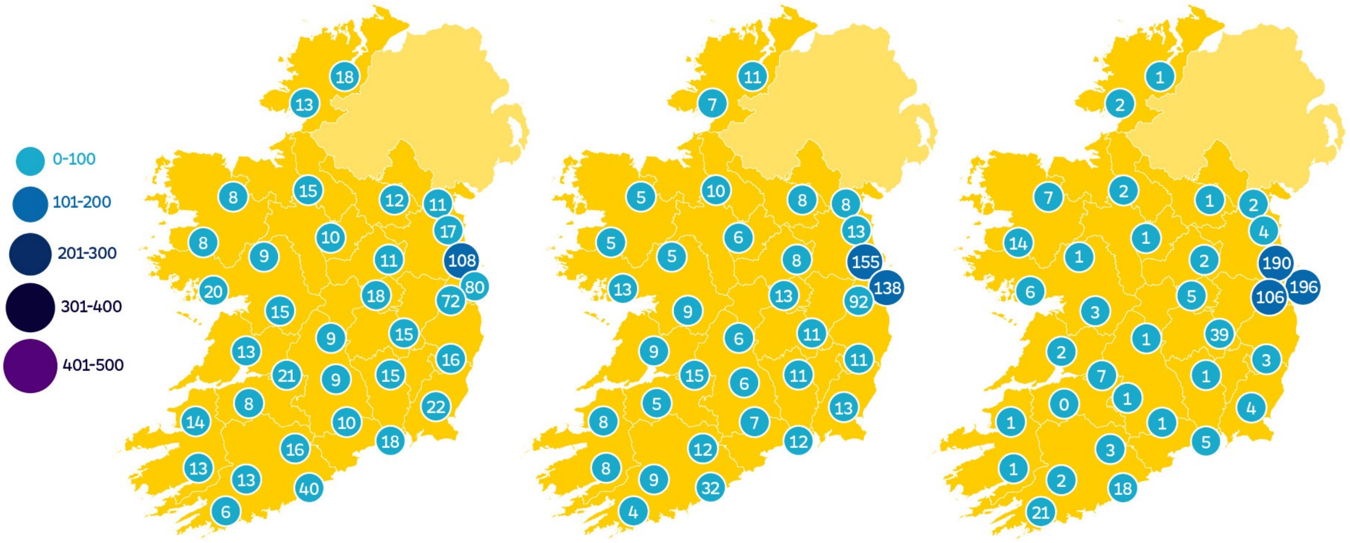
FIGURE 3.1 **SCENARIOS FOR UPTAKE OF EVS**



2030 SCENARIO 1 2030 SCENARIO 2 2030 SCENARIO 3

Heat Pumps (MW)

FIGURE 3.2 **SCENARIOS FOR UPTAKE OF HEAT PUMPS**

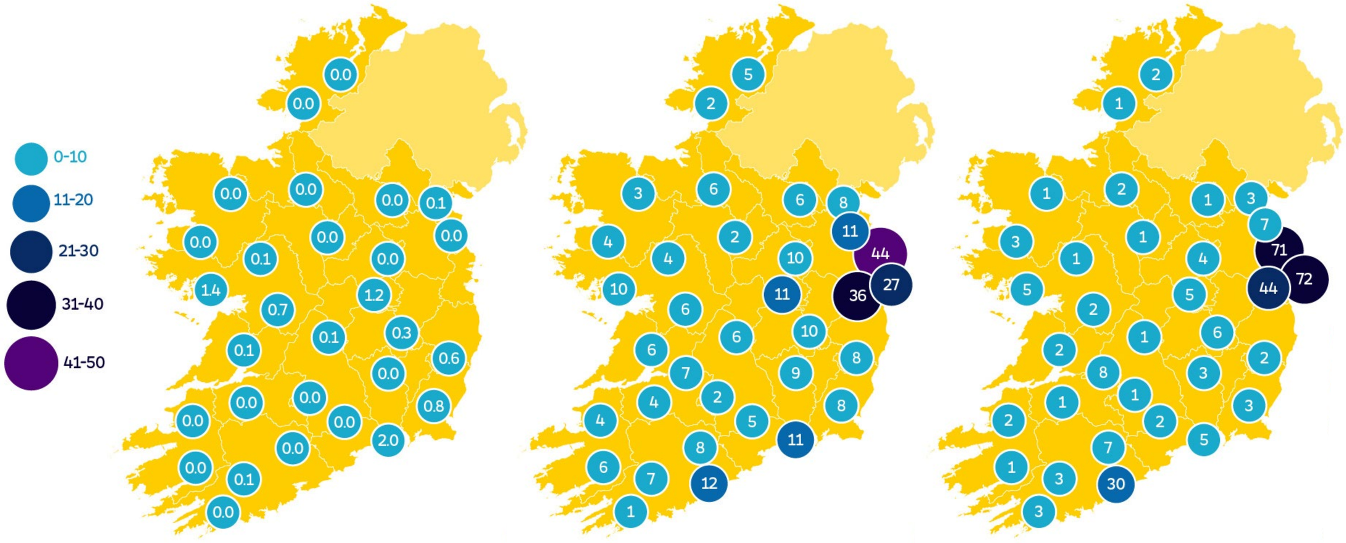


2030 SCENARIO 1 2030 SCENARIO 2 2030 SCENARIO 3

3 BACKGROUND: THE CHALLENGE

Micro Generation (MW)

FIGURE 3.3 **SCENARIOS FOR UPTAKE OF MICROGENERATION**



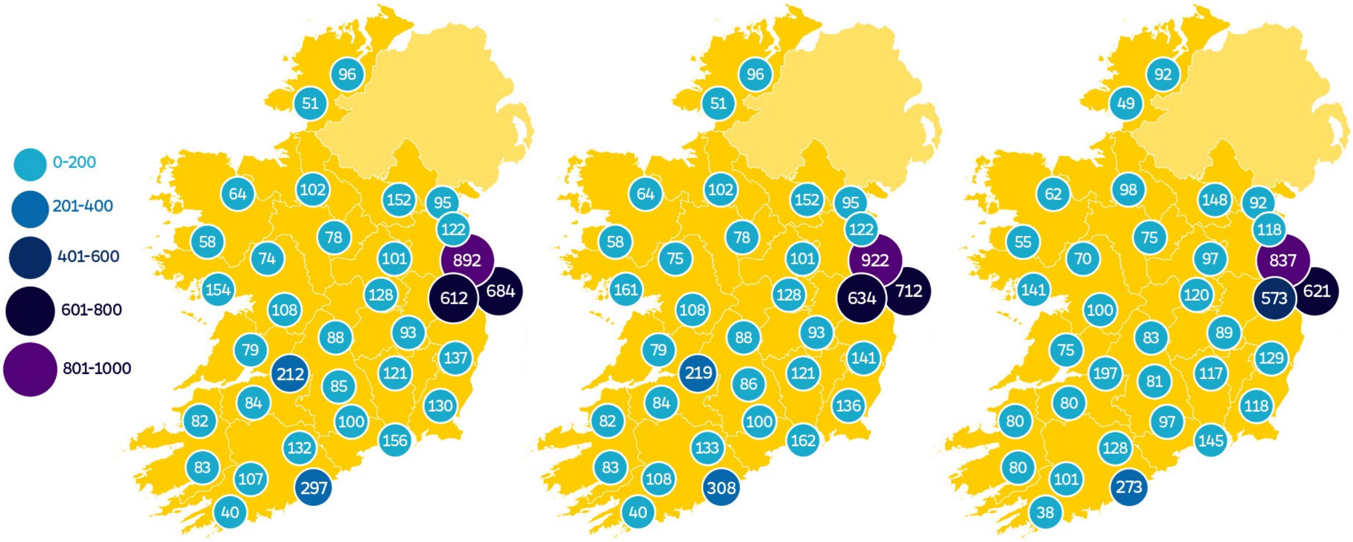
2030 SCENARIO 1

2030 SCENARIO 2

2030 SCENARIO 3

Underlying Demand (MW)

FIGURE 3.4 **SCENARIOS FOR GROWTH OF UNDERLYING DEMAND**



2030 SCENARIO 1

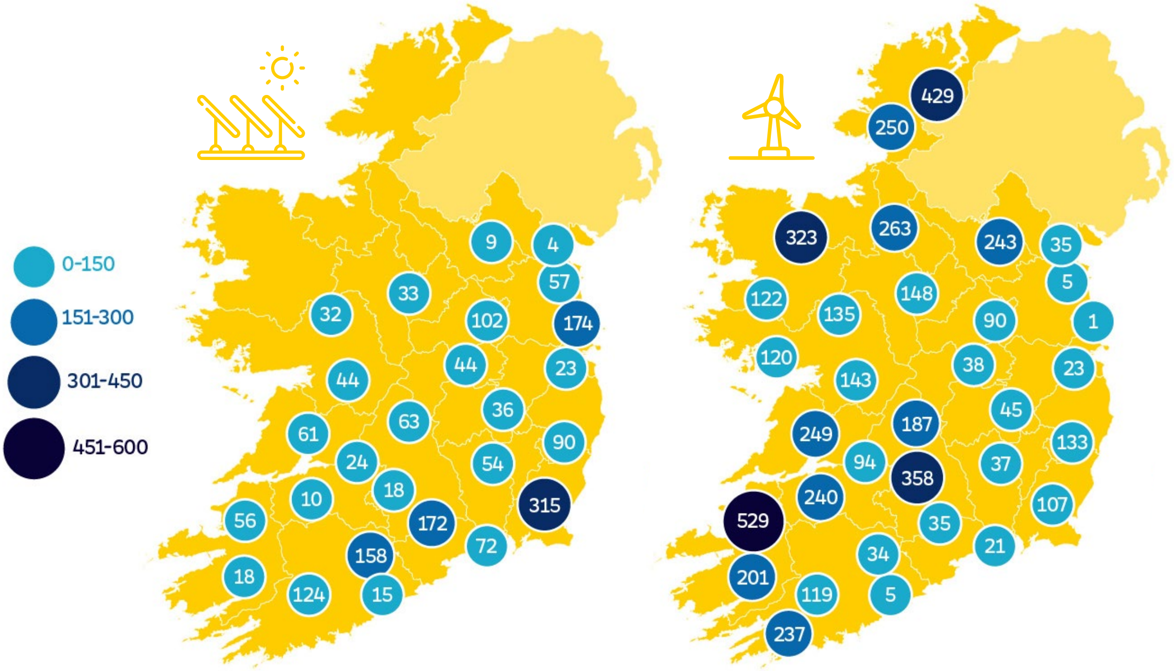
2030 SCENARIO 2

2030 SCENARIO 3

3 BACKGROUND: THE CHALLENGE

Larger Generation Scenario 1 (MW)

FIGURE 3.5 **SCENARIO 1 FOR COMMERCIAL GENERATION**

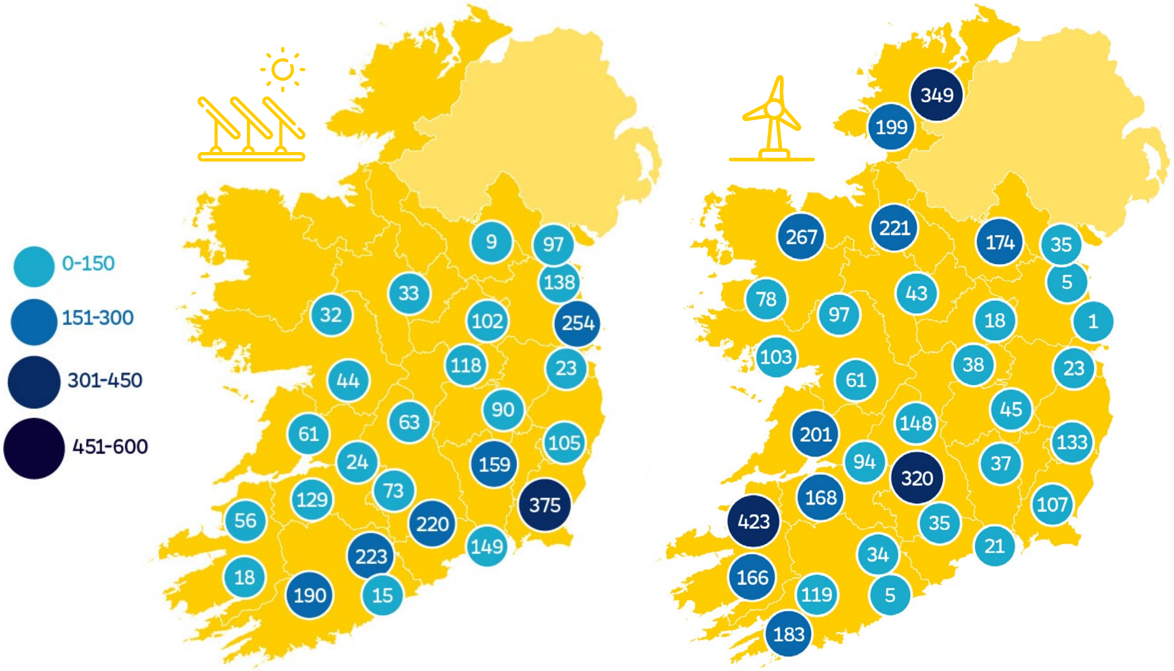


2030 SOLAR ONLY SCENARIO 1

2030 WIND ONLY SCENARIO 1

Larger Generation Scenario 2 (MW)

FIGURE 3.6 **SCENARIO 2 FOR COMMERCIAL GENERATION**



2030 SOLAR ONLY SCENARIO 2

2030 WIND ONLY SCENARIO 2

3 BACKGROUND: THE CHALLENGE

Load Flow Studies

The main source of detailed results in the 2030 Power System Requirements is a suite of load flow studies of the distribution system - at MV, 38kV and distribution 110kV. The output of these studies identifies issues or “technical scarcities” arising due to thermal and voltage constraints on the network.

These studies deliver a snapshot of capacity at all distribution voltage levels nationally, over the forthcoming decade. The studies were completed on a prioritised basis, with data analytics applied to prioritise locations where the expected uptake of EVs and heat pumps was highest. Further studies will continue into 2022.

Demand studies are being undertaken at peak loading, under normal and standby feeding arrangements. This provides information on available capacity both with and without the connection of new low carbon technology (LCT)[6] (i.e. with organic growth only and then also accounting for electric heating, transport and microgeneration as per the Climate Action Plan). These studies are based on a mix of the individual-resource scenarios, to allow us to identify the most onerous network conditions expected in a given area. Data analytics 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 (Appendix 7 provides some data on this).

Generation studies are assessing the impact and needs of distributed renewable generation, again under normal and standby feeding arrangements, at minimum loading, for both generation scenarios (high wind and high solar, in addition to batteries).

For those seeking to replicate and/or extend our analysis:

1. **Appendix 2 sets out the load flow methodology used**.
2. **Appendix 3 sets out key assumptions for the load flow studies**

Data Analysis

In addition to the load flow studies, our load database is also being assessed by data scientists. Using data science techniques, it has been possible to develop an approximate assessment of the available thermal capacity on the distribution system. Much of the information presented later in this document has been developed using these novel data analytics approaches. Appendix 5 provides results for MV capacity[7] based on data analytics.

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

[7] In parts of the country where the uptake of LCT is expected to be lower, and as a result load flow studies were not complete at time of writing this document.

3 BACKGROUND: THE CHALLENGE

International Input

ESB Networks is a member of the US based EPRI, the Electric Power Research Institute. EPRI conducts research, development, and demonstration projects for the benefit of the public in the United States and internationally, as an independent non-profit organisation for public interest energy and environment research.

EPRI has been commissioned to undertake MV power flow studies in a rural part of Ireland using their DRIVE tool. This novel approach extends the methodology used for the primary power system studies undertaken, to integrate data science and conventional powerflow techniques. The DRIVE tool uses a combination of load flow studies and data analytics to establish the 'hosting capacity' on an MV circuit. By comparing the hosting capacity with the expected load or generation on a circuit (based on ESB Networks' database as introduced in the previous section), it is possible to determine if the circuit currently has capacity to support future developments, and the degree to which this might be constrained. ESB Networks is considering how best to use this tool and adopt this approach in future studies to be undertaken.

For those seeking to replicate and/or extend this analysis:

1. **Information from the work undertaken to date is set out in later section of the paper and also in Appendix 4B.**
2. **The DRIVE tool can be found at this link https://www.epri.com/DRIVE**

4

Dealing with Demand

4 DEALING WITH DEMAND

As set out earlier in this document, the Climate Action Plan targets to reduce Ireland's carbon footprint through the electrification of heat and transport, powering this transformation largely through distributed renewable electricity generation.

4.1 DEMAND DEVELOPMENT

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

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

As can been seen in Figure 4.1, the peak load on the distribution system is forecasted to increase materially over the next 10 years, especially in the years after 2025 as uptake accelerates. This is due in large part to the uptake of low carbon technologies – such as electric vehicles and heat pumps – which are projected to comprise c. 36% of peak distribution system demand by 2030.

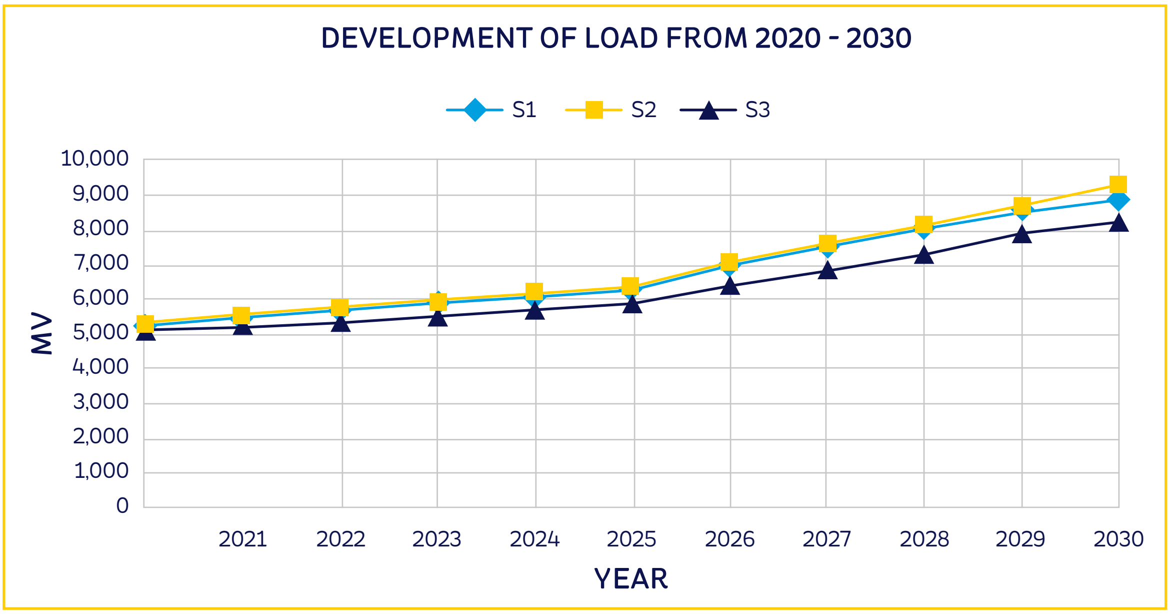
4 DEALING WITH DEMAND

4.1 DEMAND DEVELOPMENT continued

The graph below[8] shows the projected development of load to 2030 under 3 different scenarios. These core scenarios are created by combining different sub-scenarios for each of the individual types of low carbon technologies as follows (reference Appendix 1 also):

1. **Scenario 1 (S1) EV Sub-Scenario 1, HP Sub-Scenario 1, WP Sub-Scenario 1**
2. **Scenario 2 (S2) EV Sub-Scenario 2, HP Sub-Scenario 2, WP Sub-Scenario 2**
3. **Scenario 3 (S3) EV Sub-Scenario 3, HP Sub-Scenario 3, WP Sub-Scenario 3**

FIGURE 4.1 **LOAD GROWTH 2020 - 2030**



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[8] 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 4.1 **SCENARIO 1 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%

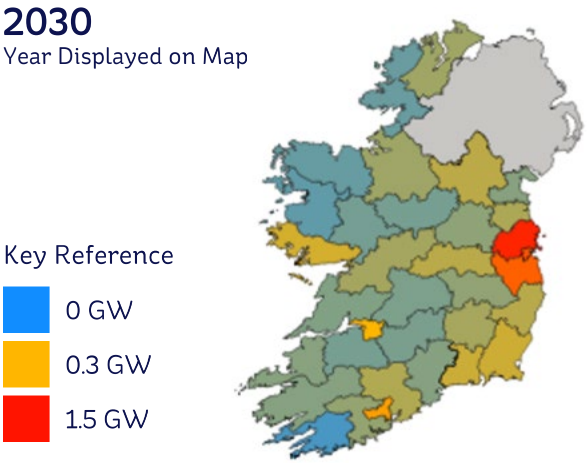


FIGURE 4.2
2030 PEAK LOAD DISTRIBUTION ACROSS THE COUNTRY - SCENARIO 1

TABLE 4.2 **SCENARIO 2 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%

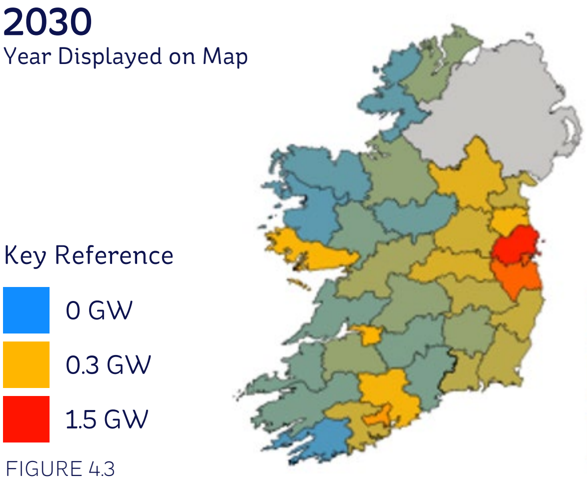


FIGURE 4.3
2030 PEAK LOAD DISTRIBUTION ACROSS THE COUNTRY - SCENARIO 2

TABLE 4.3 **SCENARIO 3 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%

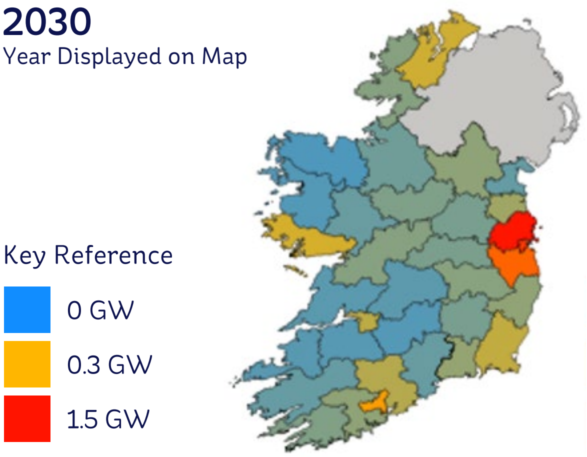


FIGURE 4.4
2030 PEAK LOAD DISTRIBUTION ACROSS THE COUNTRY - SCENARIO 2

4 DEALING WITH DEMAND

TABLE 4.4 **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 MANAGEMENT

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

Firstly, let's take electric vehicles. The figures above assume that while customers do not all charge at the same time, in the main they will charge their electric vehicles over roughly the same period in the evening. While this is likely, based on current market and behavioural dynamics, actions could be taken now to encourage more flexible charging patterns.

With the right market and technical signals, electric vehicle charging could be encouraged to charge at times which are much more favourable based on network or market conditions. Furthermore, this load – if charging at times when renewable generation is high – would increase the localised consumption of embedded renewable generation, and thus greatly decrease the need to reduce local generation. Given the nature of this 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. While heating demand is quite different from electric vehicle charging, given its "always on" nature, if customers changed their temperature requirement - for even a short period of time - substantial aggregate demand changes could be achieved.

Our analysis to date indicates that organic load growth continues to be aligned with historical patterns, reflecting social and economic patterns, and the connection of new customers and industries. As customers engage more actively in energy efficiency improvements however, the expected scale of organic demand growth may not materialise in full . More significantly, however, for active customers, energy efficiency initiatives 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 will allow customers to save money while assisting with the Climate Action Plan.

[9] Appendix 7 gives a flavour of the reduction in peak load which may result simply from moving to night-time charging. However, graphs shown also indicate the possibility of introducing a new night-time peak if all vehicles charge at night.

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

4.3 MANAGEMENT continued

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 reflected in Tables 4.1-4.4 above due to peak demand conditions typically falling after sunset) will assist in feeding some of the new demand. This is particularly the case in domestic or mixed areas, and for demand which does not solely occur at winter teatime.

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.

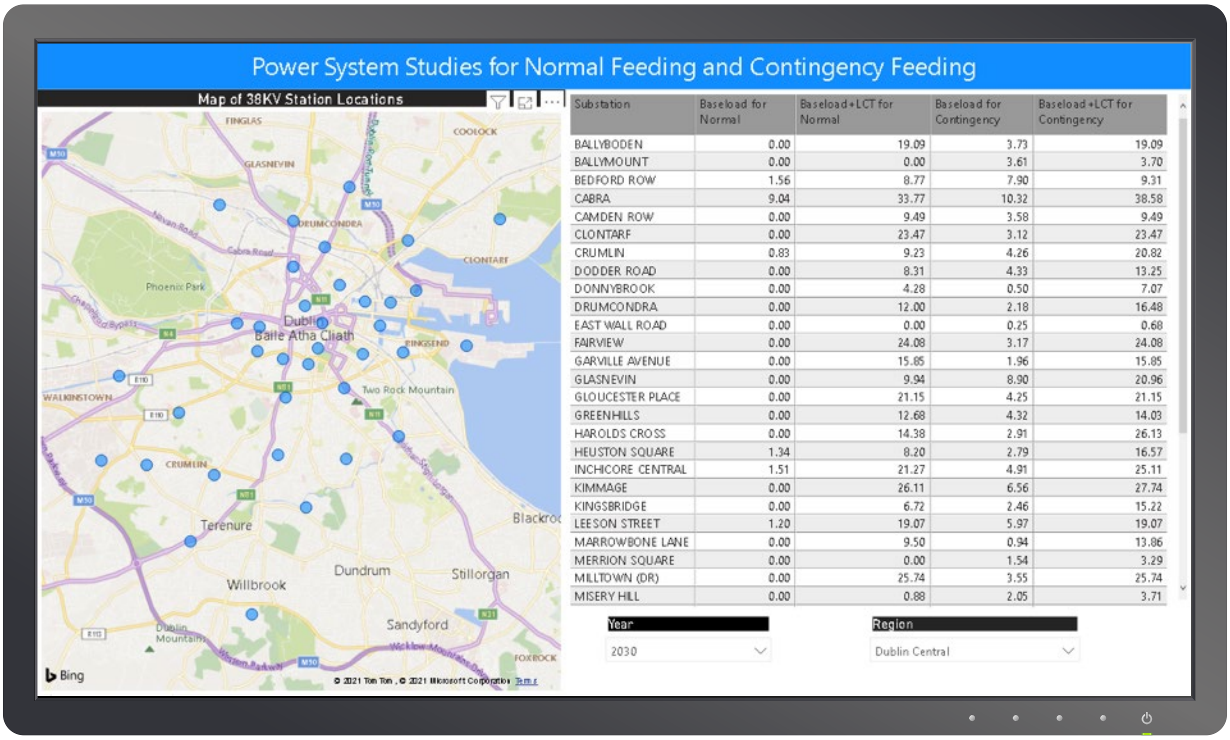
Figures 4.5-4.8 below give an example of the manner in which we will use the data generated by detailed studies:

1. **To focus on where flexible services can be used and/or should be piloted initially; 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 for customers.**

4 DEALING WITH DEMAND

4.3 EXAMPLE OF HOW WE WILL USE THIS INFORMATION continued

FIGURE 4.5 **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

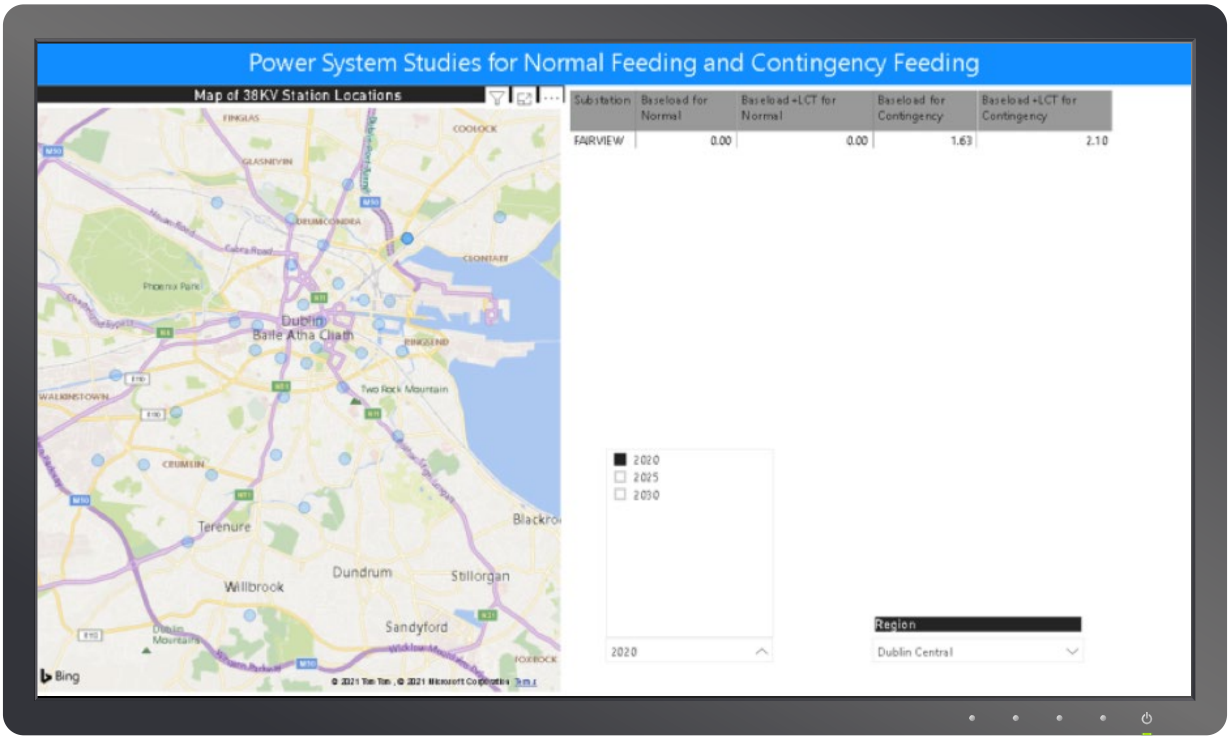
The numbers in the table above set out capacity shortfalls based on unmanaged load growth, and existing infrastructure only (i.e. before any upgrades) at high voltage stations in the Dublin area. The detail is as projected out to 2030, and the table identifies the flexible services that would be required (in MW) (columns from left to right) to meet the identified shortfall:

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

4.3 EXAMPLE OF HOW WE WILL USE THIS INFORMATION continued

FIGURE 4.6 **POWER SYSTEM STUDIES FOR NORMAL FEEDING AND CONTINGENCY FEEDING**



Power System Studies for Normal Feeding and Contingency Feeding

Substation	Baseload for Normal	Baseload +LCT for Normal	Baseload for Contingency	Baseload +LCT for Contingency
FAIRVIEW	0.00	0.00	1.63	2.10

■ 2020
☐ 2025
☐ 2030

2020

Region
Dublin Central

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 narrow as this is an older part of the city, making network upgrades particularly disruptive.

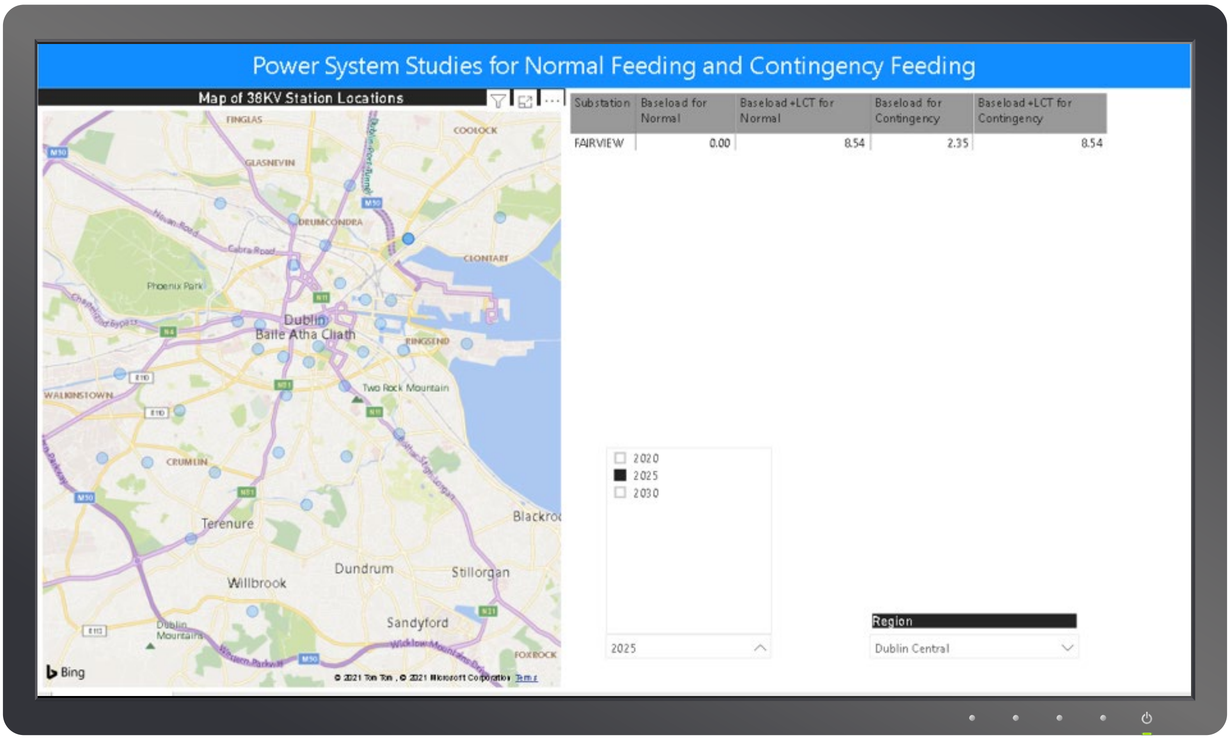
In 2020, the figures above identified the potential to introduce some flexible services (circa 2MW) under certain standby feeding arrangements. The table above identifies that this is the case even without the impact on the load due to electric vehicles and heat pumps (referred to as “LCT” below).

Currently, and in advance of having a flexible services market, load transfers between stations (especially in an urban setting) would most likely be able to address a 2MW shortfall.

4 DEALING WITH DEMAND

4.3 EXAMPLE OF HOW WE WILL USE THIS INFORMATION continued

FIGURE 4.7 **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
FAIRVIEW	0.00	8.54	2.35	8.54

☐ 2020
■ 2025
☐ 2030

2025

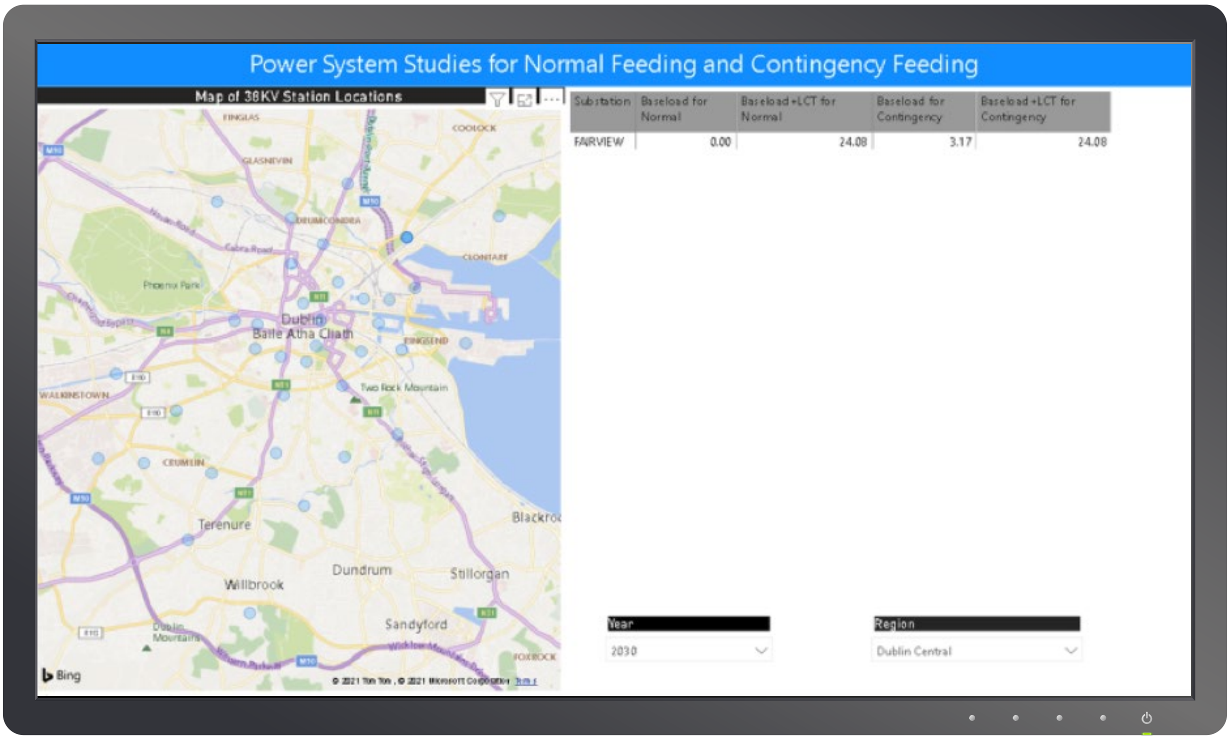
Region
Dublin Central

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 plan for alternatives to flexible services especially where the take up of LCT in the area is as currently predicted.

4.3 EXAMPLE OF HOW WE WILL USE THIS INFORMATION continued

FIGURE 4.8 **POWER SYSTEM STUDIES FOR NORMAL FEEDING AND CONTINGENCY FEEDING**



Substation	Baseload for Normal	Baseload +LCT for Normal	Baseload for Contingency	Baseload +LCT for Contingency
FAIRVIEW	0.00	24.08	3.17	24.08

Year: 2030

Region: Dublin Central

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 without any additional infrastructure added in the area in the interim.

Notwithstanding the potential for flexibility, at this level of demand relative to the underlying infrastructure in this location, this information is indicative of a need to plan for additional electricity infrastructure in the area.

4 DEALING WITH DEMAND

4.3 EXAMPLE OF HOW WE WILL USE THIS INFORMATION continued

The map below (Figure 4.9) indicates the MV/LV substations fed from Fairview 38kV / MV station. Assuming the load development in the area is as currently projected, customers who are in the vicinity of these substations in 2030 will be able to offer flexible services to alleviate congestion. Maps for other areas are included in Appendix 7. If your area is not included and you are interested in getting this detail, please contact engagement@esbnetworks.ie.

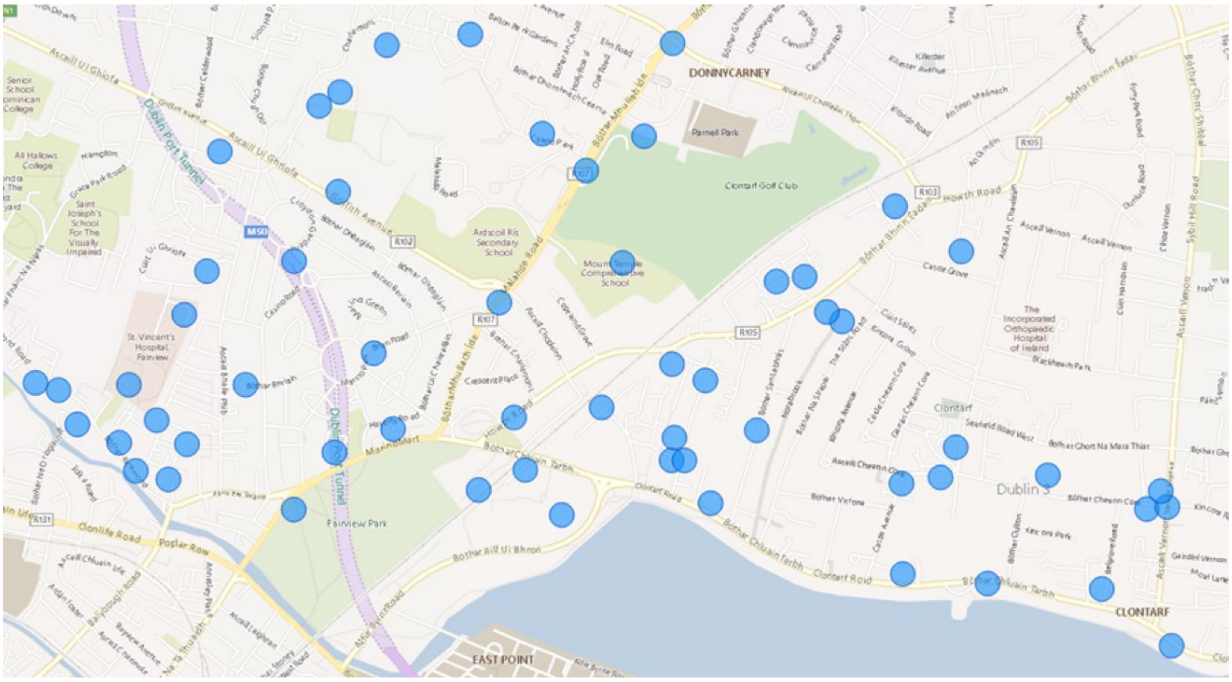


FIGURE 4.9 **MORE DETAILED MAP SHOWING MV SUBSTATIONS IN FAIRVIEW AREA**

4.4 DETAILS OF CAPACITY AVAILABLE AND POSSIBLE SCOPE FOR FLEXIBLE SERVICES

Appendix 4 provides summaries of the detailed load flow study results undertaken to date on an area-by-area basis. These detailed studies include information on the potential for flexible services in different parts of the country. Appendix 5 provides additional information - developed using novel data analytics approaches - for areas where load flow studies are not currently identified as high / medium priority based on projected uptake of low carbon technologies such as EVs, heat pumps and microgeneration.

In addition to these more detailed results, the more high-level tables below aim to provide a full picture of the capacity for load growth across the country over the next decade. It highlights what infrastructure at what voltage, is most likely to require a solution (either flexibility or additional infrastructure or both); and whether this need is primarily driven by new low carbon technologies or normal organic electricity demand growth.

This information is provided for the 3 different scenarios (labelled S1; S2; S3) set out in section 4.1 and explained in Appendix 1. The analysis below is based on analysis of the load database completed by data scientists, to assess demand and generation projections comparing this against circuit and transformer thermal capacity. As this is a novel approach and does not involve the use of powerflow analysis, the results are approximate only, and more detailed results are being obtained through load flow studies. However, this approach offers an efficient means of relatively quickly assessing capacity for a large portion of the network.

4.1.1 DEMAND DATA COUNTRYWIDE

The tables below, and the accompanying graph, indicate that the MV system is already quite heavily loaded in Ireland. As such, with the uptake of new low carbon technologies (such as EVs and HPs), loading will potentially increase significantly as we move towards 2030 and achievement of our Climate Action Plan targets. This means that solutions including flexibility and infrastructure upgrades in line with our PR5 (and expected PR6) programmes will be important.

It is worth noting that this is a picture of what would happen without new solutions, and undertaken for the purpose of planning the rollout of the necessary solutions. It is based on the most onerous conditions and assumptions regarding customer behaviours. By setting a new target for 20-30% demand side flexibility, the Climate Action Plan 2021 lays the foundations for solutions to address this.

The introduction and take up of flexible services and the delivery of improved infrastructure in the parts of the system where this is the optimum approach, is designed to address the identified shortfalls, enabling our Climate Action Plan targets and the active participation of customers.

4 DEALING WITH DEMAND

4.1.1 DEMAND DATA COUNTRYWIDE continued

TABLE 4.5 **MV CIRCUIT LOADING SUMMARY, NO LCT**

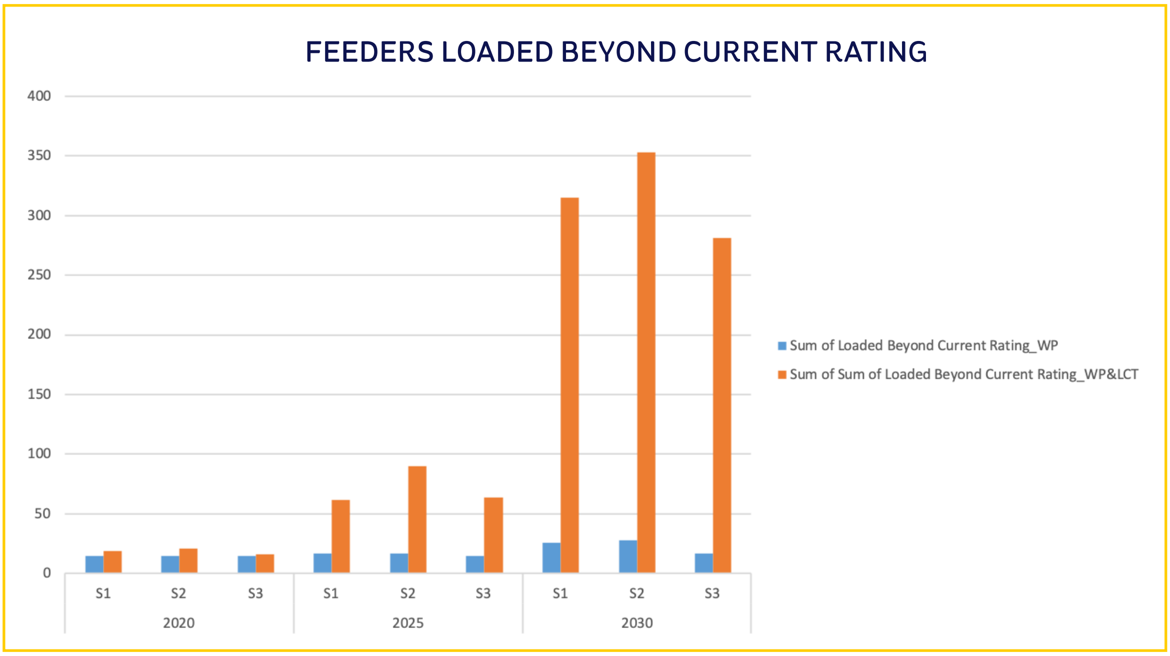
PLANT	SCENARIO	YEAR	LOAD (NO LCT)			
			Number of feeders loaded in excess of normal rating	% of feeders loaded in excess of normal rating	Average feeder loading	Highest loading in excess of normal rating
MV circuits	S1	**2020**	15	0.55%	27%	247%
		2025	17	0.63%	29%	272%
		2030	26	0.96%	31%	301%
	S2	**2020**	15	0.55%	27%	248%
		2025	17	0.63%	29%	280%
		2030	28	1.03%	32%	317%
	S3	**2020**	15	0.55%	27%	237%
		2025	15	0.55%	27%	242%
		2030	17	0.63%	29%	267%

TABLE 4.6 **MV CIRCUIT LOADING SUMMARY, INCL. PREDICTED TAKE UP OF LCT**

PLANT	SCENARIO	YEAR	LOAD (NO LCT)			
			Number of feeders loaded in excess of normal rating	% of feeders loaded in excess of normal rating	Average feeder loading	Highest loading in excess of normal rating
MV circuits	S1	**2020**	19	0.70%	29%	259%
		2025	62	2.29%	35%	325%
		2030	315	11.64%	51%	449%
	S2	**2020**	21	0.78%	29%	259%
		2025	90	3.32%	36%	339%
		2030	353	13.04%	54%	451%
	S3	**2020**	16	0.59%	28%	264%
		2025	64	2.36%	33%	364%
		2030	281	10.38%	47%	567%

4.1.1 DEMAND DATA COUNTRYWIDE continued

FIGURE 4.10 **MV CIRCUIT LOADINGS BEYOND CURRENT RATINGS - TABLE RESULTS IN GRAPHICAL FORMAT**



38kV Station Loading

The tables below, coupled with the graph, give a picture of 38kV station capacity countrywide and the level of station loading projected with unmanaged growth in low carbon technology loading and other demand over the next decade. However as with the MV results set out above, demand side flexibility coupled with infrastructure delivery will mitigate the risk of being loaded beyond current rating. Significantly, the objective of this analysis is to inform the introduction of demand side flexibility on MV circuits which will also contribute to the provision of capacity on the 38kV and 110kV distribution system.

Appendix 6 provides a full list (based on projected load in 2030) of all 38kV and 110kV stations and their loading versus rating.

4.1.1 DEMAND DATA COUNTRYWIDE continued

TABLE 4.7 **38KV STATION LOAD – NO LCT**

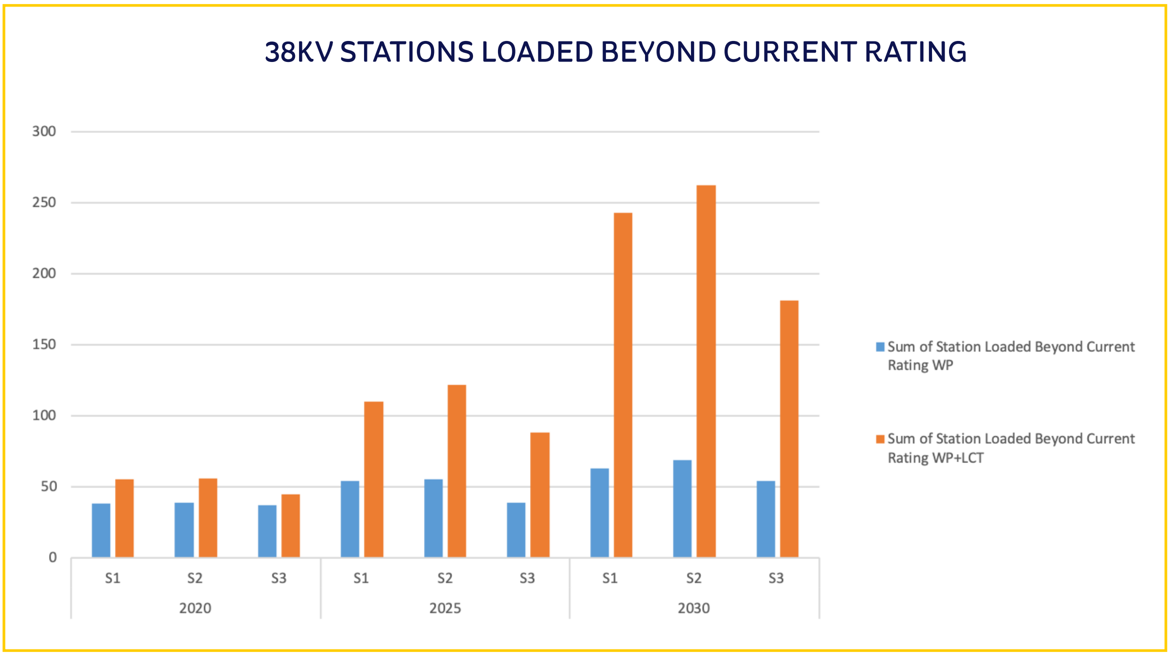
PLANT	SCENARIO	YEAR	LOAD (NO LCT)			
			Number of Stations loaded in excess of normal rating	% of Stations loaded in excess of normal rating	Average Station loading	Highest loading in excess of normal rating
38kV Stations	S1	2020	38	9%	61%	167%
		2025	54	13%	65%	175%
		2030	63	15%	68%	182%
	S2	2020	39	9%	61%	167%
		2025	55	13%	65%	175%
		2030	69	16%	70%	182%
	S3	2020	37	9%	60%	165%
		2025	39	9%	61%	168%
		2030	54	13%	63%	175%

TABLE 4.8 **38KV STATION LOAD – INCL. PREDICTED TAKE UP OF LCT**

PLANT	SCENARIO	YEAR	LOAD (INCL. LCT)			
			Number of Stations loaded in excess of normal rating	% of Stations loaded in excess of normal rating	Average Station loading	Highest loading in excess of normal rating
38kV Stations	S1	2020	55	13%	65%	169%
		2025	110	26%	79%	182%
		2030	243	57%	116%	289%
	S2	2020	56	13%	65%	175%
		2025	122	29%	80%	214%
		2030	262	61%	128%	557%
	S3	2020	45	11%	62%	165%
		2025	88	21%	72%	183%
		2030	181	42%	104%	418%

4.1.1 DEMAND DATA COUNTRYWIDE continued

FIGURE 4.11 **GEOGRAPHICAL REPRESENTATION OF STUDIES AND ESTIMATED LOAD PROFILES REPRESENTATION**



4 DEALING WITH DEMAND

4.1.1 DEMAND DATA COUNTRYWIDE continued

TABLE 4.9 **TOP 5 MOST HEAVILY LOADED 38KV STATIONS BY 2030**

MOST HEAVILY LOADED 38KV STATIONS (BASED ON TRANSFORMER CAPACITY)

	S1		S2		S3		
	Stations (WP)	**Stations (WP+LCT)**	**Stations (WP)**	**Stations (WP+LCT)**	**Stations (WP)**	**Stations (WP+LCT)**	
Station 1	**Randalstown**	**Randalstown**	**Devlin**	**Devlin**	**Randalstown**	**Milford (NR)**	
	0%	33%	0%	50%	0%	60%	% MV feeders ex station loaded beyond normal rating
Station 2	**Glenamaddy**	**Glenamaddy**	**Buttevant**	**Buttevant**	**Glenamaddy**	**Cullion**	
	0%	0%	0%	100%	0%	40%	% MV feeders ex station loaded beyond normal rating
Station 3	**Buttevant**	**Buttevant**	**Kyletaun**	**Kyletaun**	**Buttevant**	**Glenties**	
	0%	33%	0%	75%	0%	100%	% MV feeders ex station loaded beyond normal rating
Station 4	**Delvin**	**Delvin**	**Kinsale**	**Kinsale**	**Delvin**	**Newmarket (DR)**	
	0%	0%	0%	50%	0%	75%	% MV feeders ex station loaded beyond normal rating
Station 5	**Cullion**	**Cullion**	**Glasmore**	**Glasmore**	**Cullion**	**Clontarf**	
	0%	20%	0%	71%	0%	80%	% MV feeders ex station loaded beyond normal rating

4.1.1 DEMAND DATA COUNTRYWIDE continued

110kV Stations Loaded Beyond Current Rating

As with 38kV stations, the tables below give a picture of 110kV station capacity countrywide and the level of station loading which could happen with unmanaged growth of LCT and other demand over the next decade. However as with the lower voltage levels, demand side flexibility coupled with infrastructure delivery will mitigate the risk of loading challenges. Similar to 38kV, it is our objective in the National Network, Local Connections Programme that demand side flexibility on MV circuits will also contribute towards resolving loading challenges on the 110kV parts of the distribution system.

Appendix 6 provides a full list (based on predicted load in 2030) of all 38kV and 110kV stations and their loading versus rating.

TABLE 4.10 **110KV STATION LOAD – NO LCT**

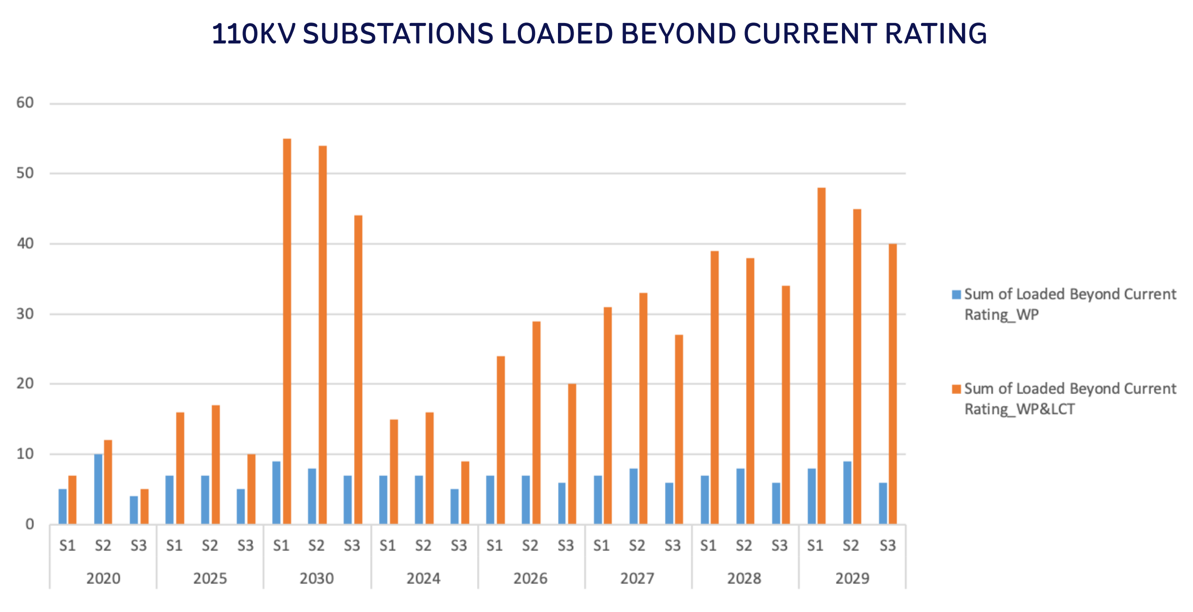
PLANT	SCENARIO	YEAR	LOAD (NO LCT)			
			Number of stations loaded in excess of normal rating	% of stations loaded in excess of normal rating	Average station loading	Highest loading in excess of normal rating
110kV stations	S1	2020	5	4%	50%	139%
		2025	7	5%	53%	149%
		2030	9	7%	57%	161%
	S2	2020	5	4%	50%	139%
		2025	7	5%	54%	153%
		2030	8	6%	57%	168%
	S3	2020	4	3%	49%	135%
		2025	5	4%	50%	136%
		2030	7	5%	51%	147%

4.1.1 DEMAND DATA COUNTRYWIDE continued

TABLE 4.11 **110KV STATION LOAD – INCL. PREDICTED TAKE UP OF LCT**

PLANT	SCENARIO	YEAR	LOAD (NO LCT)			
			Number of stations loaded in excess of normal rating	% of stations loaded in excess of normal rating	Average station loading	Highest loading in excess of normal rating
110kV stations	S1	2020	7	5%	53%	148%
		2025	16	12%	64%	186%
		2030	55	40%	92%	264%
	S2	2020	6	4%	53%	147%
		2025	17	12%	64%	187%
		2030	54	39%	97%	331%
	S3	2020	5	4%	51%	149%
		2025	10	7%	59%	202%
		2030	44	32%	83%	313%

FIGURE 4.12 **110KV STATIONS LOADED BEYOND CURRENT RATING– GRAPHICAL REPRESENTATION**



4.1.1 DEMAND DATA COUNTRYWIDE continued

TABLE 4.12 **TOP 5 110KV STATIONS MOST LOADED BEYOND CURRENT RATING IN 2030**

MOST HEAVILY LOADED 110KV STATIONS IN 2030						
	S1		S2		S3	
	Stations (WP)	**Stations (WP + LCT)**	**Stations (WP)**	**Stations (WP + LCT)**	**Stations (WP)**	**Stations (WP + LCT)**
Station 1	Finglas	Finglas	Finglas	Finglas	Finglas	Finglas
Station 2	Newbridge	Newbridge	Wolfe Tone Street	Wolfe Tone Street	Newbridge	Inchicore 220kV
Station 3	Wolfe Tone Street	Wolfe Tone Street	Newbridge	Newbridge	Wolfe Tone Street	Grange Castle
Station 4	Inchicore	Inchicore	Inchicore	Inchicore	Inchicore	Trabeg
Station 5	Blake	Blake	Blake	Blake	Blake	Macetown

Table 4.12 above lists the 110kV/38kV stations most loaded beyond current rating by 2030 and under each of the different scenarios.

4 DEALING WITH DEMAND

4.1.1 DEMAND DATA COUNTRYWIDE continued

Loading on 220kV Transformers which form part of the Distribution System

TABLE 4.13 **220KV/110KV DISTRIBUTION TRANSFORMERS – LOADING WITH LCT**

WP+LCT BSP TRANSFORMER NORMAL FEEDING RESULTS

BSP	Trafo	MVA	2020	2025	2030
Finglas	**T2101**	**250MVA (375MVA short term load limit)**	189 MVA 76%	247 MVA 99%	426 MVA 170%
	T2106	**250MVA (375MVA short term load limit)**	193 MVA 77%	251 MVA 100.5%	422 MVA 169%
	T2103	**250MVA (375MVA short term load limit)**	135 MVA 54%	204 MVA 82%	346 MVA 138%
	T2104	**250MVA (375MVA short term load limit)**	135 MVA 54%	204 MVA 82%	345 MVA 138%
Poolbeg	**TF3**	**250MVA (375MVA short term load limit)**	187 MVA 75%	213 MVA 85%	295 MVA 118%
	TF4	**250MVA (375MVA short term load limit)**	178 MVA 71%	202 MVA 81%	280 MVA 112%
Inchicore	**T2101**	**250MVA (375MVA short term load limit)**	136 MVA 55%	166 MVA 67%	235 MVA 94%
	T2106	**250MVA (375MVA short term load limit)**	140 MVA 56%	171 MVA 68%	240 MVA 96%
	T2102	**250MVA (375MVA short term load limit)**	132 MVA 53%	277 MVA 111%	448 MVA 179%
	T2104	**250MVA (375MVA short term load limit)**	110 MVA 44%	231 MVA 92%	373 MVA 149%
Carrickmines	**T2101**	**250MVA (375MVA short term load limit)**	118 MVA 47%	185 MVA 74%	268 MVA 107%
	T2103	**250MVA (375MVA short term load limit)**	100 MVA 40%	161 MVA 64%	236 MVA 95%
	T2104	**250MVA (375MVA short term load limit)**	100 MVA 40%	161 MVA 64%	236 MVA 95%
On Standby	**T2102**	**250MVA (375MVA short term load limit)**	-	-	-

While the load figures above include some additional projected large point loads (where these were known at the time of studies commencing) the rate of load enquiry and application in Dublin remains very high. As such it is possible that additional loads will arise.

Furthermore, as can be seen in section 4.5 on Dublin HV studies, additional flexibility or infrastructural solutions is typically required under contingency feeding arrangements.

4 DEALING WITH DEMAND

4.5 HV STUDIES IN DUBLIN

The initial focus of the 2030 Power System Requirements studies was on the MV system as the results of relatively recent studies of the 38kV system were available. Once these studies were underway, HV studies were commenced on a prioritised basis, accounting for known customer demand needs. The initial areas analysed were the 3 Dublin areas – Dublin Central; Dublin North and Dublin South.

Most of the 110kV network in these areas is operated by the DSO, and thus integrated studies of the 38kV and 110kV network was completed. This included analysis of loading on DSO operated 220kV transformers.

As can be seen from MV study results (Appendix 4), under all scenarios studied, there is expected to be significant new LCT load in Dublin. Addressing the capacity scarcities arising at MV will require a combination of network reinforcement and demand side flexibility.

Prior to reviewing the study results it is worth noting that:

1. **Load is being studied against current network capacity and developments underway and expected to be complete no later than 2025. Additional network infrastructure will likely be developed during this period and subsequently, based on assessed customer needs and observed changes in loading.**
2. **For the purpose of this exercise, load is assumed to be unmanaged (i.e. before the introduction of demand side flexibility as a solution). This means that much of the new LCT load is assumed to be added to peak load even after diversity curves have been applied.**
3. **Where contingency scenarios are presented, switching solutions have not yet been applied. These solutions include transferring load to adjacent networks. These solutions are, and will remain, critical to maintaining a secure supply, and thus may result in reductions to the scarcity indicated.**
4. **For contingency arrangements, loading in excess of ratings on transformers is only flagged where the short-term limits of loading beyond current rating are exceeded.**
5. **The focus of the results presented is on thermal loading. For an urban location, we expect that these results will be broadly valid. While voltage-based limitations do arise, in an urban area such as Dublin, solving the thermal constraints will also generally address any voltage limitations arising.**

4.5 HV STUDIES IN DUBLIN continued

While it is clear that based on the extent of load growth projected, some network reinforcement will be required, as pointed out by some respondents to our recent consultation, this reinforcement will need to be carefully planned to optimize the impact across all voltage levels and the transmission system. Furthermore, it is our clear belief that demand side flexibility will benefit the system as a whole.

In addition to studies for winter peak and summer valley (with generation), in certain parts of the county and in line with planning standards for Group Demand >100MVA, studies were undertaken for N-1-1 operating conditions. "N-1-1" refers to the network being short two components in a given location (for example due to a circuit being out for maintenance and a second circuit being out of service due to a network fault). Typically, this is to plan for a fault happening during maintenance season (typically summertime) and so is planned for summer peak.

HIGH LEVEL RESULTS FOR NORMAL FEEDING

110kV feeder loading beyond current rating

TABLE 4.14 **110KV FEEDER LOADINGS BEYOND CURRENT RATING – WP+LCT; SV+LCT**

WP + LCT SUMMARY							
YEAR	2024	2025	2026	2027	2028	2029	2030
No. of feeders loaded in excess of current ratings	0	0	2	2	2	4	4
No. of feeder sections loaded in excess of current ratings	0	0	5	7	7	10	10
SV + LCT + LARGE GENERATION SUMMARY							
YEAR	2024	2025	2026	2027	2028	2029	2030
No. of feeders loaded in excess of current ratings	0	0	0	0	0	0	0
No. of feeder sections loaded in excess of current ratings	0	0	0	0	0	0	0

Table 4.14 above gives information on 110kV feeder loadings beyond current rating under WP+ LCT (EV's and heat pumps), normal loading. Please note that while loading beyond current rating in excess of normal network ratings does not occur until 2026, by 2030, without some intervention, the most heavily loaded 110kV feeder is potentially loaded 80% in excess of its current normal rating.

As can be seen, results for summer valley loading + LCT (microgeneration) and larger generation indicate no loading in excess of current rating under normal feeding arrangements.

4.5 HV STUDIES IN DUBLIN continued

Transformer Loading in excess of current rating (110kV/38kV and 220kV/110kV) – based on existing transformer capacity

TABLE 4.15 **TRANSFORMERS LOADED IN EXCESS OF CURRENT RATINGS – WP+LCT; SV+LCT**

WP + LCT SUMMARY							
YEAR	2024	2025	2026	2027	2028	2029	2030
No. of 110kV/38kV Transformers loaded in excess of current ratings	4	6	9	17	19	25	25
No. of 220kV Transformers loaded in excess of current ratings	0	1	3	6	6	8	9
SV + LCT + LARGE GENERATION SUMMARY							
YEAR	2024	2025	2026	2027	2028	2029	2030
No. of Transformers loaded in excess of current ratings	0	0	0	0	0	0	0

Table 4.15 above gives information on transformer loading under WP+ LCT (EVs and heat pumps), normal loading. By 2030, and without intervention (in the form of additional capacity and flexible demand) some 110kV/38kV transformers are potentially loaded by 100% in excess of their current operating limits. The most heavily loaded 220kV transformer is potentially loaded by up to 70% in excess of its current operating limits.

As with 110kV feeders, results for summer valley loading + LCT (microgeneration) and larger commercial generation - indicate no loading in excess of current ratings under normal feeding arrangements.

4 DEALING WITH DEMAND

4.5 HV STUDIES IN DUBLIN continued

38kv Feeder Loading Information

TABLE 4.16 **38KV FEEDERS LOADED IN EXCESS OF CURRENT RATINGS– WP+LCT; SV+LC**

WP + LCT SUMMARY							
YEAR	2024	2025	2026	2027	2028	2029	2030
No. of 38kV feeders loaded in excess of current ratings	2	2	2	3	5	13	13
No. of feeder sections loaded in excess of current ratings	4	4	4	5	10	28	31
SV + LCT + LARGE GENERATION SUMMARY							
YEAR	2024	2025	2026	2027	2028	2029	2030
No. of 38kV feeders loaded in excess of current ratings	1	1	1	1	1	1	1
No. of feeder sections loaded in excess of current ratings	7	7	7	7	7	7	7

Table 4.16 above indicates the extent of 38kV feeder loading in excess of current ratings under WP+LCT (EV's and heat pumps), normal feeding arrangements. In the event that load growth develops as projected and before network reinforcement and demand side flexibility, the most heavily loaded sections are loaded by more than 100% beyond their current ratings in 2030.

As with other plant items, loading at summer valley due to microgeneration and larger commercial generation is less onerous than loading at winter peak.

4.5 HV STUDIES IN DUBLIN continued

High level Results for contingency feeding WP&LCT

On occasion, the distribution system is required to operate with an item of plant unavailable. This could be due to a fault on the system or simply to allow maintenance take place. It is appropriate, therefore, to study the impact on the system of such a contingency.

As noted previously, studies undertaken did not take account of any load transfers which may be possible to alleviate a station loading beyond current rating. In real time, therefore, we would expect operator action to alleviate the loadings beyond current rating in many cases. However, this does reflect that - even without comprehensive automation - the system needs to be operated in an active manner with a view to minimizing disruptions to customers and stress on the system. As load grows, this need will grow, and automation will become more central to ensuring security of supply.

The tables below give a flavour of the level of loading which could occur on the 38kV and 110kV system – for loss of a single item of plant:

1. **Should load growth continue in an unmanaged manner and**
2. **Before any network reinforcement is undertaken.**

For ease of reference, the results are divided into 5 different parts of the county.

While in some cases a circuit can become heavily loaded for a number of different scenarios, it is counted based on the earliest year of where loading exceeds networks' current ratings only.

TABLE 4.17 **CONTINGENCY LOADING BEYOND CURRENT RATINGS IN NORTH COUNTY DUBLIN**

NORTH COUNTY CONTINGENCY	2024	2025	2026	2027	2028	2029	2030
Number of 110kV circuits loaded beyond current ratings under various contingency scenarios	4	4	4	5	5	7	7
Number of 38kV circuits loaded beyond current ratings under various contingency scenarios	8	8	9	11	11	11	15
110kV/38kV transformers loaded beyond current ratings	6	6	6	6	6	6	6

4.5 HV STUDIES IN DUBLIN continued

TABLE 4.18 **CONTINGENCY LOADING BEYOND CURRENT RATINGS IN NORTH DUBLIN CITY**

NORTH CITY	2024	2025	2026	2027	2028	2029	2030
Number of 110kV circuits loaded beyond current ratings under various contingency scenarios	1	1	3	4	4	6	6
Number of 38kV circuits loaded beyond current ratings under various contingency scenarios	10	12	18	20	20	21	21
110kV/38kV transformers loaded beyond current ratings	4	4	4	4	4	4	4

TABLE 4.19 **CONTINGENCY LOADING BEYOND CURRENT RATINGS IN SOUTH DUBLIN COUNTY**

SOUTH COUNTY CONTINGENCY	2024	2025	2026	2027	2028	2029	2030
Number of 110kV circuits loaded beyond current ratings under various contingency scenarios						3	3
Number of 38kV circuits loaded beyond current ratings under various contingency scenarios	9	10	14	15	15	15	15
110kV/38kV transformers loaded beyond current ratings	6	6	6	6	6	6	6
220kV/110kV trafos loaded beyond current ratings		1	3	3	3	3	3

4 DEALING WITH DEMAND

4.5 HV STUDIES IN DUBLIN continued

TABLE 4.20 **CONTINGENCY LOADING BEYOND CURRENT RATINGS IN SOUTH DUBLIN CITY**

SOUTH COUNTY	2024	2025	2026	2027	2028	2029	2030
Number of 110kV circuits loaded beyond current ratings under various contingency scenarios	4	6	7	9	9	13	14
Number of 38kV circuits loaded beyond current ratings under various contingency scenarios	4	5	9	10	13	19	22
110kV/38kV transformers loaded beyond current ratings	8	8	8	8	8	8	8
220kV/110kV trafos loaded beyond current ratings	4	4	4	4	4	4	4

TABLE 4.21 **CONTINGENCY LOADING BEYOND CURRENT RATINGS IN WEST COUNTY DUBLIN**

WEST COUNTY CONTINGENCY	2024	2025	2026	2027	2028	2029	2030
Number of 110kV circuits loaded beyond current ratings under various contingency scenarios							
Number of 38kV circuits loaded beyond current ratings under various contingency scenarios	10	11	14	15	15	18	21
110kV/38kV transformers loaded beyond current ratings	10	10	10	10	10	10	10
220kV/110kV trafos loaded beyond current ratings	2	2	2	2	2	2	2

4.5 HV STUDIES IN DUBLIN continued

N-1-1 Studies

As noted previously in a small number of cases, the network is currently planned for a double contingency scenario.[11]

While studies in many cases reflect high loading, what is presented in the tables below are the most onerous double contingencies. These events are rare. It is our intention that demand side flexibility will play a significant role in alleviating the risk arising of these scenarios in future.

TABLE 4.22 **LOADING BEYOND CURRENT RATINGS UNDER N-1-1**

N-1-1		2024	2025	2026	2027	2028	2029	2030
Number of 110kV circuits loaded beyond current ratings under various contingency scenarios	North County	5	4	4	5	5	5	5
	North City	5	5	6	6	6	7	7
	South County							
	South City	2	2	2	2	2	2	2
	West County							
220kV/110kV trafo loaded beyond current ratings	North County							
	North City							
	South County	1	1	1	1	1	1	1
	South City	3	4	4	4	4	4	4
	West County	2	2	2	2	2	2	2

---

[11] Typically, this is to plan for a fault happening during maintenance season (which is summer time) and so is planned for summer peak. As per planning standards N-1-1 is studied where Group Demand is >100MVA.

4.5 HV STUDIES IN DUBLIN continued

Distribution connected generation in Dublin

The table below indicates the extent of generation connected, contracted or predicted to connect into the distribution system in Dublin.

TABLE 4.23 **GENERATION PREDICTED FOR DUBLIN**

Total Generation to be connected in area by 2030		**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
		MW	MW	MW	MW	MW	MW	MW	MW	MW	MW
Distribution Generation connected	132										
Wind Contracted											
Solar Contracted		35	4	8		25					
Battery Contracted			8.5								
Offer issued (OCGT)	115										
Wind Pipeline											
Solar Pipeline						1.4	20	7	23	27	16
Battery Pipeline						2.5					
Other			0.5		80	2.5					
Overall total	**507.4**										

As can be seen there is a substantial amount of generation already connected – this includes 1 large unit of 72MW with circa 60MW of capacity from units smaller than 10MW.

Units contracted total circa 117MW – 3 large units make up 70MW with the balance from units <10MW.

Finally, in terms of pipeline projects (circa 179MW), aside from one large CHP project the bulk of this is from solar.

4 DEALING WITH DEMAND

4.5 HV STUDIES IN DUBLIN continued

In terms of locations impacted by pipeline projects, while there are small projects proposed to connect across the county, the bulk of the larger projects are in the west and north of the county. This is where the need for solutions including demand side flexibility and additional infrastructure arise if connections are made on a firm basis rather than a managed basis. However, as these needs arise primarily under contingency conditions, they present good candidates for solutions including making connections on a flexible basis or contracting demand side flexibility from existing customers in the location.

TABLE 4.24 **SUMMER VALLEY – GENERATION – CONTINGENCY**

N-1 SUMMER VALLEY		2024	2025	2026	2027	2028	2029	2030
Total Generation to be connected in area by 2030	West County	1	1	1	1	1	1	1
	North County							3

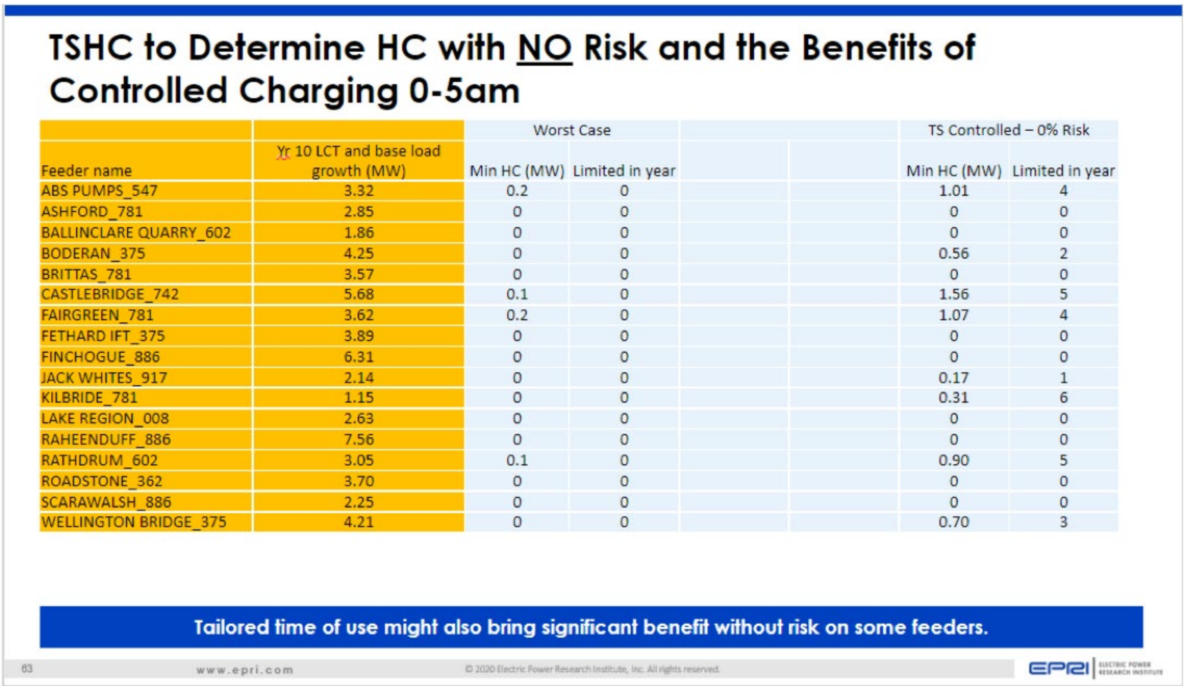
4.6 EPRI STUDIES

As noted in section 3, EPRI was commissioned to analyse one of our operational network areas using the DRIVE tool. The results from this work are included in Appendix 4B.

This analysis involved studying the network under normal feeding arrangements (to assess the impact of the projected increase in load due to EVs and HPs and the impact of microgeneration) and also studying some feeders under standby feeding. These studies also assessed the network impact of flexibility whereby loads such as EVs are importing during specific periods only. The focus of the initial studies was on a small number of circuits which had no capacity for additional demand, even under normal feeding arrangements. Intuitively these feeders should have capacity for new loads at certain times when existing loads are not on (for example at night).

The studies undertaken indicated that of the 17 feeders studied, 9 feeders could not accommodate additional demand even when the new loads charged exclusively between midnight and 5am. However, for the remaining 8 feeders, additional demand could be supported provided charging was subject to demand side flexibility.

TABLE 4.25 **BENEFITS OF CONTROLLED CHARGING**



TSHC to Determine HC with NO Risk and the Benefits of Controlled Charging 0-5am

		Worst Case				TS Controlled – 0% Risk	
Feeder name	Yr 10 LCT and base load growth (MW)	Min HC (MW)	Limited in year			Min HC (MW)	Limited in year
ABS PUMPS_547	3.32	0.2	0			1.01	4
ASHFORD_781	2.85	0	0			0	0
BALLINCLARE QUARRY_602	1.86	0	0			0	0
BODERAN_375	4.25	0	0			0.56	2
BRITTAS_781	3.57	0	0			0	0
CASTLEBRIDGE_742	5.68	0.1	0			1.56	5
FAIRGREEN_781	3.62	0.2	0			1.07	4
FETHARD IFT_375	3.89	0	0			0	0
FINCHOGUE_886	6.31	0	0			0	0
JACK WHITES_917	2.14	0	0			0.17	1
KILBRIDE_781	1.15	0	0			0.31	6
LAKE REGION_008	2.63	0	0			0	0
RAHEENDUFF_886	7.56	0	0			0	0
RATHDRUM_602	3.05	0.1	0			0.90	5
ROADSTONE_362	3.70	0	0			0	0
SCARAWALSH_886	2.25	0	0			0	0
WELLINGTON BRIDGE_375	4.21	0	0			0.70	3

Tailored time of use might also bring significant benefit without risk on some feeders.

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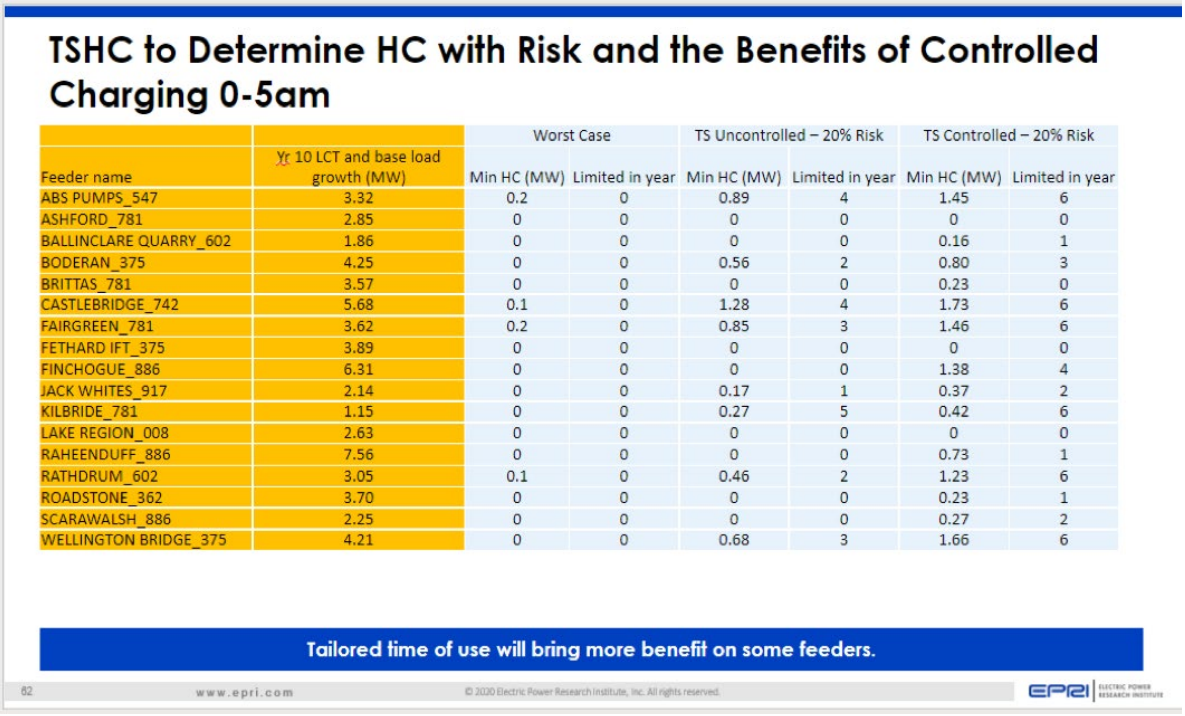
4 DEALING WITH DEMAND

4.6 EPRI STUDIES continued

Furthermore, by accepting a level of risk[12], the hosting capacity can be increased on all bar 3 feeders of the 17.

TABLE 4.26 **BENEFITS OF CONTROLLED CHARGING**



TSHC to Determine HC with Risk and the Benefits of Controlled Charging 0-5am

		Worst Case		TS Uncontrolled – 20% Risk		TS Controlled – 20% Risk	
Feeder name	Yr 10 LCT and base load growth (MW)	Min HC (MW)	Limited in year	Min HC (MW)	Limited in year	Min HC (MW)	Limited in year
ABS PUMPS_547	3.32	0.2	0	0.89	4	1.45	6
ASHFORD_781	2.85	0	0	0	0	0	0
BALLINCLARE QUARRY_602	1.86	0	0	0	0	0.16	1
BODERAN_375	4.25	0	0	0.56	2	0.80	3
BRITTAS_781	3.57	0	0	0	0	0.23	0
CASTLEBRIDGE_742	5.68	0.1	0	1.28	4	1.73	6
FAIRGREEN_781	3.62	0.2	0	0.85	3	1.46	6
FETHARD IFT_375	3.89	0	0	0	0	0	0
FINCHOGUE_886	6.31	0	0	0	0	1.38	4
JACK WHITES_917	2.14	0	0	0.17	1	0.37	2
KILBRIDE_781	1.15	0	0	0.27	5	0.42	6
LAKE REGION_008	2.63	0	0	0	0	0	0
RAHEENDUFF_886	7.56	0	0	0	0	0.73	1
RATHDRUM_602	3.05	0.1	0	0.46	2	1.23	6
ROADSTONE_362	3.70	0	0	0	0	0.23	1
SCARAWALSH_886	2.25	0	0	0	0	0.27	2
WELLINGTON BRIDGE_375	4.21	0	0	0.68	3	1.66	6

Tailored time of use will bring more benefit on some feeders.

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Following on from these studies, some data analytics work was undertaken on a number of feeders in other areas to assess the impact of the shifting of load (to night-time hours). This data is included in Appendix 7.

While it is worth noting that shifting the charging from daytime to night-time does drive an improvement in capacity, it may also drive the possibility of a new peak – at night-time. For this reason, more nuanced solutions to managing load will be much more effective in optimizing network capacity than simple time restrictions on EV charging or other new loads.

---

[12] By accepting a 20% level of risk this means that for circa 20% of the time, the hosting capacity noted will not be available.

4.7 KEY FINDINGS - DEMAND

There are some key findings which are worth identifying specifically following a review of the detailed information above. These can be summarised as follows:

1. **The benefits of a flexible services market are clear – even if we are only dealing with the additional load which would arise due to organic load growth.**
2. **To cater - additionally and in the most cost-effective manner - for the electrification of heat and transport a flexible services market is key.**
3. **The benefits of flexible load – which can respond to signals for load up or load down in response to needs of other customers especially renewable generation – is also clear.**
4. **Further network reinforcement will be required in the next decade and beyond.**
5. **Combining reinforcement and customer participation allowing for better management of demand will provide the best results in terms of:**
    - Cost of new connections.
    - New load being able to connect more quickly.
    - The impact of making these new connections (on existing customers) being minimised.

Furthermore, it is clear from the response to our consultation, that customers want and need information with regard to where flexibility will provide the best response and how much flexibility is required, in order to work towards a cleaner future. The provision of such information will be a key aim of the Power Systems Requirements team in the future.

5

The Generation Challenge

5 THE GENERATION CHALLENGE

As of April 2021, there was c. 2.5GW of wind generation connected[13] 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[14] between distribution and transmission connections[15]. 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 set out in Table 5.1, 5.2 and 5.3 below (scenarios 1,2 and 3 refer to the microgeneration/summer valley[16] combined scenarios - PV1 and SV1, PV2 and SV2, and PV3 and SV3 - and are as described in Appendix 1).

TABLE 5.1 **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 5.2 **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

Note:

1. **The commercial generation set out in the tables above is existing and new/predicted wind and solar generation only. Other sources of generation (such as CHP, hydro and biomass) are predicted to be small in comparison. Should generation be available from other technologies, however, the impact of same on initial network capacity studies will be similar to the impact of wind or solar.**
2. **The microgeneration figures are for new installations only, as existing microgeneration is embedded within demand figures.**

[13] With an additional 1.17GW contracted but not yet connected. This contracted capacity forms part of the 2030 forecast.
[14] Based on historical information.
[15] The bulk of the connections to the Transmission System are expected to be offshore wind.
[16] 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 5.3 **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

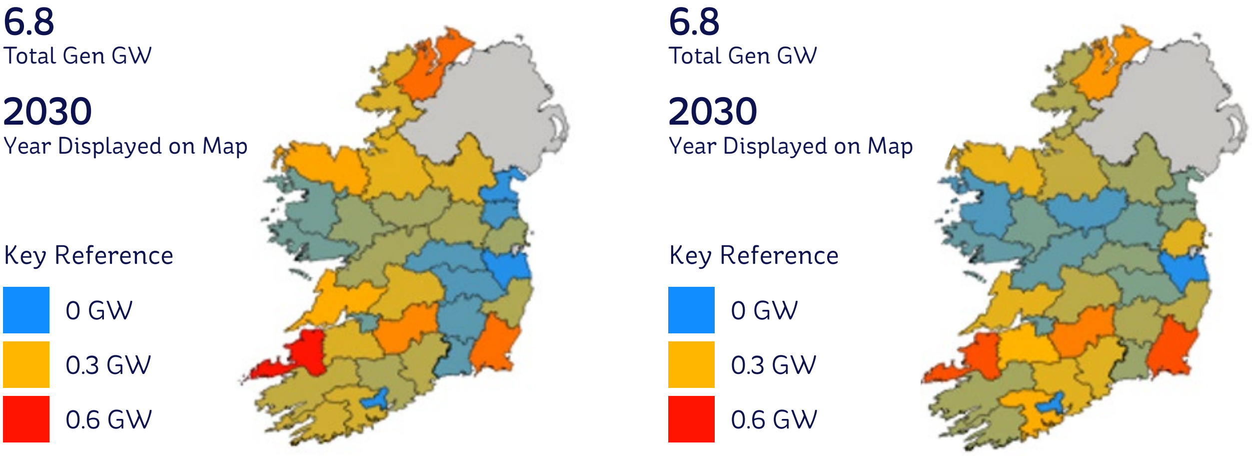

FIGURE 9 **LEFT HAND SIDE - LARGE SCALE GENERATION SCENARIO 1 ; RIGHT HAND SIDE SCENARIO 2**

5 THE GENERATION CHALLENGE

ANALYSIS OF STUDY RESULTS

Load flow studies have been completed for a significant part of the MV system due to the high priority indicated for the medium voltage system. While under standby feeding arrangements, microgeneration contributes to voltage rising above standard on the MV network, under normal feeding arrangements this has not been observed in any areas studied to date.

To put these results in context:

1. **These results do not take account of voltage rise occurring on the low voltage (LV) system. International experience indicates that as residential and commercial microgeneration grows, the output from microgeneration will need to be more actively managed to ensure that voltages at LV remain within standard. By customers and communities aiming to align energy usage with energy production at a local level, the need for additional infrastructure will be minimized.**
2. **Studies take into account the load associated with each MV/LV substation but do not take account of the capacity at MV/LV substations.**
3. **As noted by one respondent to our public consultation of Q4 2021, the assumptions regarding microgeneration pre-date recent changes in building regulations[17]. As a result, it is likely that microgeneration - and in particular solar PV - will be more extensive than assumed[18].**
4. **No conclusion has yet been reached as to whether (based on these results) the provision in HV and MV capacity for expected future growth in microgeneration connections should be revised. Any revision to this policy would need to take account of a likely increased take up of microgeneration. ESB Networks has, however, committed to reviewing the 'Provision in HV and MV Capacity for Expected Future Growth in Microgeneration Connections'. Results from the 2030 Power System Requirements studies, along with other analyses relating to the likely increased take-up of microgeneration, will be used to inform the review and analysis.**

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[17] It is noteworthy also that other legislative changes are underway which may also favour an increase in rooftop solar.

[18] Future studies will take this into account.

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[19]. 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.

However – as per the results set out in the previous section – even in these areas, under normal feeding arrangements, voltage at MV is not expected to rise above the standard allowed voltage. (Although noting that this does not account for voltage rise at LV.)

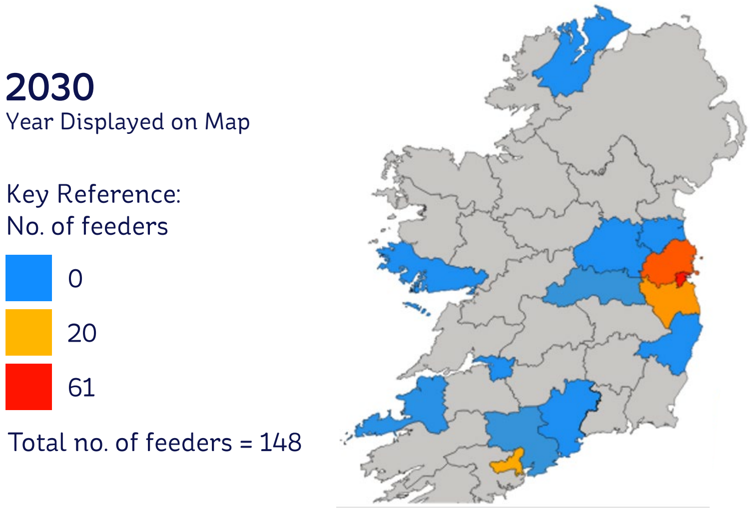

FIGURE 5.2 **MV FEEDERS WITH PV LOAD GREATER THAN SUMMER VALLEY**

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

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[20] 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[21] will be issued under certain circumstances[22]. 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[23] (which represents the worst case for generation).
4. **The extensive deep works which would otherwise be required to deliver on the CAP targets.**

---

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

[21] Circa 5-10 of 76 offers were assessed as being eligible for non-firm offers. However, some customers have opted not to proceed to full offer issue.

[22] 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)

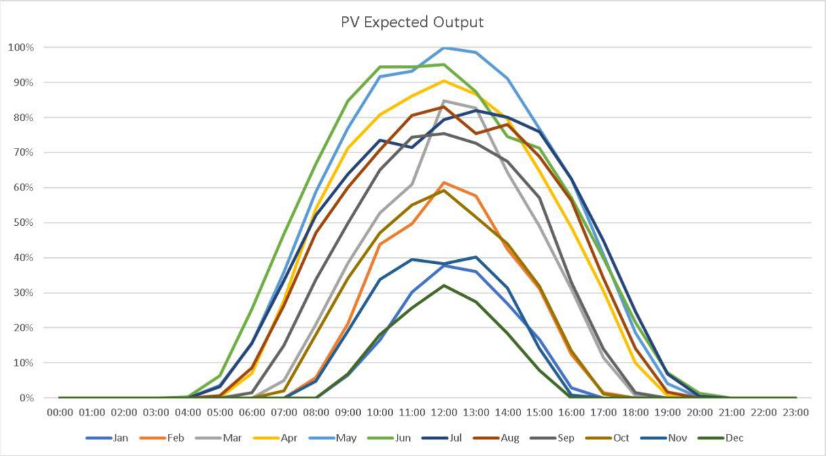
[23] It should be noted, however, that mid-morning load on a local network can be low – especially in a residential area.

5 THE GENERATION CHALLENGE

5.2 FIRM VERSUS FLEXIBLE continued

As noted in the response to feedback on our consultation paper, we are working across ESB Networks to ensure that connections being offered on a more flexible basis take account of the tools available to manage connections and learnings from pilots undertaken. From the feedback received on this issue, many customers indicated an interest in a flexible connection on an enduring basis (in order to reduce their connection costs).

FIGURE 5.3 **PV EXPECTED OUTPUT**



5.3 LOAD FLOW STUDIES FOR LARGER GENERATION

The purpose of the studies set out below is to provide a nationwide profile of the operational impact of connecting 5GW additional generation to the distribution system in line with the Climate Action Plan. The purpose of these studies is not to form part of any connection method studies currently underway in ESB Networks. Due to the timing of data becoming available, these studies do not align in all cases with studies associated with connection offers under ECP2.

For the purposes of this suite of 2030 Power System Studies and as set out in Appendix 3, larger scale generation (making up circa 5GW of new generation to be connected to the distribution system by 2030) is proposed to be connected at:

1. **MV into an MV B/B of the nearest 38kV/MV or 110kV/MV station.**
2. **38kV or 110kV directly (larger generation projects).**

This is in line with node allocation rules for generation. These rules can be found at this link http://www.eirgridgroup.com/site-files/library/EirGrid/Node-Assignment-Rules-ECP-2.pdf

In line with this, it is not necessary to account for any impact of larger generation through MV power flow studies[24] as these installations are on dedicated MV circuits to the extent that they connect at MV. However, studies have commenced at 38kV (and 110kV) and the results for commercial generation in some network locations are available[25]. The tables below indicate the level of constraint that may arise, based on the locations studied to date, if:

a. **New generation was connected before any reinforcement work is undertaken to accommodate the additional generation arising.**

b. **All generation in the area was at peak export simultaneously. (As noted earlier, this scenario may occur but would be expected to be infrequent especially with a mix of technology types.)**

c. **The generation was at peak export during summer valley or other low load periods (for example mid-afternoon).**

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[24] Which study the MV circuits ex 38kV and 110kV stations.

[25] The early areas studied were chosen to include a mix of areas – some with predominantly solar generation and others predominantly wind.

5 THE GENERATION CHALLENGE

5.3 LOAD FLOW STUDIES FOR LARGER GENERATION continued

The generation studies include the impact of local microgeneration under low load conditions.

In addition to the assumptions included in Appendix 3, some other parameters are listed below:

1. **Studies are undertaken at summer valley load.**
2. **All generation is exporting at full MEC.**
3. **Micro generation is included.**
4. **Scenarios are selected based on the most onerous operating conditions for a given area.**
5. **Transformer capacity is assumed as 110% of rating in all cases.**
6. **Generation is assumed to connect at MV into the nearest 38kV/MV or 110kV/MV station.**

5.3.1 DETAIL OF STUDIES UNDERTAKEN TO DATE

5.3.1.1 CAVAN/SLIGO AREA

The Cavan-Sligo area was studied for Scenario 1 which is the high wind scenario (circa 80% wind in total countrywide). While there is some generation already connected, the bulk of the 465MW predicted to be connected by 2030 is future connections – and primarily wind.

TABLE 5.4 **HIGH LEVELGENERATION STATISTICS FOR CAVAN/SLIGO BY 2030**

Total Generation to be connected in area by 2030	Overall Total	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	465 MW										
Wind Contracted		44									
Solar Contracted			4	4							
Battery Contracted											
Wind Pipeline				34		19	47	67	34	50	83
Solar Pipeline						9					
Battery Pipeline				40	30						

5.3.1 DETAIL OF STUDIES UNDERTAKEN TO DATE continued

TABLE 5.5 **ADDITIONAL CAPACITY NEEDED FOR FIRM CONNECTIONS TO THE DISTRIBUTION SYSTEM**

YEAR	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Number of stations with 110/38 kV Transformer loading beyond current ratings (normal feeding) and planning for 1 trafo only in 2 trafo station	0	0	0	2	2	2	2	3	3	4	4
Sligo											
Tonroe								14	14	19	19
Gortawee											
Shankill											
Lisdrum				3	3	3	3	3	3	24	30
Meath Hill				8	8	8	8	8	18	30	40
Carrick on Shannon										5	5
Total Generation that can't be connected based on Transformer loading beyond current ratings (MVA)	0	0	0	11	11	11	11	25	35	78	94

Table 5.5 above indicates the level of generation which would not currently be able to connect on a firm basis to the distribution system until additional transformer capacity is installed, as per the CRU approved planning standards.

5.3.1 DETAIL OF STUDIES UNDERTAKEN TO DATE continued

Table 5.6 below indicates how the picture may change with the introduction of preliminary flexible connections, whereby:

1. **Capacity could be offered based on the full capacity of the station (under normal operating or 'N' conditions).**
2. **For a transformer outage at the station, generation could be constrained by the DSO. This is a scenario which would be possible to facilitate in the future, subject to the development of appropriate rules relating to flexible and managed access for generation.**

TABLE 5.6 **DETAILS OF STATIONS WHERE THE PROPOSED GENERATORS TO BE CONNECTED WOULD DRIVE LOADING BEYOND CURRENT RATINGS ON THE 110KV/38KV TRANSFORMER UNDER NORMAL FEEDING BUT FULL STATION CAPACITY WAS CONSIDERED.**

YEAR	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Number of stations with 110/38 kV Transformer loading beyond current rating (normal feeding)	0	0	0	0	0	0	0	1	1	1	2
Sligo											
Tonroe								14	14	19	19
Gortawee											
Shankill											5
Lisdrum											
Meath Hill											
Carrick on Shannon											
Total Generation that can't be connected based on Transformer loading beyond current rating (MVA)	0	0	0	0	0	0	0	14	14	19	24
Additional generation which may be possible to accommodate based on the introduction of managed generation connections	0	0	0	11	11	11	11	11	21	59	70

While in some cases the most onerous limits will arise due to 38kV circuit loading beyond current ratings, this is more unusual so the focus is on station loadings beyond current rating.

5.3.1 DETAIL OF STUDIES UNDERTAKEN TO DATE continued

CONTINGENCY FEEDING

The network has also been studied under contingency scenarios (an item of plant being unavailable due to maintenance or fault conditions). Flexible management of distributed generation export by the DSO in response to contingencies could result in material reductions in the time and costs of connection without significant constraint on generation. For this reason, while loading in excess of current ratings may arise at an earlier stage than for normal feeding, issues arising under contingency feeding arrangements are likely to have less impact on generation export.

In Cavan/Sligo, the 110kV/38kV stations will become more heavily loaded at an earlier stage under contingency scenarios.

The MW figures recorded below are those arising under the most onerous contingency for each transformer. This may arise for loss of a second 110kV transformer or for the loss of a 38kV circuit. Details of circuit or booster loading in excess of current ratings are not detailed in this paper.

TABLE 5.7 **STATION LOADING UNDER WORST CASE CONTINGENCY SCENARIOS**

YEAR	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Station loaded beyond current rating under worst case contingency's	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW
Sligo											
Tonroe					2	2	10	25	25	30	30
Gortawee											
Shankill											
Lisdrum				3	3	3	3	3	3	24	30
Meath Hill				8	8	8	8	8	18	30	40
Carrick on Shannon										5	5
Total Generation that can't be connected based on Transformer loading beyond current rating (MVA)	0	0	0	11	13	13	21	36	46	89	105
Additional generation (compared with table 5.6) which may be possible to accommodate based on the introduction of managed generation connections and if connection is planned for normal feeding arrangements only	0	0	0	11	13	13	21	22	32	70	81

5.3.1 DETAIL OF STUDIES UNDERTAKEN TO DATE continued

38KV STATION LOADING AND SHALLOW CONNECTION WORKS

Finally, in terms of 38kV station loading, a high level assessment based on current network found that circa 35% of connections may drive new transformer infrastructure as part of their shallow connection works.

5.3.1 DETAIL OF STUDIES UNDERTAKEN TO DATE continued

5.3.1.2 FERMOY AREA

Fermoy was studied for Scenario 2 which is the high solar scenario (circa 60% solar in total countrywide). All circa 171MW of the generation in the area by 2030 is predicted as future connections (all solar).

There are 3 110kV/38kV stations in Fermoy.

TABLE 5.8 **HIGH LEVEL GENERATION STATISTICS FOR FERMOY BY 2030**

Total Generation to be connected in area by 2030 (MW)	Overall total	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	171										
Wind Contracted											
Solar Contracted		19									
Wind Pipeline											
Solar Pipeline				7	14	20	11	64	15	21	

5.3.1 DETAIL OF STUDIES UNDERTAKEN TO DATE continued

TABLE 5.9 **ADDITIONAL CAPACITY NEEDED FOR FIRM CONNECTIONS TO THE DISTRIBUTION SYSTEM**

YEAR	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Number of stations with 110/38 kV Transformer loading beyond current ratings (normal feeding) and planning for 1 trafo only in 2 trafo station	0	0	0	0	0	1	1	3	3	3	3
Barrymore MVA loading beyond current ratings						4	8	26	33	51	51
Mallow MVA loading beyond current ratings								5	5	9	9
Middleton MVA loading beyond current ratings								2	10	10	10
Total Generation could not currently be connected based on Transformer loading beyond current ratings (MVA)	0	0	0	0	0	4	8	33	48	70	70

Table 5.9 above indicates the level of generation for which additional capacity would be needed for a generator to be able to connect on a firm basis to the distribution system. This is in line with the current CRU approved planning standards.

Table 5.10 below indicates how the picture may change with the introduction of preliminary flexible connections, whereby:

1. **Capacity was offered based on the full capacity of the station (under normal operating or 'N' conditions).**
2. **For a transformer outage at the station (i.e. N-1 conditions) the generation could be constrained by the DSO.**
3. **This is a scenario which would be possible to facilitate in the future, subject to the development of the rules, processes and control systems for flexible and managed access for generation.**

5 THE GENERATION CHALLENGE

5.3.1 DETAIL OF STUDIES UNDERTAKEN TO DATE continued

TABLE 5.10 **DETAILS OF STATIONS WHERE THE PROPOSED GENERATORS TO BE CONNECTED WOULD DRIVE LOADING BEYOND CURRENT RATINGS ON THE 110KV/38KV TRANSFORMER UNDER NORMAL FEEDING BUT FULL STATION CAPACITY WAS CONSIDERED**

YEAR	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Number of stations with 110/38 kV Transformer loading beyond current ratings	0	0	0	0	0	1	1	2	2	2	2
Barrymore MVA loading beyond current ratings						4	8	26	33	51	51
Mallow MVA loading beyond current ratings											
Midleton MVA loading beyond current ratings								2	10	10	10
Total Generation that can't be connected based on Transformer Overloads (MVA)	0	0	0	0	0	4	8	28	43	61	61
Additional generation which may be possible to accommodate based on the introduction of managed generation connections	0	0	0	0	0	0	0	5	5	9	9

While in some cases the most onerous conditions will arise due to 38kV circuit loading beyond current ratings, this is more unusual, so the focus is on station loading beyond current ratings.

5.3.1 DETAIL OF STUDIES UNDERTAKEN TO DATE continued

CONTINGENCY FEEDING

The network has also been studied under contingency scenarios (an item of plant being unavailable due to maintenance or fault conditions). When considering the impact of contingencies on network loading it is of note that DSO management of localised generation export actively, for example in response to contingencies, can materially reduce the time and costs of connection without significant constraint on generation. For this reason, while the loading beyond current ratings may arise at an earlier stage than for normal feeding, issues arising under contingency feeding arrangements are likely to have less impact on generation export.

In Fermoy, the 3 110kV/38kV stations will become loaded beyond current ratings more significantly and at an earlier stage under standby feeding arrangements. The table below gives the worst case[26] conditions which apply, where a contingency can be a loss of transformer or loss of feeder.

TABLE 5.11 **STATION LOADING BEYOND CURRENT RATINGS UNDER CONTINGENCY CONDITIONS**

YEAR	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stations loaded beyond current rating under contingency scenarios	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW
Barrymore MVA loading beyond current ratings				20	21	45	48	69	88	101	101
Dungarvan MVA loading beyond current ratings				4	7	11	11	34	37	40	40
Mallow MVA loading beyond current ratings								5	5	9	9
Midleton MVA loading beyond current ratings								4	12	12	12
Total Generation that can't be connected based on Transformer loading beyond current ratings (MVA)	0	0	0	24	28	56	59	112	142	162	162
Additional generation (compared with table 5.10) which may be possible to accommodate based on the introduction of managed generation connections and if connection is planned for normal feeding arrangements only	0	0	0	24	28	52	51	84	99	101	101

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[26] In the case of Barrymore, there is a very onerous condition which arises for loss of a 38kV circuit between Barrymore and Dungarvan. However, this is primarily driven by a significant new connection (37MW) into a 38kV station fed from Dungarvan 110kV station. Should this connection proceed it is likely to drive reinforcement works even with the option to manage export. For this reason, these loadings beyond current rating are not recorded.

5 THE GENERATION CHALLENGE

5.3.1 DETAIL OF STUDIES UNDERTAKEN TO DATE **continued**

38KV STATION LOADING AND SHALLOW CONNECTION WORKS

Finally, in terms of 38kV station loading, a high level assessment indicates that – based on current network – circa 40% of connections may drive new transformer infrastructure as part of their shallow connection works.

5 THE GENERATION CHALLENGE

5.3.1 DETAIL OF STUDIES UNDERTAKEN TO DATE continued

5.3.1.3 LETTERKENNY/KILLYBEGS AREA

Letterkenny/Killybegs was studied for Scenario 1 which is the high wind scenario (circa 80% wind in total countrywide). All circa 422MW of the generation in the area by 2030 is predicted to be wind.

There are 5 110kV/38kV stations in the Letterkenny/Killybegs area.

TABLE 5.12 **HIGH LEVEL VIEW OF GENERATION PREDICTED TO CONNECT UP TO 2030**

Total Generation to be connected in area by 2030 (MW)	Overall total	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	422										
Wind Contracted			22	20							
Solar Contracted											
Wind Pipeline		11	60	3	36	1	98	45	64	24	37
Solar Pipeline											

5.3.1 DETAIL OF STUDIES UNDERTAKEN TO DATE continued

TABLE 5.13 **ADDITIONAL CAPACITY NEEDED FOR FIRM CONNECTIONS TO THE DISTRIBUTION SYSTEM**

YEAR	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Number of stations with 110/38 kV Transformer loading beyond current ratings (normal feeding) and planning for 1 trafo only in 2 trafo station	0	0	0	0	1	1	2	2	4	4	4
Cathaleen Falls									8	20	20
Binbane			17	17	19	19	40	56	60	60	60
Ardnagappary							25	25	39	39	39
Letterkenny				12	12	12	55	70	80	80	95
Trillick					13	13	19	39	52	68	68
Total Generation that can't be connected based on Transformer loading beyond current ratings (MVA)	0	0	17	29	44	44	140	51	240	268	293

Table 5.13 above indicates the level of generation which would not currently be able to connect on a firm basis to the distribution system without additional transformer capacity being installed. This is in line with the current CRU approved planning standards.

Table 5.14 below indicates how the picture may change with the introduction of preliminary flexible connections, whereby:

1. **Capacity was offered based on the full capacity of the station (under normal operating or 'N' conditions).**
2. **For a transformer outage at the station (i.e. N-1 conditions) the generation could be constrained by the DSO.**
3. **This is a scenario that will be facilitated in the future, subject to the development of the rules, processes and control systems for flexible and managed access for generation.**

5 THE GENERATION CHALLENGE

5.3.1 DETAIL OF STUDIES UNDERTAKEN TO DATE continued

TABLE 5.14 **DETAILS OF STATIONS WHERE THE PROPOSED GENERATORS TO BE CONNECTED WOULD DRIVE LOADING BEYOND CURRENT RATINGS ON THE 110KV/38KV TRANSFORMER UNDER NORMAL FEEDING BUT FULL STATION CAPACITY WAS CONSIDERED**

YEAR	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Number of stations with 110/38 kV Transformer loading beyond current rating	0	0	0	0	1	1	2	2	4	4	4
Cathaleen Falls									8	20	20
Binbane											
Ardnagappary							25	25	39	39	39
Letterkenny									3	3	13
Trillick					13	13	19	39	52	68	68
Total Generation that can't be connected based on Transformer loading beyond current rating (MVA)	0	0	0	0	13	13	45	51	103	131	151
Additional generation which may be possible to accommodate based on the introduction of managed generation connections	0	0	17	29	31	31	95	0	137	137	142

While in some cases the most onerous restrictions will arise due to 38kV circuit loading beyond current ratings, this is more unusual so the focus here is on station loading beyond current ratings.

5.3.1 DETAIL OF STUDIES UNDERTAKEN TO DATE continued

CONTINGENCY FEEDING

The network has also been studied under contingency scenarios (an item of plant being unavailable due to maintenance or fault conditions). DSO management of export actively based on localised network conditions, for example in response to network contingencies, could result in material reductions in the time and costs of connection without significant constraint on generation. For this reason, while the loading beyond current ratings may arise at an earlier stage than for normal feeding, issues arising under contingency feeding arrangements are likely to have less impact on generation export.

In Letterkenny, the 110kV/38kV stations will become loaded beyond current ratings more significantly and at an earlier stage under standby. The table below gives the most onerous conditions which apply.

TABLE 5.15 **STATION LOADING BEYOND CURRENT RATINGS UNDER MOST ONEROUS CONTINGENCY**

YEAR	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stations loaded beyond current rating under contingency scenarios	0	0	0	0	1	1	2	2	4	4	4
Cathaleen Falls									21	33	33
Binbane			17	17	19	19	40	56	60	60	60
Ardnagappary			21	21	21	21	42	42	59	59	81
Letterkenny				12	12	12	55	70	80	80	95
Trillick											
Total Generation that may be turned down based on Transformer loadings beyond current ratings (MVA)	0	0	38	50	52	52	137	168	220	232	269
Additional generation (compared with table 5.14) which may be possible to accommodate based on the introduction of managed generation connections and if connection is planned for normal feeding arrangements only	0	0	38	50	39	39	92	117	117	101	118

5.3.1 DETAIL OF STUDIES UNDERTAKEN TO DATE continued

In addition, it should be noted that contingency feeding arrangements:

1. **Have the potential to give rise to a number of 38kV circuit loading beyond current ratings from as early as 2022.**
2. **Under some contingencies may give rise to extensive over-voltages.**

38KV STATION LOADING AND SHALLOW CONNECTION WORKS

Finally, in terms of 38kV station loading, a high level assessment indicates that – based on current network – over 50% of connections may drive new transformer infrastructure as part of their shallow connection works.

5 THE GENERATION CHALLENGE

5.3.1 DETAIL OF STUDIES UNDERTAKEN TO DATE continued

5.3.1.4 WATERFORD/CLONMEL AREA

Waterford/Clonmel was studied for Scenario 2 which is the high solar scenario (circa 60% solar in total countrywide). All circa 489MW of the generation in the area by 2030 is predicted as future connections (primarily solar).

There are 7 110kV/38kV stations in the Waterford/Clonmel area.

TABLE 5.16 **HIGH LEVEL GENERATION STATISTICS FOR WATERFORD/CLONMEL BY 2030**

Total Generation to be connected in area by 2030 (MW)	Overall Total	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	489	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW
Wind Contracted											
Solar Contracted		58	28								
Battery Contracted			30								
Hydro Contracted			1								
Wind Pipeline		30								6	
Solar Pipeline		12	9	41	5	19	68	81	20	56	25
Battery Pipeline											
Hydro Pipeline											

5.3.1 DETAIL OF STUDIES UNDERTAKEN TO DATE continued

TABLE 5.17 **ADDITIONAL CAPACITY NEEDED FOR FIRM CONNECTIONS TO THE DISTRIBUTION SYSTEM**

YEAR	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Number of stations with 110/38 kV Transformer loading beyond current rating (normal feeding) and planning for 1 trafo only in 2 trafo station				1	1	1	1	2	2	2	3
Cahir								13	21	27	40
Doon											
Ballydine											
Butlerstown									2	2	9
Dungarvan		4	8	46	52	60	60	89	No convergence. Assume 89MW min		
Waterford											
Great Island			12	12	12	12	32	41	41	50	51
Total Generation that can't be connected based on Transformer loading beyond current rating (MVA)	0	4	20	58	64	72	92	143	153	168	189

Table 5.17 above indicates the level of generation for which additional network capacity would be needed to connect on a firm basis to the distribution system. This is in line with the current CRU approved planning standards. As noted earlier, the restriction arises where all local generation is exporting at full MEC and where the load is at summer valley.

5 THE GENERATION CHALLENGE

5.3.1 DETAIL OF STUDIES UNDERTAKEN TO DATE continued

Table 5.18 below indicates how the picture may change with the introduction of preliminary flexible connections, whereby:

1. **Capacity was offered based on the full capacity of the station (under normal operating or 'N' conditions).**
2. **For a transformer outage at the station (i.e. N-1 conditions) the generation could be constrained by the DSO.**
3. **This is a scenario which would be possible to facilitate in the future. However is subject to discussion on rules around flexible and managed access for generation.**

TABLE 5.18 **DETAILS OF STATIONS WHERE THE PROPOSED GENERATORS TO BE CONNECTED WOULD DRIVE LOADING BEYOND CURRENT RATINGS ON THE 110KV/38KV TRANSFORMER UNDER NORMAL FEEDING BUT FULL STATION CAPACITY WAS CONSIDERED**

YEAR	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Number of stations with 110/38 kV Transformer loading beyond current rating	0	0	0	1	1	1	1	2	2	2	3
Cahir											3
Doon											
Ballydine											
Butlerstown											5
Dungarvan				10	14	23	23	48	55	72	72
Waterford											
Great Island								6	6	15	16
Total Generation that can't be connected based on Transformer loading beyond current rating (MVA)	0	0	0	10	14	23	23	53	60	86	90
Additional generation which may be possible to accommodate based on the introduction of managed generation connections	0	4	20	48	50	49	69	90	93	82	99

5.3.1 DETAIL OF STUDIES UNDERTAKEN TO DATE continued

While in some cases the most onerous restrictions will arise due to 38kV circuit loadings beyond current rating, this is more unusual so the focus here is on station loadings beyond current rating.

From the results, Dungarvan station loading reaches current ratings earliest and continues to be most heavily loaded relative to this over the course of the 10-year period. This is primarily driven by a single large solar connection which is studied to connect in 2023. This is a pipeline project. However, there is a 37MW solar project assigned to the Dungarvan node for offer in ECP2.1.

CONTINGENCY FEEDING

The network has also been studied under contingency scenarios (an item of plant being unavailable due to maintenance or fault conditions). When considering the impact of contingencies on network loading, it is of note that DSO active management of export based on local network conditions, for example in response to network contingencies, can materially reduce the time and costs of connection without significant constraint on generation. For this reason, while loading beyond current ratings may arise at an earlier stage than for normal feeding, issues arising under contingency feeding arrangements are likely to have less impact on generation export.

In Waterford/Clonmel, the 110kV/38kV stations will become loaded beyond current ratings more significantly and at an earlier stage under standby. The table below gives the most onerous conditions which apply.

TABLE 5.19 **STATION LOADING BEYOND CURRENT RATINGS UNDER WORST CASE CONTINGENCY**

YEAR	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Stations loaded beyond current rating under contingency scenarios	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW	MW
Cahir								13	21	27	40
Doon											
Ballydine									4	4	4
Butlerstown									2	2	9
Dungarvan		4	8	46	52	60	60	89	No convergence. Assume 89MW min		
Waterford											
Great Island			12	12	12	12	32	41	41	50	51
Total Generation that may be turned down based on Transformer loading beyond current rating (MVA)	0	4	20	58	64	72	92	143	157	172	193
Additional generation (compared with table 5.14) which may be possible to accommodate based on the introduction of managed generation connections and if connection is planned for normal feeding arrangements only	0	4	20	48	50	49	69	90	97	86	103

38KV STATION LOADING AND SHALLOW CONNECTION WORKS

Finally, in terms of 38kV station loading, a high level assessment indicates that – based on current network – just under 50% of connections may drive new transformer infrastructure as part of their shallow connection works.

5.4 KEY FINDINGS - GENERATION

The key findings insights developed following a review of the detailed information above can be summarised as follows:

1. **With an increase in solar generation expected to complement wind, there is scope to make better use of the distribution connection assets via active management.**
2. **Tools which allow effective active management of generation output will also facilitate the planning of connections based on full station capacity (i.e. based on normal or "N" operating conditions). The tables in Section 5.3 above give detail as to the level of additional generation which it may be possible to accommodate. For example, in Waterford-Clonmel area, in 2030, it may be possible to accommodate over 100MW additional generation if connections were planned on a normal feeding basis.**
3. **The benefits of flexible load – which can respond to signals for load up or load down in response to needs of other customers especially renewable generation – is also clear. Section 6.3 sets out some detail indicating how aligning generation and demand can be beneficial.**
4. **As with demand, further network reinforcement will also be required in the next decade and beyond due to the absolute scale of increase in generation. This is apparent, for example, when we note that it is estimated that between 35 and 50% of new connections are likely to drive the need for new 38kV/MV (or 110kV/MV) transformer capacity.**

6

Applying These Insights

6 APPLYING THESE INSIGHTS

6.1 INFORMING THE DEVELOPMENT OF A MARKET FOR DISTRIBUTION SERVICES

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. As such, though our scenario analysis helps us to identify low regret and no regret options, decisions to invest in long-term capital infrastructure have the potential to lead to stranded assets. In addition to this, capital infrastructure takes time to develop and frequently impacts on the availability of existing infrastructure during the build, due to the outages required. In contrast with this, the new low carbon technologies which we are aiming to facilitate can be connected very quickly and often require very limited additional dedicated infrastructure as they use existing network connections. It is the volume of these new demands that is giving rise to the challenge, but which is also creating opportunity.

As such, the purpose of the work 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.

For the reasons set out above, and to meet these new demands in a cost effective and timely manner, a market for flexibility services, MW or MVAr[27] up or down, is essential to supporting electricity system development.

The market design and the definition of standardized flexibility services to meet the needs set out in this report, are set out in detail in the National Network, Local Connections Phased Flexibility Market Development Plan, in particular in Section 4.3 of same. However, as a general point, the type of service required in terms of the volume of flexible demand and how quickly this flexibility must be delivered will depend on the local network conditions and load in the area at the time.

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

6.2 CAPITAL INFRASTRUCTURE VERSUS MARKET SERVICES

As stated previously, the pace and distribution of demand growth is uncertain, and thus decisions to invest in capital infrastructure involve risk. 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 market for flexibility service on the distribution system.

With a strong flexibility market, however, the development of capital infrastructure can be better targeted to areas where there is a particularly acute customer need, especially under normal feeding arrangements. The initial approach to how decisions regarding the use of flexibility as an alternative or a complement to conventional reinforcement will be made has been set out in the 'Guide – Non-Wires Alternatives to Network Development' published in May 2021[28]. This work provides a good foundation on which to build the processes and policy underpinning the introduction of local flexibility markets.

Flexibility services are adopted as an alternative to capital infrastructure:

1. **Where there are active customers who are eager to get involved and optimise their energy costs. Ultimately, we need all customers seeking to participate – from a domestic customer with an immersion heater to a larger industrial customer – for flexibility services to offer a viable option.**
2. **Where load has not yet developed and its development is not yet certain.**
3. **Where network loadings beyond current rating primarily arise under non-standard feeding arrangements which may only arise infrequently.**
4. **Where the local demand profile is 'peaky' and therefore there is the potential to shift load to another part of the daily load profile, and thus optimise the use of existing local assets.**

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

1. **Allowing new demand and new generation customers to connect prior to the required reinforcement being completed.**
2. **Providing the system operators with additional tools which will facilitate the outages required to deliver identified and required capital infrastructure.**
3. **Offering the system operators a solution to improve local security of supply until reinforcement works have been completed.**

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[28] 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 flexibility services market will allow the customer to:

1. **Get more value out of their investment in new low carbon technologies.**
2. **Get rewarded for working with the DSO to manage their load, and by doing so optimise the use of existing infrastructure and renewable energy (both locally and nationally).**
3. **Optimise their own energy costs while playing a central role in delivering the Climate Action Plan.**

In short, the best strategy for power system to rise to the challenge of delivering on climate action is a combination of infrastructure build and demand side flexibility.

To illustrate this, the tables below give a picture of load versus capacity across the country. The first table gives a picture of the additional transformer capacity that would be required to support the expected growth in demand if this demand was unmanaged and no demand side flexibility were introduced.

The second table sets out a high-level indication of the maximum flexibility that would be needed over the coming decade countrywide to meet the additional capacity required in excess of today's network infrastructure.

The tables are based on:

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

TABLE 6.1

Overall Analysis	Stations Loaded Beyond Current Rating			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 6.2 **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 substantial potential for improved alignment of local demand with local generation. As noted previously, there are household loads which are not particularly time sensitive. 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 household's second or 'about town' vehicle), they will be plugged in more often and for longer.
- **To some extent heat pumps**[29]: Where the demand can be reduced 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 6.1 and Figure 6.2 below illustrate this concept.

Figure 6.1 is based on summer valley load which is the most onerous condition for accommodating new generation. In the absence of any 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 local demand. The total excess generation which would have to be exported from the distribution system up to the transmission system in this scenario is more than 6GW. Much of this generation can and will be exported onto the transmission system, but given the finite capacity of the transmission system, 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 excess generation which needs to be exported to the transmission system. Most importantly, a lot less of this renewable generation, which is core to the Climate Action Plan, will need to be curtailed or constrained.

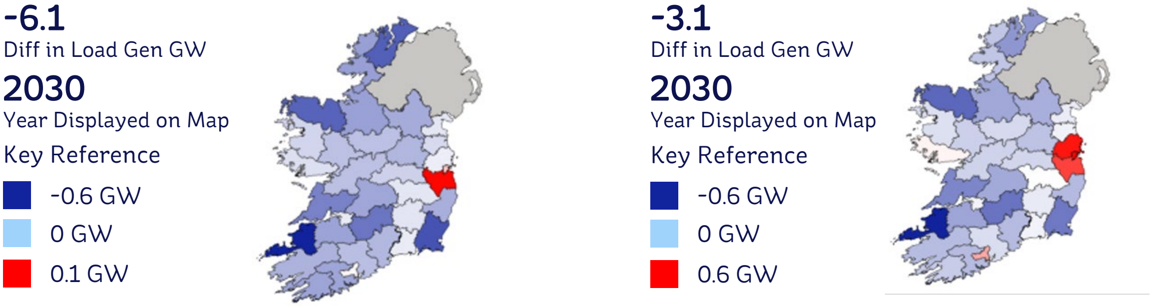

FIGURE 6.1

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

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

6.3 CAN GENERATION AND LOAD BE MORE CLOSELY ALIGNED? continued

Figure 6.2 is based on winter peak demand, and again, our focus is on whether locally produced generation can supply the local load. The figure on the left shows that in the absence of new low carbon technologies, there will still be an excess of 2.6GW of renewable generation which needs to be exported onto the transmission system and/or faces dispatch down. However, with the addition of new low carbon technology load (right hand side of the graph), there is no longer an issue with excess generation – distributed generation is being consumed locally, and just 1.5GW of residual demand will need to be serviced by more traditional generation (connected to the transmission system).

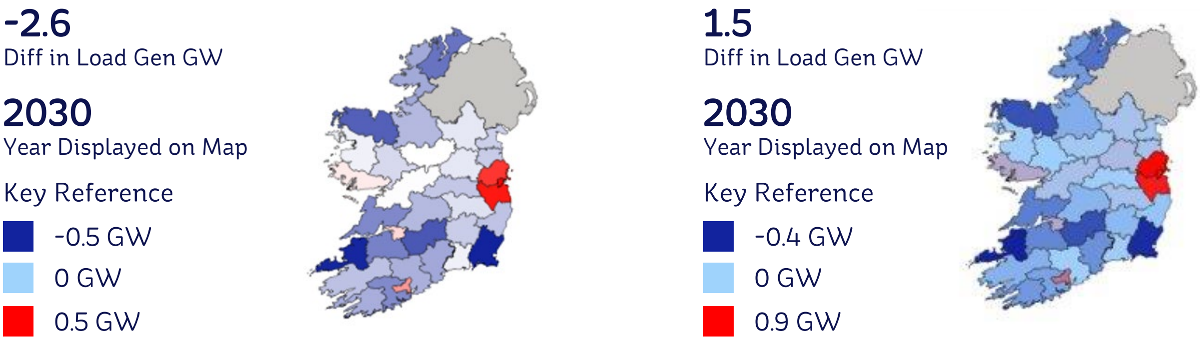

FIGURE 6.2
LEFT HAND SIDE IS GENERATION -LOAD AT WINTER PEAK (NO LCT). RIGHT HAND SIDE IS GENERATION -LOAD AT WINTER PEAK (INCLUDING LCT)

The graphs above offer a high level snapshot indicating that the scale of generation and load projected create significant opportunity to optimise our load and generation, and minimise the carbon emissions arising of electricity. But we cannot control the weather – so demand side flexibility and storage are critical to leverage these opportunities.

As a further example of what can be achieved in this regard, and bringing the analysis to a more granular level, we have assessed the level of demand side flexibility on the distribution system needed to optimise the use of locally connected generation. The table below indicates:

1. **The demand side flexibility needed taking account of limits on medium voltage networks[30] and at 38kV stations[31] (columns 1 and 2).**
2. **The demand side flexibility (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).**

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

[31] 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 6.3 **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

So, what does this mean? Using domestic customers as an example, the volumes set out in the first two 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, this clean energy would be consumed locally, minimising the risk that it would be constrained or that additional infrastructure is needed to accommodate it, with little or no inconvenience to customers.

The third column represents the flexible load – primarily electric vehicles – projected to be available at each of the locations where demand side flexibility is needed to increase demand. The shortfall between the first two columns and the third indicates that unless a broad range of alternative sources of demand side flexibility can be developed, 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 seek 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 three, is likely to be adequate for a significant portion of the time.

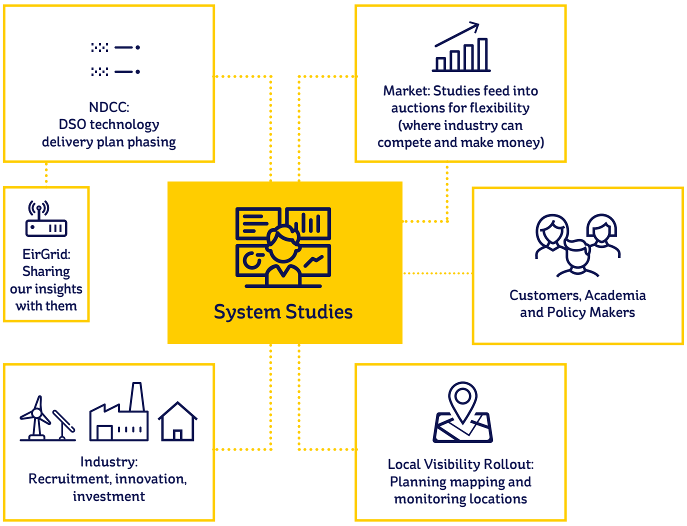
This will rely on active customers being aware and willing to participate in demand side flexibility. It also requires those customers to have the right technology to do so. For more information on the technology standards that will be needed, please refer to the National Networks, Local Connections Programme Data Exchange & Signals Guidance document.

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 3)**
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.

TABLE 6.4 **RISK ASSESSMENT**

	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 increases possible in areas 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 increases 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

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 AREA BY AREA ANALYSIS

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 7.1 **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 7.2 **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 7.3 **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

DEMAND

Section 3.1 shows the national peak demand as forecasted to be between 8.2GW and 9.2GW. As shown in Tables 7.4-7.6 (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 7.4 **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 7.5 **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 7.6 **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

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 7.7 **SCENARIO 1 NORTH REGION MICROGENERATION FORECAST**

Scenario 1 Microgeneration	**Generation connected**		
	2020	**2025**	**2030**
Existing generation			
Impact of PVs	0.1 MW	0.7 MW	1.6 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 7.8 **SCENARIO 2 NORTH REGION MICROGENERATION FORECAST**

Scenario 2 Microgeneration	**Generation connected**		
	2020	**2025**	**2030**
Existing generation			
Impact of PVs	5 MW	40.6 MW	612 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

GENERATION continued

TABLE 7.9 **SCENARIO 3 NORTH REGION MICROGENERATION FORECAST**

Scenario 3 Microgeneration	**Generation connected**		
	2020	**2025**	**2030**
Existing generation			
Impact of PVs	1 MW	17.2 MW	26.7 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

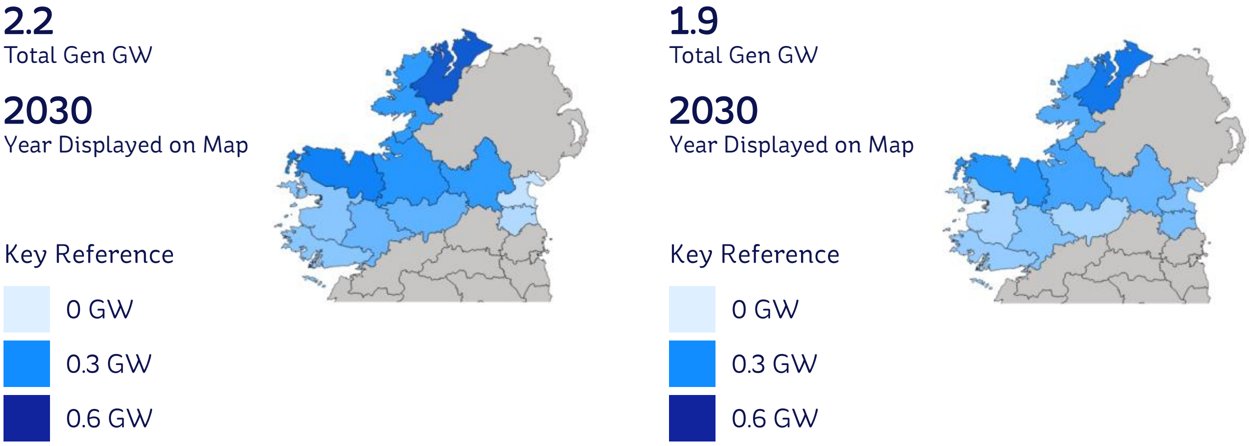


FIGURE 7.1 **LEFT HAND SIDE - LARGE SCALE GENERATION SCENARIO 1– HIGH WIND; RIGHT HAND SIDE SCENARIO 2– HIGH SOLAR**

7 AREA BY AREA ANALYSIS

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 7.10 **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 7.11 **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 7.12 **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

DEMAND

As shown in Section 3.1, the national peak demand in 2030 is forecasted to be between 8.2GW and 9.2GW. Tables 7.13-7.15, 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 7.13 **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 7.14 **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 7.15 **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

GENERATION

The central region is generally a flat region making it suitable for both wind and solar installations. As shown in Table 7.16-7.18, 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 7.16 **SCENARIO 1 CENTRAL REGION MICROGENERATION FORECAST**

Scenario 1 Microgeneration	**Generation connected**		
	2020	**2025**	**2030**
Existing generation			
Impact of PVs	0.4 MW	2.8 MW	5.9 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 7.17 **SCENARIO 2 CENTRAL REGION MICROGENERATION FORECAST**

Scenario 2 Microgeneration	**Generation connected**		
	2020	**2025**	**2030**
Existing generation			
Impact of PVs	5 MW	42.5 MW	70.9 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

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	21.2 MW	32.7 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

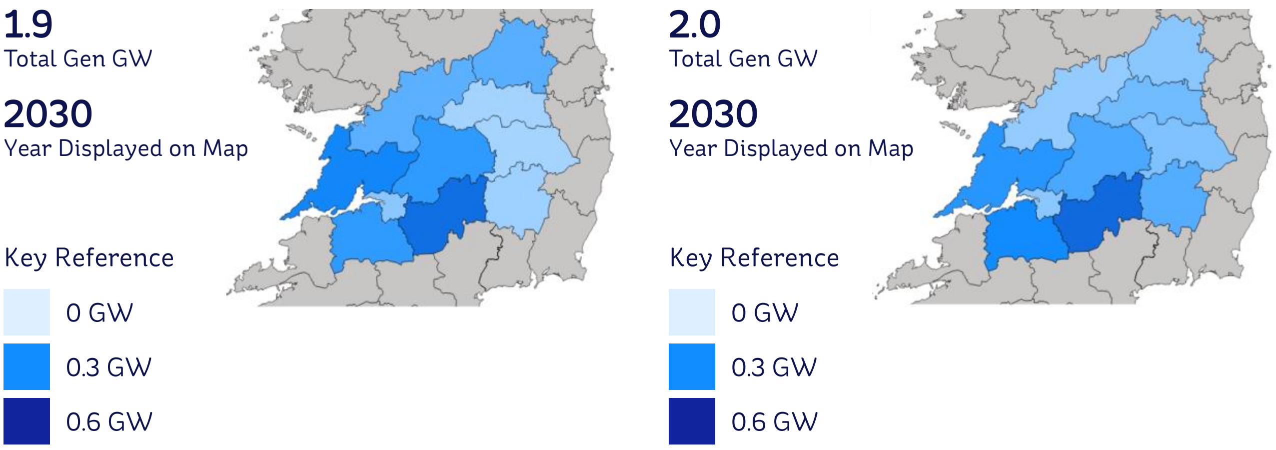


FIGURE 7.2
LEFT HAND SIDE GENERATION MW IN 2030 FOR CENTRAL REGION (SCENARIO 1) – HIGH WIND; RIGHT HAND SIDE SCENARIO 2

7 AREA BY AREA ANALYSIS

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.

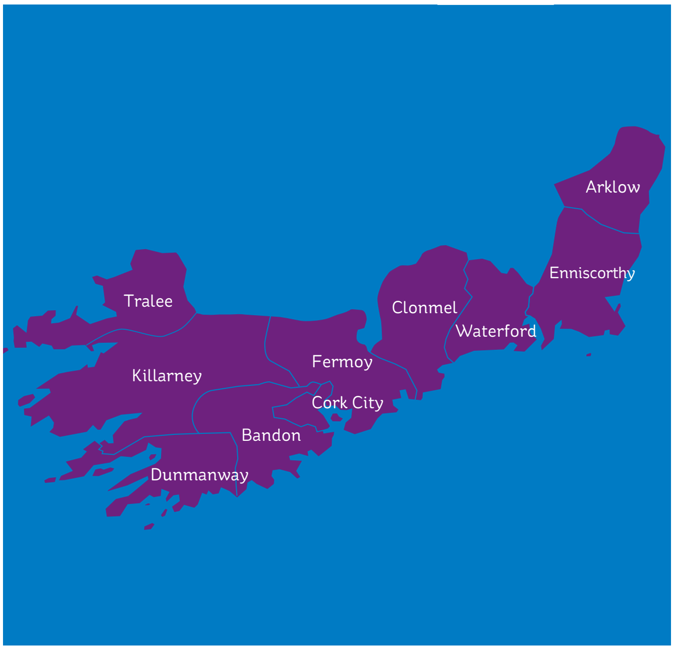


TABLE 7.19 **HIGHEST AND LOWEST LCT NUMBERS IN SOUTH REGION**

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	Tralee 0	Dunmanway 7,886	Dunmanway 4,730	Tralee 0

TABLE 7.20 **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 7.21 **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

DEMAND

As shown in Section 3.1, the national peak demand is forecasted to be between 8.2GW and 9.2GW. As shown in Tables 7.22-7.24 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 7.22 **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 7.23 **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 7.24 **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

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 7.25 **SCENARIO 1 SOUTH REGION MICROGENERATION FORECAST**

Scenario 1 Microgeneration	Generation connected		
	2020	**2025**	**2030**
Existing generation			
Impact of PVs	1 MW	5.6 MW	11.5 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

TABLE 7.26 **SCENARIO 2 SOUTH REGION MICROGENERATION FORECAST**

Scenario 2 Microgeneration	Generation connected		
	2020	**2025**	**2030**
Existing generation			
Impact of PVs	5 MW	41.8 MW	68.6 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

GENERATION continued

TABLE 7.27 **SCENARIO 3 SOUTH REGION MICROGENERATION FORECAST**

Scenario 3 Microgeneration	**Generation connected**		
	2020	**2025**	**2030**
Existing generation			
Impact of PVs	4 MW	38.6 MW	58.4 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

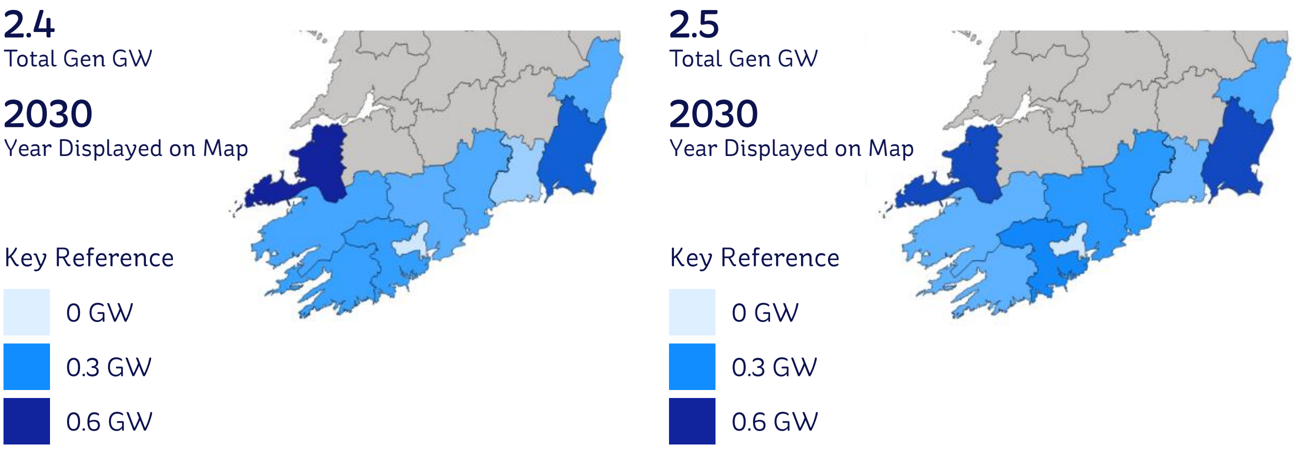


FIGURE 7.3
LEFT HAND SIDE GENERATION MW IN 2030 FOR SOUTH REGION (SCENARIO 1) – HIGH WIND; RIGHT HAND SIDE SCENARIO 2

7 AREA BY AREA ANALYSIS

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.

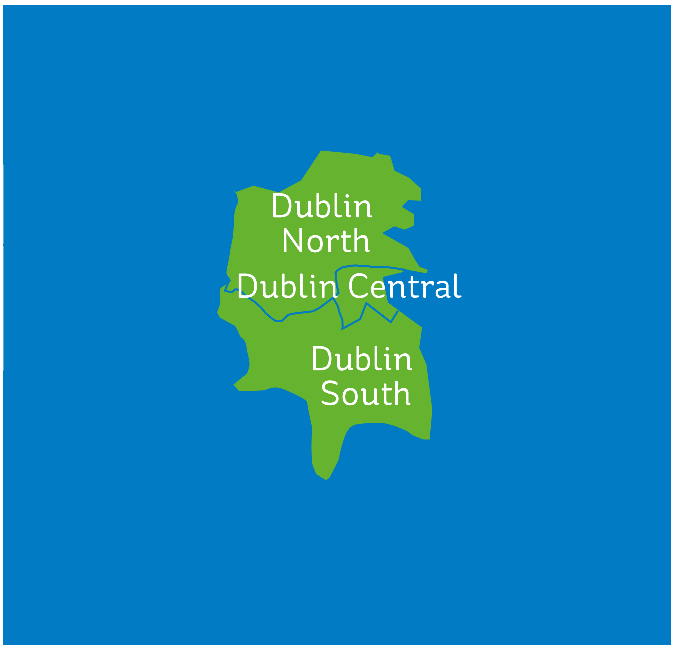


TABLE 7.28 **HIGHEST AND LOWEST LCT NUMBERS IN DUBLIN REGION**

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 7.29 **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 7.30 **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

DEMAND

As shown in Section 3.1, the national peak demand is forecasted to be between 8.2GW and 9.2GW. As shown in Tables 7.31-7.33 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 7.31 **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 7.32 **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 7.33 **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%

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 7.34 **SCENARIO 1 DUBLIN REGION MICROGENERATION FORECAST**

Scenario 1 Microgeneration	**Generation connected**		
	2020	**2025**	**2030**
Existing generation			
Impact of PVs	4 MW	26.9 MW	55.2 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 7.35 **SCENARIO 2 DUBLIN REGION MICROGENERATION FORECAST**

Scenario 2 Microgeneration	**Generation connected**		
	2020	**2025**	**2030**
Existing generation			
Impact of PVs	10 MW	71.8 MW	107.2 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

GENERATION continued

TABLE 7.36 **SCENARIO 3 DUBLIN REGION MICROGENERATION FORECAST**

Scenario 3 Microgeneration	**Generation connected**		
	2020	**2025**	**2030**
Existing generation			
Impact of PVs	13 MW	122.5 MW	187 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

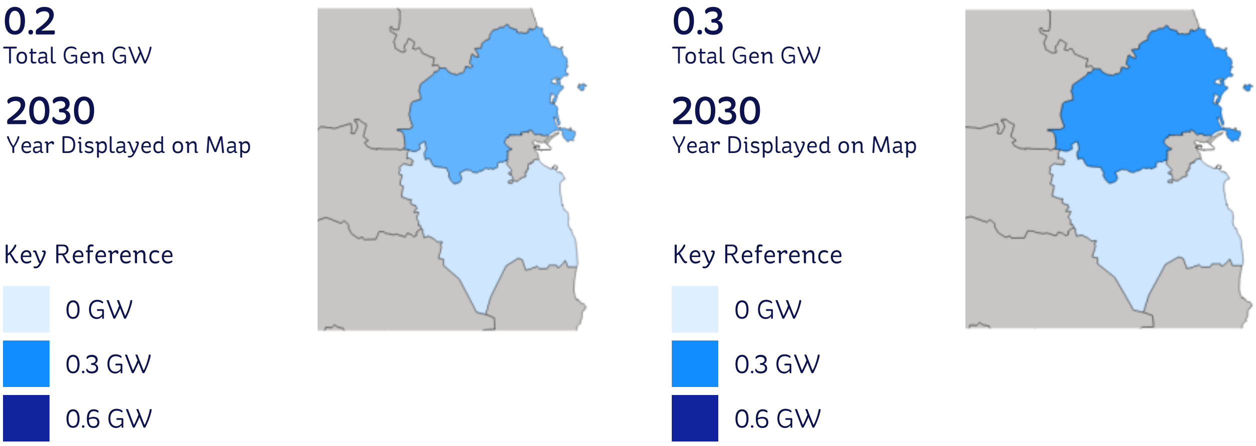


FIGURE 7.4
LEFT HAND SIDE GENERATION MW IN 2030 FOR DUBLIN REGION (SCENARIO 1) – HIGH WIND; RIGHT HAND SIDE SCENARIO 2

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. This document sets out the breadth and depth of insights developed to date regarding the available capacity across the country (depending on the expected local uptake). In 2022, additional analyses will be undertaken 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:

TABLE 8.1 **PROPOSED LOCATIONS FOR PILOT 1**

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

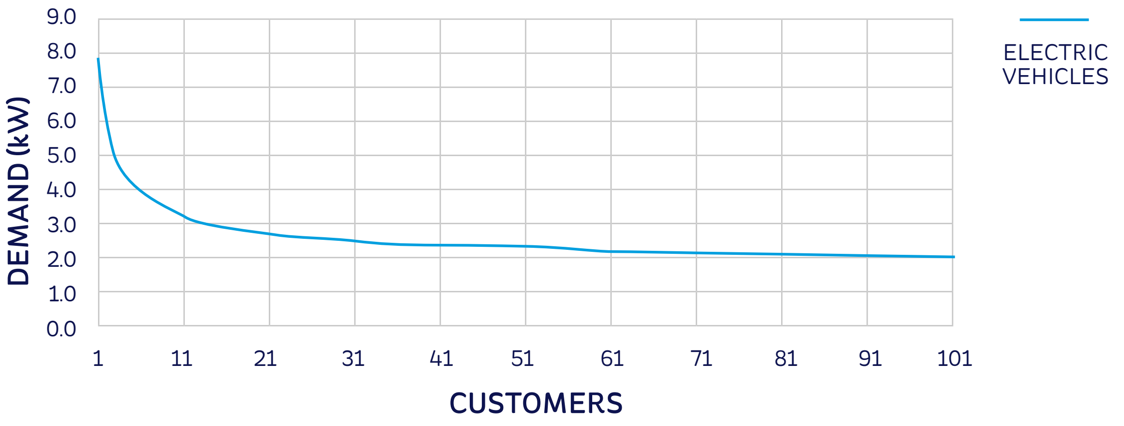
SEAI INPUTS

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 A1.1 **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 A1.2 **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.**

TABLE A1.1 **DATA FROM BER DATABASE**

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:

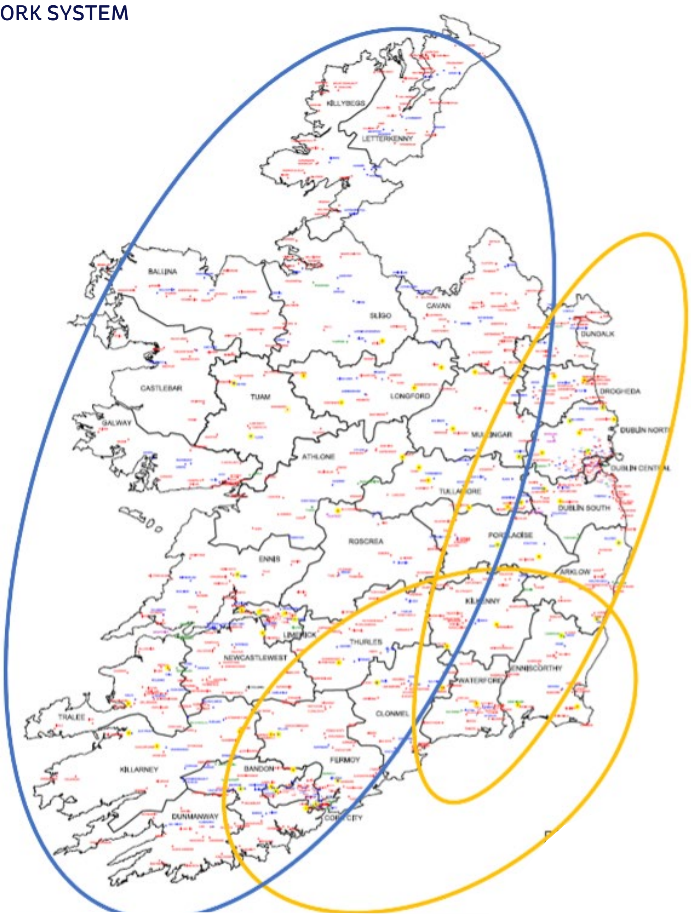
1. 500MW to be connected per year on distribution system.
2. IWEA pipeline study to help inform on likely locations for connections.
3. SEAI planning database & LARES tool to help inform on likely locations for connections.
4. Blue circle (on below figure) predominantly wind connections.
5. Orange circle (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 A1.3 **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 locations 1%.

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 will have loadings beyond current rating.**
2. **The time/year that the loading beyond current rating first occurs.**
3. **The extent of the loading beyond current rating.**

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 A2.1)

For the purpose of the 2030 studies, all new renewable commercial generation is modelled as being connected to the MV B/B's of 38kV or 110kV/MV stations or to 38 kV or 110kV 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 (using summer valley load). As was the case with the MV analysis, the demand scenario simulation looks to forecast feeders and transformers that might become loaded beyond current rating in the future, and the time that the loading beyond current rating might first occur.

The generation analysis – which is conducted based on the assumption that 5 GW of additional renewable generation will be connected to the distribution networks by 2030 – seeks to identify occasions where circuits or transformers become loaded beyond current rating, 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 A2.1 **PERMITTED VOLTAGE DROPS**[32]

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

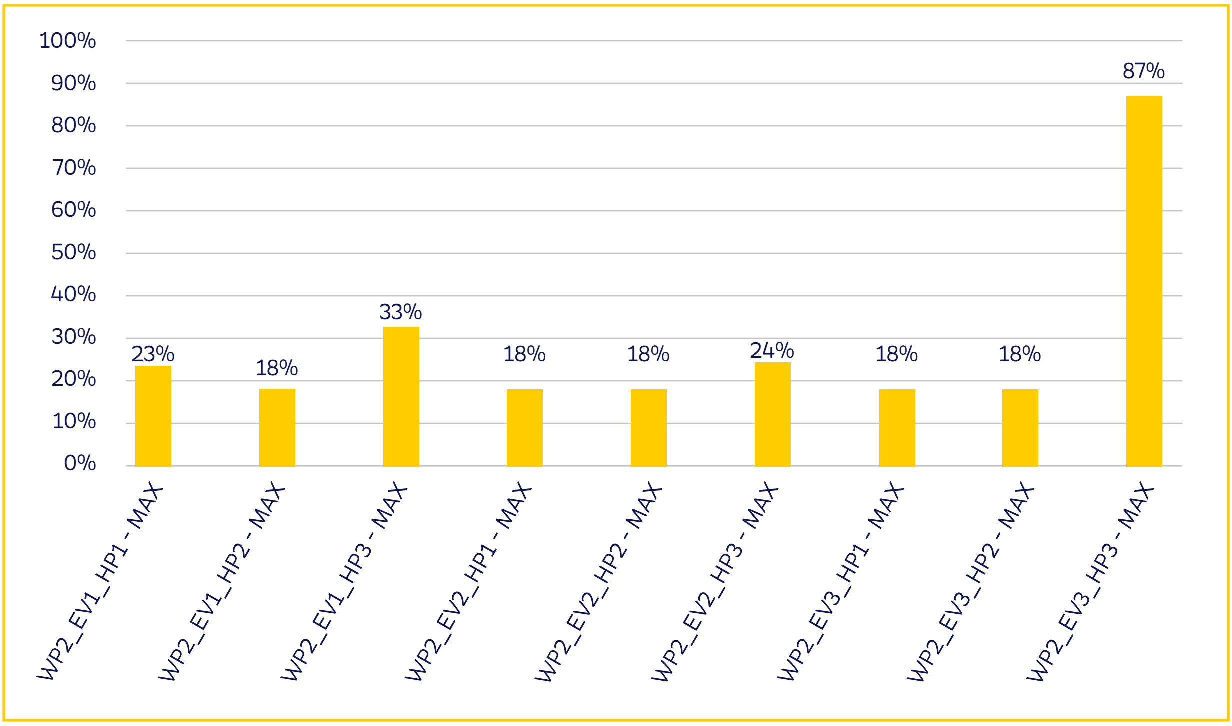
[32] Main source voltages on the 110kV networks are generally controlled by TSO. Permitted voltage drops on distribution 110kV networks should be determined on a case by case basis; however volt drop assessments shall maintain the receiving voltage on all distribution 110kV and lower voltage (38kV and 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 A2.1 is a sample of a graph produced by the excel analysis when identifying the worst-case scenario in a particular network area[33].

FIGURE A2.1 **SCENARIO IDENTIFICATION GRAPH**



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

9 APPENDIX 3 – KEY ASSUMPTIONS

Studies undertaken to date have been based on static conditions. As such, it is important to identify the key assumptions on which the studies were based.

ASSUMPTION	RISK/IMPACT/OPPORTUNITY
LOAD	
The basis for the load database was the winter peak load of 2019/20	The load profile since that time may have changed – especially with COVID
LCT uptake is based on delivery of the Climate Action Plan (2019). SEAI also provided some valuable feedback on scenarios developed identifying how this LCT might be distributed across the country	LCT estimate for a given year will invariably be different to that forecast
LCT distribution was developed for a number of different scenarios. For the purpose of the studies, the scenario combination that was chosen was the one which drove the highest load in an area	The accuracy of the LCT distribution will not be known until after the EV is purchased; heat pump is installed
LOAD PROFILE	
Studies are done at peak load conditions	The system needs to be able to cope with the system peak. However, in many cases the peak will only last for 2-3 hours
Studies assume EV charging at peak load time	This assumption has the potential to be correct (i.e. customers plug in the EV as soon as they return home). However, it is critical that EV charging is managed such that this is the exception. Options adopted in other utilities include a default charging time which is off-peak
Diversified EV and HP load assumed	The diversification factor takes into account that an EV will typically only need to be charged 1 day in 3 or 4 (or if charged more frequently, most likely not for very long). As EVs become more mainstream, this diversification factor will need to be assessed
Demand studies assume no local generation is available to reduce the demand on the system	Where local generation is solar, this assumption is realistic (peak load is 5-7 in winter – no solar available.). However, a couple of things to account for as experience grow: 1. Home batteries, which may allow solar energy to be stored; 2. As we move up the voltages, generation may be wind and may be available; 3. As there is a bigger uptake of local generation, there is likely to be some baseline level of output a significant portion of the time.

9 APPENDIX 3 – KEY ASSUMPTIONS

GENERATION	
The quantity of installed generation needed to be connected was based on an assumption as to how much energy will be generated per MW of renewable generation	If levels of constraint are too high, then not enough renewable energy will be available to meet our targets
Circa 50% of the required generation, to reach 70% RES-E[34], was assumed to be connected to the distribution system	If there is more generation connected at distribution, potentially the ability of load to absorb same locally will be less. This in turn may increase the likelihood of constraint. If there is less local generation, there will be less power available to supply local load. This may drive the need for reinforcements
Connecting locations of distribution generation were assumed based on input from WEI and use of SEAI LARES tool	Locations and timelines will inevitably vary. However, the actual connection and works will be based on Connection Studies undertaken by Renewable Planners
Studies were undertaken with demand assumed to be at minimum load	This was done to identify likely areas of congestion due to generation.

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[34] While assumptions were based on delivery of 70% RES (which reflected the target at the time), we note that this target has since been updated to 80%. Following an initial impact assessment, no change in process/studies is proposed.

9 APPENDIX 4A – DETAILED LOAD FLOW RESULTS

PSS DEMAND STUDIES

The tables below present key loading and capacity restrictions/information for each of the areas for which load flow studies at MV have been undertaken[35]. The lines setting out MW scarcities for each year are based on thermal loading beyond current rating only – rather than voltage. However, in the majority of cases it has been noted that the demand reduction required to alleviate station loadings beyond current rating is significantly greater than required to alleviate MV circuit violations due to either thermal or voltage. For this reason, an additional line has been included to identify station capacity scarcities.

In terms of the table structure, while the first 9 rows relate to information derived directly from the load flow studies, the last row – relating to 38kV station capacity – derives from the load database directly.

EPRI STUDIES

Appendix 4B includes the table of results from EPRI for normal feeding WP+LCT only.

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[35] All figures provided have been rounded to the nearest whole number

9 APPENDIX 4A – DETAILED LOAD FLOW RESULTS

PSS DEMAND STUDIES continued

Athlone/Longford
WP & LCT

ATHLONE/LONGFORD AREA NORMAL FEEDING WP+LCT	2024	2025	2026	2027	2028	2029	2030
No. of feeders loaded beyond current rating (Balanced)	5	5	8	9	10	11	14
% of feeders loaded beyond current rating (Balanced)	5%	5%	7%	8%	9%	10%	13%
No. of feeders with voltage issues	25	26	32	34	37	41	44
% of feeders with voltage issues	23%	23%	29%	31%	33%	37%	40%
No. of HV stations with MV feeders below standard voltage	13	14	16	16	17	18	18
% of HV stations with MV feeders below standard voltage	68%	74%	84%	84%	89%	95%	95%
No. of Network Breakdowns	0	0	0	0	0	0	0
MW scarcity (scarcity on single feeders most loaded beyond current rating)	2	2	4	5	6	7	8
MW scarcity (total scarcity on all feeders loaded beyond current rating)	4	5	10	15	20	25	31
38kV station MW scarcity WP + LCT*	18	20	33	45	58	72	84

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

WP Only

ATHLONE/LONGFORD AREA NORMAL FEEDING WP ONLY	2024	2025	2026	2027	2028	2029	2030
No. of feeders loaded beyond current rating (Balanced)	1	1	2	2	2	3	3
% of feeders loaded beyond current rating (Balanced)	1%	1%	2%	2%	2%	3%	3%
No. of feeders with voltage issues	20	20	21	23	23	24	26
% of feeders with voltage issues	18%	18%	19%	21%	21%	22%	23%
No. of HV stations with MV feeders below standard voltage	12	12	13	13	13	13	14
% of HV stations with MV feeders below standard voltage	63%	63%	68%	68%	68%	68%	74%
No. of Network Breakdowns	0	0	0	0	0	0	0
MW scarcity (scarcity on single feeders most loaded beyond current rating)	0.4	0.4	0.5	0.5	0.6	0.6	0.7
MW scarcity (total scarcity on all feeders loaded beyond current rating)	0.4	0.4	0.6	0.8	1.0	1.2	1.5
38kV station MW scarcity WP only*	0.3	0.5	0.7	0.9	1.2	1.6	2.0

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

9 APPENDIX 4A – DETAILED LOAD FLOW RESULTS

PSS DEMAND STUDIES continued

Ballina/Castlebar
WP & LCT

BALLINA/CASTLEBAR, NORMAL FEEDING WP+LCT	2024	2025	2026	2027	2028	2029	2030
No. of feeders loaded beyond current rating (Balanced)	0	0	0	0	0	1	2
% of feeders loaded beyond current rating (Balanced)	0%	0%	0%	0%	0%	1%	2%
No. of feeders with voltage issues	16	16	21	26	26	26	30
% of feeders with voltage issues	16%	16%	21%	25%	25%	25%	29%
No. of HV stations with MV feeders below standard voltage	12	12	13	15	15	15	15
% of HV stations with MV feeders below standard voltage	52%	52%	57%	65%	65%	65%	65%
No. of Network Breakdowns	0	0	0	0	0	0	0
MW scarcity (scarcity on single feeders most loaded beyond current rating)	0	0	0	0	0	1	1
MW scarcity (total scarcity on all feeders loaded beyond current rating)	0	0	0	0	1	2	3
38kV station MW scarcity WP + LCT*	3	4	12	18	24	30	35

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

WP Only

BALLINA/CASTLEBAR, NORMAL FEEDING WP ONLY	2024	2025	2026	2027	2028	2029	2030
No. of feeders loaded beyond current rating (Balanced)	0	0	0	0	0	0	0
% of feeders loaded beyond current rating (Balanced)	0%	0%	0%	0%	0%	0%	0%
No. of feeders with voltage issues	12	12	12	12	12	12	12
% of feeders with voltage issues	12%	12%	12%	12%	12%	12%	12%
No. of HV stations with MV feeders below standard voltage	10	10	10	10	10	10	10
% of HV stations with MV feeders below standard voltage	43%	43%	43%	43%	43%	43%	43%
No. of Network Breakdowns	0	0	0	0	0	0	0
MW scarcity (scarcity on single feeders most loaded beyond current rating)	0	0	0	0	0	0	0
MW scarcity (total scarcity on all feeders loaded beyond current rating)	0	0	0	0	0	0	0
38kV station MW scarcity WP only*	1	1	1	1	1	1	1

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

9 APPENDIX 4A – DETAILED LOAD FLOW RESULTS

PSS DEMAND STUDIES continued

Cavan /Sligo
WP & LCT

CAVAN/SLIGO AREA NORMAL FEEDING WP+LCT	2024	2025	2026	2027	2028	2029	2030
No. of feeders loaded beyond current rating (Balanced)	4	5	5	9	11	12	12
% of feeders loaded beyond current rating (Balanced)	2%	3%	3%	5%	6%	7%	7%
No. of feeders with voltage issues	33	37	45	46	50	56	59
% of feeders with voltage issues	18%	21%	25%	26%	28%	31%	33%
No. of HV stations with MV feeders below standard voltage	21	22	24	25	27	30	30
% of HV stations with MV feeders below standard voltage	60%	63%	69%	71%	77%	86%	86%
No. of Network Breakdowns	0	0	0	0	0	0	0
MW scarcity (scarcity on single feeders most loaded beyond current rating)	2	2	3	3	3	4	4
MW scarcity (total scarcity on all feeders loaded beyond current rating)	5	5	7	10	13	16	20
38kV station MW scarcity WP + LCT*	6	8	22	33	53	72	91

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

WP Only

CAVAN/SLIGO AREA NORMAL FEEDING WP ONLY	2024	2025	2026	2027	2028	2029	2030
No. of feeders loaded beyond current rating (Balanced)	3	3	3	3	3	3	3
% of feeders loaded beyond current rating (Balanced)	2%	2%	2%	2%	2%	2%	2%
No. of feeders with voltage issues	23	23	24	24	26	26	28
% of feeders with voltage issues	13%	13%	13%	13%	15%	15%	16%
No. of HV stations with MV feeders below standard voltage	18	18	18	18	18	18	19
% of HV stations with MV feeders below standard voltage	51%	51%	51%	51%	51%	51%	54%
No. of Network Breakdowns	0	0	0	0	0	0	0
MW scarcity (scarcity on single feeders most loaded beyond current rating)	2	2	2	2	2	2	2
MW scarcity (total scarcity on all feeders loaded beyond current rating)	3	3	3	3	4	4	4
38kV station MW scarcity WP only*	0	0	0	0	0	0	0

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

9 APPENDIX 4A – DETAILED LOAD FLOW RESULTS

PSS DEMAND STUDIES continued

Cork City
WP & LCT

CORK CITY AREA NORMAL FEEDING WP+LCT	2024	2025	2026	2027	2028	2029	2030
No. of feeders loaded beyond current rating (Balanced)	6	6	15	27	31	37	41
% of feeders loaded beyond current rating (Balanced)	3%	3%	8%	15%	17%	21%	23%
No. of feeders with voltage issues	8	9	15	15	19	22	25
% of feeders with voltage issues	4%	5%	8%	8%	11%	12%	14%
No. of HV stations with MV feeders below standard voltage	7	8	10	10	10	10	12
% of HV stations with MV feeders below standard voltage	37%	42%	53%	53%	53%	53%	63%
No. of Network Breakdowns	0	0	0	0	0	0	0
MW scarcity (scarcity on single feeders most loaded beyond current rating)	3	3	4	5	5	6	7
MW scarcity (total scarcity on all feeders loaded beyond current rating)	9	10	16	26	39	59	75
38kV station MW scarcity WP + LCT*	21	25	44	66	88	111	122

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

WP Only

CORK CITY AREA NORMAL FEEDING WP ONLY	2024	2025	2026	2027	2028	2029	2030
No. of feeders loaded beyond current rating (Balanced)	4	4	4	4	4	4	4
% of feeders loaded beyond current rating (Balanced)	2%	2%	2%	2%	2%	2%	2%
No. of feeders with voltage issues	6	7	7	7	7	7	8
% of feeders with voltage issues	3%	4%	4%	4%	4%	4%	4%
No. of HV stations with MV feeders below standard voltage	6	7	7	7	7	7	7
% of HV stations with MV feeders below standard voltage	32%	37%	37%	37%	37%	37%	37%
No. of Network Breakdowns	0	0	0	0	0	0	0
MW scarcity (scarcity on single feeders most loaded beyond current rating)	2	2	2	2	3	3	3
MW scarcity (total scarcity on all feeders loaded beyond current rating)	6	6	7	7	7	8	8
38kV station MW scarcity WP only*	1	2	2	3	3	4	5

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

9 APPENDIX 4A – DETAILED LOAD FLOW RESULTS

PSS DEMAND STUDIES continued

Dublin Central
WP & LCT

DUBLIN CENTRAL AREA NORMAL FEEDING WP+LCT	2024	2025	2026	2027	2028	2029	2030
No. of feeders loaded beyond current rating	27	32	55	70	80	92	98
% of feeders loaded beyond current rating	7%	8%	13%	17%	19%	22%	24%
No. of feeders with voltage issues	4	4	7	10	13	16	21
% of feeders with voltage issues	1%	1%	2%	2%	3%	4%	5%
No. of HV stations with MV feeders below standard voltage	4	4	5	7	9	11	13
% of HV stations with MV feeders below standard voltage	11%	11%	13%	18%	24%	29%	34%
MW scarcity (scarcity on single feeders most loaded beyond current rating)	12	13	14	16	17	20	22
MW scarcity (total scarcity on all feeders loaded beyond current rating)	34	44	72	107	131	187	234
38kV station MW scarcity WP + LCT*	36	53	95	141	168	230	278

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

WP Only

DUBLIN CENTRAL AREA NORMAL FEEDING WP ONLY	2024	2025	2026	2027	2028	2029	2030
No. of feeders loaded beyond current rating	7	8	9	10	11	11	11
% of feeders loaded beyond current rating	2%	2%	2%	2%	3%	3%	3%
No. of feeders with voltage issues	1	1	1	1	1	1	1
% of feeders with voltage issues	0%	0%	0%	0%	0%	0%	0%
No. of HV stations with MV feeders below standard voltage	1	1	1	1	1	1	1
% of HV stations with MV feeders below standard voltage	3%	3%	3%	3%	3%	3%	3%
MW scarcity (scarcity on single feeders most loaded beyond current rating)	7	7	8	8	8	9	9
MW scarcity (total scarcity on all feeders loaded beyond current rating)	10	11	12	13	15	16	18
38kV station MW scarcity WP only	0	0	0	0	0	0	1

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

9 APPENDIX 4A – DETAILED LOAD FLOW RESULTS

PSS DEMAND STUDIES continued

Dublin North
WP & LCT

DUBLIN NORTH AREA NORMAL FEEDING WP+LCT	2024	2025	2026	2027	2028	2029	2030
No. of feeders loaded beyond current rating (Balanced)	70	77	90	97	100	113	121
% of feeders loaded beyond current rating (Balanced)	19%	21%	25%	26%	27%	31%	33%
No. of feeders with voltage issues	52	57	66	74	79	87	89
% of feeders with voltage issues	14%	16%	18%	20%	22%	24%	24%
No. of HV stations with MV feeders below standard voltage	29	30	35	36	37	37	37
% of HV stations with MV feeders below standard voltage	71%	73%	85%	88%	90%	90%	90%
No. of Network Breakdowns	0	0	0	0	0	0	0
MW scarcity (scarcity on single feeders most loaded beyond current rating)	5	5	8	10	11	13	14
MW scarcity (total scarcity on all feeders loaded beyond current rating)	91	113	171	231	265	342	401
38kV station MW scarcity WP + LCT	55	70	107	145	182	225	262

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

WP Only

DUBLIN NORTH AREA NORMAL FEEDING WP ONLY	2024	2025	2026	2027	2028	2029	2030
No. of feeders loaded beyond current rating (Balanced)	27	27	30	33	36	38	39
% of feeders loaded beyond current rating (Balanced)	7%	7%	8%	9%	10%	10%	11%
No. of feeders with voltage issues	32	33	33	35	36	37	37
% of feeders with voltage issues	9%	9%	9%	10%	10%	10%	10%
No. of HV stations with MV feeders below standard voltage	19	19	19	19	20	21	21
% of HV stations with MV feeders below standard voltage	46%	46%	46%	46%	49%	51%	51%
No. of Network Breakdowns	0	0	0	0	0	0	0
MW scarcity (scarcity on single feeders most loaded beyond current rating)	2	2	2	3	3	3	3
MW scarcity (total scarcity on all feeders loaded beyond current rating)	23	25	27	29	32	34	37
38kV station MW scarcity WP only *	0	0	1	2	3	4	6

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

9 APPENDIX 4A – DETAILED LOAD FLOW RESULTS

PSS DEMAND STUDIES continued

Dublin South
WP & LCT

DUBLIN SOUTH AREA NORMAL FEEDING WP+LCT	2024	2025	2026	2027	2028	2029	2030
No. of feeders loaded beyond current rating (Balanced)	19	23	28	36	39	47	53
% of feeders loaded beyond current rating (Balanced)	6%	7%	9%	12%	13%	15%	17%
No. of feeders with voltage issues	22	24	34	36	38	42	44
% of feeders with voltage issues	7%	8%	11%	12%	12%	14%	14%
No. of HV stations with MV feeders below standard voltage	16	18	21	22	22	24	24
% of HV stations with MV feeders below standard voltage	48%	55%	64%	67%	67%	73%	73%
No. of Network Breakdowns	0	0	0	0	0	0	0
MW scarcity (scarcity on single feeders most loaded beyond current rating)	2	3	4	5	5	6	7
MW scarcity (total scarcity on all feeders loaded beyond current rating)	16	22	37	54	65	92	114
38kV station MW scarcity WP + LCT*	10	13	31	58	90	120	148

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

WP Only

DUBLIN SOUTH AREA NORMAL FEEDING WP ONLY	2024	2025	2026	2027	2028	2029	2030
No. of feeders loaded beyond current rating (Balanced)	6	7	7	7	8	9	11
% of feeders loaded beyond current rating (Balanced)	2%	2%	2%	2%	3%	3%	4%
No. of feeders with voltage issues	17	17	18	19	20	20	22
% of feeders with voltage issues	6%	6%	6%	6%	6%	6%	7%
No. of HV stations with MV feeders below standard voltage	13	13	13	14	14	14	15
% of HV stations with MV feeders below standard voltage	39%	39%	39%	42%	42%	42%	45%
No. of Network Breakdowns	0	0	0	0	0	0	0
MW scarcity (scarcity on single feeders most loaded beyond current rating)	1	1	2	2	2	2	2
MW scarcity (total scarcity on all feeders loaded beyond current rating)	4	4	5	5	6	7	8
38kV station MW scarcity WP only	0	0	0	1	1	1	1

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

9 APPENDIX 4A – DETAILED LOAD FLOW RESULTS

PSS DEMAND STUDIES continued

Fermoy
WP & LCT

FERMOY AREA NORMAL FEEDING WP+LCT	2024	2025	2026	2027	2028	2029	2030
No. of feeders loaded beyond current rating (Balanced)	7	8	10	13	19	20	25
% of feeders loaded beyond current rating (Balanced)	9%	11%	13%	17%	25%	27%	33%
No. of feeders with voltage issues	18	18	26	26	29	28	32
% of feeders with voltage issues	24%	24%	35%	35%	39%	37%	43%
No. of HV stations with MV feeders below standard voltage	13	13	16	16	16	16	16
% of HV stations with MV feeders below standard voltage	72%	72%	89%	89%	89%	89%	89%
No. of Network Breakdowns	0	0	0	0	0	2	2
MW scarcity (scarcity on single feeders most loaded beyond current rating)	2	2	4	6	8	10	10
MW scarcity (total scarcity on all feeders loaded beyond current rating)	6	7	16	24	41	60	66
38kV station MW scarcity WP + LCT*	9	11	30	44	69	97	104

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

WP Only

FERMOY AREA NORMAL FEEDING WP ONLY	2024	2025	2026	2027	2028	2029	2030
No. of feeders loaded beyond current rating (Balanced)	3	3	3	3	4	4	4
% of feeders loaded beyond current rating (Balanced)	4%	4%	4%	4%	5%	5%	5%
No. of feeders with voltage issues	10	9	9	9	10	10	10
% of feeders with voltage issues	13%	12%	12%	12%	13%	13%	13%
No. of HV stations with MV feeders below standard voltage	9	8	8	8	9	9	9
% of HV stations with MV feeders below standard voltage	50%	44%	44%	44%	50%	50%	50%
No. of Network Breakdowns	0	0	0	0	0	0	0
MW scarcity (scarcity on single feeders most loaded beyond current rating)	1	1	1	1	1	1	1
MW scarcity (total scarcity on all feeders loaded beyond current rating)	2	2	2	2	2	2	2
38kV station MW scarcity WP only*	1	1	1	1	2	2	2

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

9 APPENDIX 4A – DETAILED LOAD FLOW RESULTS

PSS DEMAND STUDIES continued

Galway/Tuam
WP & LCT

GALWAY/TUAM AREA NORMAL FEEDING WP+LCT	2024	2025	2026	2027	2028	2029	2030
No. of feeders loaded beyond current rating (Balanced)	8	9	17	18	21	25	28
% of feeders loaded beyond current rating (Balanced)	6%	7%	13%	14%	16%	19%	21%
No. of feeders with voltage issues	29	29	34	37	36	39	44
% of feeders with voltage issues	22%	22%	26%	28%	27%	30%	34%
No. of HV stations with MV feeders below standard voltage	16	16	17	17	16	17	17
% of HV stations with MV feeders below standard voltage	73%	73%	77%	77%	73%	77%	77%
No. of Network Breakdowns	0	0	0	3	5	5	6
MW scarcity (scarcity on single feeders most loaded beyond current rating)	3	4	6	7	9	11	11
MW scarcity (total scarcity on all feeders loaded beyond current rating)	12	20	37	49	50	65	62
38kV station MW scarcity WP + LCT*	23	26	52	81	103	130	149

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

WP Only

GALWAY/TUAM AREA NORMAL FEEDING WP ONLY	2024	2025	2026	2027	2028	2029	2030
No. of feeders loaded beyond current rating (Balanced)	4	4	4	4	4	4	4
% of feeders loaded beyond current rating (Balanced)	3%	3%	3%	3%	3%	3%	3%
No. of feeders with voltage issues	22	23	23	24	25	26	26
% of feeders with voltage issues	17%	18%	18%	18%	19%	20%	20%
No. of HV stations with MV feeders below standard voltage	14	15	15	15	15	15	15
% of HV stations with MV feeders below standard voltage	64%	68%	68%	68%	68%	68%	68%
No. of Network Breakdowns	0	0	0	0	0	0	0
MW scarcity (scarcity on single feeders most loaded beyond current rating)	1	1	1	1	1	1	2
MW scarcity (total scarcity on all feeders loaded beyond current rating)	2	3	3	3	4	4	4
38kV station MW scarcity WP only*	5	6	6	7	8	9	9

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

9 APPENDIX 4A – DETAILED LOAD FLOW RESULTS

PSS DEMAND STUDIES continued

Letterkenny/Killybegs
WP & LCT

LETTERKENNY/KILLYBEGS AREA NORMAL FEEDING WP+LCT	2024	2025	2026	2027	2028	2029	2030
No. of feeders loaded beyond current rating (Balanced)	8	11	15	18	18	18	18
% of feeders loaded beyond current rating (Balanced)	9%	12%	16%	19%	19%	19%	19%
No. of feeders with voltage issues	37	39	41	37	36	34	34
% of feeders with voltage issues	40%	42%	44%	40%	39%	37%	37%
No. of HV stations with MV feeders below standard voltage	19	19	22	21	21	21	21
% of HV stations with MV feeders below standard voltage	76%	76%	88%	84%	84%	84%	84%
No. of Network Breakdowns	0	0	6	11	12	14	14
MW scarcity (scarcity on single feeders most loaded beyond current rating)	4	5	6	6	7	9	9
MW scarcity (total scarcity on all feeders loaded beyond current rating)	14	20	38	50	55	64	65
38kV station MW scarcity WP + LCT*	20	23	43	61	79	96	110

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

WP Only

LETTERKENNY/KILLYBEGS AREA NORMAL FEEDING WP ONLY	2024	2025	2026	2027	2028	2029	2030
No. of feeders loaded beyond current rating (Balanced)	0	0	0	0	0	0	0
% of feeders loaded beyond current rating (Balanced)	0%	0%	0%	0%	0%	0%	0%
No. of feeders with voltage issues	21	22	23	23	23	23	23
% of feeders with voltage issues	23%	24%	25%	25%	25%	25%	25%
No. of HV stations with MV feeders below standard voltage	12	13	13	13	13	13	13
% of HV stations with MV feeders below standard voltage	48%	52%	52%	52%	52%	52%	52%
No. of Network Breakdowns	0	0	0	0	0	0	0
MW scarcity (scarcity on single feeders most loaded beyond current rating)	0	0	0	0	0	0	0
MW scarcity (total scarcity on all feeders loaded beyond current rating)	0	0	0	0	0	0	0
38kV station MW scarcity WP only*	2	2	2	2	2	3	3

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

9 APPENDIX 4A – DETAILED LOAD FLOW RESULTS

PSS DEMAND STUDIES continued

Waterford/Clonmel
WP & LCT

WATERFORD/CLONMEL AREA NORMAL FEEDING WP+LCT	2024	2025	2026	2027	2028	2029	2030
No. of feeders loaded beyond current rating (Balanced)	6	6	6	7	11	13	14
% of feeders loaded beyond current rating (Balanced)	4%	4%	4%	5%	7%	8%	9%
No. of feeders with voltage issues	16	19	24	29	30	33	33
% of feeders with voltage issues	10%	12%	16%	19%	19%	21%	21%
No. of HV stations with MV feeders below standard voltage	9	12	15	17	18	20	20
% of HV stations with MV feeders below standard voltage	33%	44%	56%	63%	67%	74%	74%
No. of Network Breakdowns	0	0	0	0	0	0	0
MW scarcity (scarcity on single feeders most loaded beyond current rating)	3	3	4	5	6	7	7
MW scarcity (total scarcity on all feeders loaded beyond current rating)	6	7	11	14	18	23	27
38kV station MW scarcity WP + LCT*	8	10	20	30	41	51	60

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

WP Only

WATERFORD/CLONMEL AREA NORMAL FEEDING WP ONLY	2024	2025	2026	2027	2028	2029	2030
No. of feeders loaded beyond current rating (Balanced)	4	4	4	4	5	5	5
% of feeders loaded beyond current rating (Balanced)	3%	3%	3%	3%	3%	3%	3%
No. of feeders with voltage issues	12	13	13	14	16	16	18
% of feeders with voltage issues	8%	8%	8%	9%	10%	10%	12%
No. of HV stations with MV feeders below standard voltage	8	9	9	9	9	9	10
% of HV stations with MV feeders below standard voltage	30%	33%	33%	33%	33%	33%	37%
No. of Network Breakdowns	0	0	0	0	0	0	0
MW scarcity (scarcity on single feeders most loaded beyond current rating)	1	2	2	2	2	2	2
MW scarcity (total scarcity on all feeders loaded beyond current rating)	3	4	4	4	5	5	6
38kV station MW scarcity WP only*	2	2	2	2	2	2	2

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

9 APPENDIX 4B – EPRI RESULTS FOR ARKLOW/ENNISCORTHY

ARKLOW/ENNISCORTHY AREA NORMAL FEEDING WP+LCT ONLY	2024	2025	2026	2027	2028	2029	2030
No. of feeders loaded beyond current rating (Balanced)	7	8	13	15	15	16	18
% of feeders loaded beyond current rating (Balanced)*	7%	8%	13%	15%	15%	16%	18%
No. of feeders with voltage issues	29	29	29	30	33	36	38
% of feeders with voltage issues	29%	29%	29%	30%	33%	36%	38%
No. of HV stations with MV feeders below standard voltage	17	17	17	18	19	20	20
% of HV stations with MV feeders below standard voltage	65%	65%	65%	65%	65%	65%	65%
No. of Network Breakdowns	0	0	0	0	0	0	0
MW scarcity (scarcity on single feeders most loaded beyond current rating)	4	4	4	4	4	4	4
MW scarcity (total scarcity on all feeders loaded beyond current rating)	17	20	27	28	28	29	29
38kV station MW scarcity WP only*	11	13	27	41	53	69	88

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

9 APPENDIX 5 – RESULTS FROM DATA ANALYTICS WORK

DA DEMAND

Bandon – WP + LCT

BANDON NORMAL FEEDING WP+LCT	2024	2025	2026	2027	2028	2029	2030
No of 110kV stations loaded beyond current ratings	0	0	1	1	2	2	2
% 110kV stations loading beyond current ratings	0%	0%	33%	33%	66%	66%	50%
No of 38kV stations loading beyond current ratings	4	6	8	8	10	10	10
% 38kV stations loading beyond current ratings	40%	60%	80%	80%	100%	100%	100%
No. of MV feeders loading beyond current ratings (Balanced)	2	2	3	3	6	10	14
% of MV feeders loading beyond current ratings (Balanced)	4%	4%	6%	6%	11%	19%	26%
No. of MV feeders with voltage issues	N/A FOR DA						
% of MV feeders with voltage issues							
No. of HV stations below standard voltage							
% of HV stations below standard voltage							
No. of Network Breakdowns							
EV load (in MW)	20	23	48	65	85	108	116
HP load (in MW)	5	6	6	7	7	8	9
PV (in MW)	-3	-4	-4	-5	-6	-6	-7
Scarcity in capacity (in MW)	0	1	4	7	12	20	23
38kV station MW scarcity WP + LCT*	13	15	37	57	80	108	117

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

9 APPENDIX 5 – RESULTS FROM DATA ANALYTICS WORK

DA DEMAND

Drogheda – WP + LCT

DROGHEDA NORMAL FEEDING WP+LCT	2024	2025	2026	2027	2028	2029	2030
No of 110kV stations loaded beyond current ratings	1	1	2	2	2	2	2
% 110kV stations loading beyond current ratings	50%	50%	100%	100%	100%	100%	100%
No of 38kV stations loading beyond current ratings	6	7	7	8	8	9	10
% 38kV stations loading beyond current ratings	60%	70%	70%	80%	80%	90%	100%
No. of MV feeders loading beyond current ratings (Balanced)	3	3	7	10	12	13	14
% of MV feeders loading beyond current ratings (Balanced)	5%	5%	12%	18%	21%	23%	25%
No. of MV feeders with voltage issues	N/A FOR DA						
% of MV feeders with voltage issues							
No. of HV stations below standard voltage							
% of HV stations below standard voltage							
No. of Network Breakdowns							
EV load (in MW)	35	40	71	94	120	145	149
HP load (in MW)	8	9	9	10	11	12	13
PV (in MW)	-6	-8	-8	-9	-10	-10	-11
Scarcity in capacity (in MW)	1	1	10	18	28	41	44
38kV station MW scarcity WP + LCT*	27	31	56	76	98	121	126

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

9 APPENDIX 5 – RESULTS FROM DATA ANALYTICS WORK

DA DEMAND

Dundalk – WP + LCT

DUNDALK NORMAL FEEDING - WP+LCT	2024	2025	2026	2027	2028	2029	2030
No of 110kV stations loaded beyond current ratings	0	0	1	1	2	2	2
% 110kV stations loading beyond current ratings	0%	0%	50%	50%	100%	100%	100%
No of 38kV stations loading beyond current ratings	5	5	9	10	10	12	12
% 38kV stations loading beyond current ratings	42%	42%	75%	83%	83%	100%	100%
No. of MV feeders loading beyond current ratings (Balanced)	4	4	4	6	12	13	15
% of MV feeders loading beyond current ratings (Balanced)	6%	6%	6%	10%	19%	21%	24%
No. of MV feeders with voltage issues	N/A FOR DA						
% of MV feeders with voltage issues							
No. of HV stations below standard voltage							
% of HV stations below standard voltage							
No. of Network Breakdowns							
EV load (in MW)	29	33	59	77	99	121	125
HP load (in MW)	5	5	6	6	7	8	8
PV (in MW)	-5	-6	-6	-6	-7	-7	-8
Scarcity in capacity (in MW)	3	3	8	12	21	32	35
38kV station MW scarcity WP + LCT*	7	8	21	35	54	75	81

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

9 APPENDIX 5 – RESULTS FROM DATA ANALYTICS WORK

DA DEMAND

Dunmanway – WP + LCT

DUNMANWAY NORMAL FEEDING WP+LCT	2024	2025	2026	2027	2028	2029	2030
No of 110kV stations loaded beyond current ratings	0	0	0	0	0	0	0
% 110kV stations loading beyond current ratings	0%	0%	0%	0%	0%	0%	0%
No of 38kV stations loading beyond current ratings	1	1	3	3	4	5	5
% 38kV stations loading beyond current ratings	13%	13%	38%	38%	50%	63%	62%
No. of MV feeders loading beyond current ratings (Balanced)	0	0	0	0	4	5	8
% of MV feeders loading beyond current ratings (Balanced)	0%	0%	0%	0%	13%	16%	25%
No. of MV feeders with voltage issues	N/A FOR DA						
% of MV feeders with voltage issues							
No. of HV stations below standard voltage							
% of HV stations below standard voltage							
No. of Network Breakdowns							
EV load (in MW)	7	8	19	29	58	75	82
HP load (in MW)	0	0	0	0	21	21	21
PV (in MW)	-1	-1	-1	-1	-3	-3	-3
Scarcity in capacity (in MW)	0	0	0	0	2	4	6
38kV station MW scarcity WP + LCT*	1	2	9	15	22	30	33

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

9 APPENDIX 5 – RESULTS FROM DATA ANALYTICS WORK

DA DEMAND

Ennis – WP + LCT

ENNIS NORMAL FEEDING WP+LCT	2024	2025	2026	2027	2028	2029	2030
No of 110kV stations loaded beyond current ratings	0	1	1	1	1	1	1
% 110kV stations loading beyond current ratings	0%	33%	33%	33%	33%	33%	33%
No of 38kV stations loading beyond current ratings	5	5	7	9	9	9	9
% 38kV stations loading beyond current ratings	50%	50%	70%	90%	90%	90%	90%
No. of MV feeders loading beyond current ratings (Balanced)	1	1	1	3	4	7	9
% of MV feeders loading beyond current ratings (Balanced)	2%	2%	5%	6%	8%	14%	18%
No. of MV feeders with voltage issues	N/A FOR DA						
% of MV feeders with voltage issues							
No. of HV stations below standard voltage							
% of HV stations below standard voltage							
No. of Network Breakdowns							
EV load (in MW)	10	11	23	31	38	45	51
HP load (in MW)	7	8	9	11	12	13	13
PV (in MW)	0	0	0	0	0	0	0
Scarcity in capacity (in MW)	0	0	1	2	3	4	7
38kV station MW scarcity WP + LCT*	9	11	17	24	31	37	43

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

9 APPENDIX 5 – RESULTS FROM DATA ANALYTICS WORK

DA DEMAND

Kilkenny – WP + LCT

KILKENNY NORMAL FEEDING WP+LCT	2024	2025	2026	2027	2028	2029	2030
No of 110kV stations loaded beyond current ratings	0	0	0	0	0	1	1
% 110kV stations loading beyond current ratings	300%	0%	0%	0%	0%	33%	33%
No of 38kV stations loading beyond current ratings	6	6	8	9	10	10	10
% 38kV stations loading beyond current ratings	50%	50%	67%	75%	83%	83%	83%
No. of MV feeders loading beyond current ratings (Balanced)	3	5	6	7	9	10	10
% of MV feeders loading beyond current ratings (Balanced)	5%	8%	10%	12%	15%	17%	17%
No. of MV feeders with voltage issues	N/A FOR DA						
% of MV feeders with voltage issues							
No. of HV stations below standard voltage							
% of HV stations below standard voltage							
No. of Network Breakdowns							
EV load (in MW)	12	13	24	33	40	47	53
HP load (in MW)	8	10	11	12	13	15	15
PV (in MW)	0	0	0	0	0	0	0
Scarcity in capacity (in MW)	1	2	4	6	9	12	14
38kV station MW scarcity WP + LCT*	9	11	19	25	34	42	49

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

9 APPENDIX 5 – RESULTS FROM DATA ANALYTICS WORK

DA DEMAND

Killarney – WP + LCT

KILLARNEY NORMAL FEEDING WP+LCT	2024	2025	2026	2027	2028	2029	2030
No of 110kV stations loaded beyond current ratings	1	1	1	2	2	2	2
% 110kV stations loading beyond current ratings	`33%	33%	33%	66%	66%	66%	66%
No of 38kV stations loading beyond current ratings	4	4	4	5	6	6	6
% 38kV stations loading beyond current ratings	40%	40%	40%	50%	60%	60%	60%
No. of MV feeders loading beyond current ratings (Balanced)	1	1	1	1	1	1	1
% of MV feeders loading beyond current ratings (Balanced)	2%	2%	2%	2%	2%	2%	2%
No. of MV feeders with voltage issues	N/A FOR DA						
% of MV feeders with voltage issues							
No. of HV stations below standard voltage							
% of HV stations below standard voltage							
No. of Network Breakdowns							
EV load (in MW)	10	11	23	32	39	46	53
HP load (in MW)	7	8	9	10	11	12	13
PV (in MW)	0	0	0	0	0	0	0
Scarcity in capacity (in MW)	1	1	2	3	3	4	4
38kV station MW scarcity WP + LCT*	9	11	19	25	32	39	45

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

9 APPENDIX 5 – RESULTS FROM DATA ANALYTICS WORK

DA DEMAND

Limerick – WP+LCT

LIMERICK NORMAL FEEDING - WP+LCT	2024	2025	2026	2027	2028	2029	2030
No of 110kV stations loaded beyond current ratings	0	0	1	1	1	1	2
% 110kV stations loading beyond current ratings	0%	0%	20%	20%	20%	50%	40%
No of 38kV stations loading beyond current ratings	6	7	8	9	10	12	12
% 38kV stations loading beyond current ratings	40%	47%	53%	60%	67%	80%	80%
No. of MV feeders loading beyond current ratings (Balanced)	1	4	4	7	8	9	9
% of MV feeders loading beyond current ratings (Balanced)	1%	4%	4%	8%	9%	10%	10%
No. of MV feeders with voltage issues	N/A FOR DA						
% of MV feeders with voltage issues							
No. of HV stations below standard voltage							
% of HV stations below standard voltage							
No. of Network Breakdowns							
EV load (in MW)	17	20	34	46	56	67	77
HP load (in MW)	9	9	10	11	13	14	15
PV (in MW)	-4	-5	-5	-6	-6	-7	-7
Scarcity in capacity (in MW)	3	3	6	9	14	19	22
38kV station MW scarcity WP + LCT*	15	18	30	43	56	71	82

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

9 APPENDIX 5 – RESULTS FROM DATA ANALYTICS WORK

DA DEMAND

Mullingar – WP + LCT

MULLINGAR NORMAL FEEDING WP+LCT	2024	2025	2026	2027	2028	2029	2030
No of 110kV stations loaded beyond current ratings	0	0	1	1	1	1	1
% 110kV stations loading beyond current ratings	0%	0%	33%	33%	33%	33%	33%
No of 38kV stations loading beyond current ratings	6	6	6	7	8	8	8
% 38kV stations loading beyond current ratings	67%	66%	66%	78%	89%	89%	89%
No. of MV feeders loading beyond current ratings (Balanced)	0	0	3	5	10	19	19
% of MV feeders loading beyond current ratings (Balanced)	0%	0%	6%	10%	19%	37%	37%
No. of MV feeders with voltage issues	N/A FOR DA						
% of MV feeders with voltage issues							
No. of HV stations below standard voltage							
% of HV stations below standard voltage							
No. of Network Breakdowns							
EV load (in MW)	25	28	57	75	100	125	131
HP load (in MW)	5	5	6	6	7	8	8
PV (in MW)	-5	-6	-6	-7	-8	-9	-10
Scarcity in capacity (in MW)	0	0	2	5	13	27	30
38kV station MW scarcity WP + LCT*	14	17	38	53	75	99	102

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

9 APPENDIX 5 – RESULTS FROM DATA ANALYTICS WORK

DA DEMAND

Newcastlewest – WP+LCT

NEWCASTLEWEST NORMAL FEEDING WP+LCT	2024	2025	2026	2027	2028	2029	2030
No of 110kV stations loaded beyond current ratings	0	0	1	1	1	1	2
% 110kV stations loading beyond current ratings	0%	0%	33%	33%	33%	33%	66%
No of 38kV stations loading beyond current ratings	3	3	3	4	4	4	5
% 38kV stations loading beyond current ratings	30%	30%	30%	40%	40%	40%	50%
No. of MV feeders loading beyond current ratings (Balanced)	1	1	3	5	6	6	6
% of MV feeders loading beyond current ratings (Balanced)	2%	2%	6%	10%	12%	12%	12%
No. of MV feeders with voltage issues	N/A FOR DA						
% of MV feeders with voltage issues							
No. of HV stations below standard voltage							
% of HV stations below standard voltage							
No. of Network Breakdowns							
EV load (in MW)	12	13	31	40	55	70	79
HP load (in MW)	3	3	3	4	4	4	5
PV (in MW)	-2	-2	-2	-3	-3	-3	-4
Scarcity in capacity (in MW)	0	0	4	7	16	27	28
38kV station MW scarcity WP + LCT*	10	11	21	28	40	52	57

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

9 APPENDIX 5 – RESULTS FROM DATA ANALYTICS WORK

DA DEMAND

Portlaoise – WP+LCT

PORTLAOISE NORMAL FEEDING WP+LCT	2024	2025	2026	2027	2028	2029	2030
No of 110kV stations loaded beyond current rating	0	0	1	1	1	1	1
% 110kV stations loaded beyond current rating	0%	0%	33%	50%	50%	50%	50%
No of 38kV stations loaded beyond current rating	4	4	5	6	6	6	6
% 38kV stations loaded beyond current rating	67%	67%	83%	100%	100%	100%	100%
No. of MV feeders loaded beyond current rating (Balanced)	5	7	10	12	12	13	14
% of MV feeders loaded beyond current rating (Balanced)	10%	15%	21%	25%	25%	27%	29%
No. of MV feeders with voltage issues	N/A FOR DA						
% of MV feeders with voltage issues							
No. of HV stations below standard voltage							
% of HV stations below standard voltage							
No. of Network Breakdowns							
EV load (in MW)	22	25	49	67	85	106	114
HP load (in MW)	6	7	7	8	9	10	11
PV (in MW)	-5	-6	-7	-7	-8	-9	-10
Scarcity in capacity (in MW)	2	4	13	22	32	45	49
38kV station MW scarcity WP + LCT*	11	13	29	45	61	79	85

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

9 APPENDIX 5 – RESULTS FROM DATA ANALYTICS WORK

DA DEMAND

Roscrea – WP+LCT

ROSCREA NORMAL FEEDING WP+LCT	2024	2025	2026	2027	2028	2029	2030
No of 110kV stations loaded beyond current ratings	1	1	1	1	1	1	2
% 110kV stations loading beyond current ratings	33%	33%	33%	33%	33%	33%	66%
No of 38kV stations loading beyond current ratings	0	1	2	2	5	6	8
% 38kV stations loading beyond current ratings	0%	9%	18%	18%	45%	55%	73%
No. of MV feeders loading beyond current ratings (Balanced)	3	3	4	4	5	7	7
% of MV feeders loading beyond current ratings (Balanced)	6%	6%	8%	8%	10%	14%	14%
No. of MV feeders with voltage issues	N/A FOR DA						
% of MV feeders with voltage issues							
No. of HV stations below standard voltage							
% of HV stations below standard voltage							
No. of Network Breakdowns							
EV load (in MW)	9	10	25	36	46	57	68
HP load (in MW)	4	4	4	5	5	6	6
PV (in MW)	-3	-3	-4	-4	-5	-5	-6
Scarcity in capacity (in MW)	1	1	3	5	7	12	13
38kV station MW scarcity WP + LCT*	0	0	9	18	27	38	49

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

9 APPENDIX 5 – RESULTS FROM DATA ANALYTICS WORK

DA DEMAND

Tipperary – WP+LCT

TIPPERARY NORMAL FEEDING WP+LCT	2024	2025	2026	2027	2028	2029	2030
No of 110kV stations loaded beyond current ratings	0	0	0	0	0	0	0
% 110kV stations loading beyond current ratings	0%	0%	0%	0%	0%	0%	0%
No of 38kV stations loading beyond current ratings	3	3	5	5	5	5	5
% 38kV stations loading beyond current ratings	30%	30%	50%	50%	50%	50%	50%
No. of MV feeders loading beyond current ratings (Balanced)	1	1	4	4	4	4	5
% of MV feeders loading beyond current ratings (Balanced)	2%	2%	8%	8%	8%	8%	10%
No. of MV feeders with voltage issues	N/A FOR DA						
% of MV feeders with voltage issues							
No. of HV stations below standard voltage							
% of HV stations below standard voltage							
No. of Network Breakdowns							
EV load (in MW)	6	7	17	24	30	35	46
HP load (in MW)	3	4	4	4	5	5	6
PV (in MW)	-1	-1	-1	-2	-2	-2	-2
Scarcity in capacity (in MW)	2	3	6	12	15	19	21
38kV station MW scarcity WP + LCT*	2	2	6	13	19	24	30

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

9 APPENDIX 5 – RESULTS FROM DATA ANALYTICS WORK

DA DEMAND

Tralee – WP+LCT

TRALEE NORMAL FEEDING WP+LCT	2024	2025	2026	2027	2028	2029	2030
No of 110kV stations loaded beyond current ratings	0	0	0	0	0	0	0
% 110kV stations loading beyond current ratings	0%	0%	0%	0%	0%	0%	0%
No of 38kV stations loading beyond current ratings	1	2	4	6	6	7	7
% 38kV stations loading beyond current ratings	10%	20%	40%	60%	60%	70%	70%
No. of MV feeders loading beyond current ratings (Balanced)	0	0	0	3	3	3	4
% of MV feeders loading beyond current ratings (Balanced)	0%	0%	0%	5%	5%	5%	7%
No. of MV feeders with voltage issues	N/A FOR DA						
% of MV feeders with voltage issues							
No. of HV stations below standard voltage							
% of HV stations below standard voltage							
No. of Network Breakdowns							
EV load (in MW)	10	11	24	33	41	48	54
HP load (in MW)	8	9	10	11	13	14	14
PV (in MW)	0	0	0	0	0	0	0
Scarcity in capacity (in MW)	0	0	0	1	2	3	4
38kV station MW scarcity WP + LCT*	1	1	6	12	18	24	30

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

9 APPENDIX 5 – RESULTS FROM DATA ANALYTICS WORK

DA DEMAND

Tullamore – WP + LCT

TULLAMORE NORMAL FEEDING WP+LCT	2024	2025	2026	2027	2028	2029	2030
No of 110kV stations loaded beyond current ratings	2	2	2	2	2	2	2
% 110kV stations loading beyond current ratings	66%	67%	67%	66%	66%	66%	66%
No of 38kV stations loading beyond current ratings	4	4	5	6	7	7	9
% 38kV stations loading beyond current ratings	40%	40%	50%	60%	70%	70%	90%
No. of MV feeders loading beyond current ratings (Balanced)	2	2	5	8	10	11	14
% of MV feeders loading beyond current ratings (Balanced)	3%	3%	8%	14%	17%	19%	24%
No. of MV feeders with voltage issues	N/A FOR DA						
% of MV feeders with voltage issues							
No. of HV stations below standard voltage							
% of HV stations below standard voltage							
No. of Network Breakdowns							
EV load (in MW)	24	28	49	68	83	99	111
HP load (in MW)	8	8	9	10	11	12	13
PV (in MW)	-6	-7	-8	-9	-10	-10	-11
Scarcity in capacity (in MW)	1	2	4	11	18	27	31
38kV station MW scarcity WP + LCT*	15	18	34	54	70	88	99

* This is based on a comparison of load versus firm capacity (acknowledging the possibility of a transformer outage)

9 APPENDIX 6 - 38KV AND 110KV STATION LOADINGS

The tables below indicate – on an area by area basis - predicted 38kV and 110kV station peak loads in 2030. The scenario chosen is that which is the most onerous for the area in question.

Arklow Enniscorthy - Scenario 2

38KV STATION NAME	PLANNING CAP	AREA	WP LOADING	WP+LCT LOADING
BARNTOWN	5	Enniscorthy	2.22	4.21
BEALISTOWN	10	Enniscorthy	8.60	16.25
BELLFIELD	18	Enniscorthy	8.80	15.04
BUNCLODY	19	Enniscorthy	4.93	10.47
CARRIGLAWN	9	Enniscorthy	6.30	11.22
CLONARD	9	Enniscorthy	5.75	10.44
CLONROCHE	9	Enniscorthy	8.32	15.39
COOLGREANEY ROAD	9	Arklow	1.51	4.32
FERNS	10	Enniscorthy	6.20	9.29
GARDEN CITY	9	Arklow	8.68	23.71
KILLINICK	20	Enniscorthy	11.66	25.08
KILMAGIG	5	Arklow	3.14	11.28
KILMARTIN	5	Arklow	3.24	10.53
MONFIN	3.6	Enniscorthy	2.78	5.53
MULGANNON	20	Enniscorthy	11.81	22.76
NEW ROSS	9	Enniscorthy	8.23	15.51
RAMSTOWN	9	Arklow	4.67	8.19
RATHDRUM	5	Arklow	4.47	14.51
SHILLELAGH	9	Arklow	5.69	11.22
TINAHASK	9	Arklow	9.71	26.43
TULLOW	20	Arklow	9.23	18.94

AREA	110KV STATION NAME	STATION CAPACITY	STATION LOADING WP&LCT	STATION WP LOADING	LCT LOADING
ENNISCORTHY	Crane	31.5	42.99	30.25	12.74
ENNISCORTHY	Crane	20	28.88	16.51	12.37
ARKLOW	Arklow	56.7	90.77	35.54	55.23
ENNISCORTHY	Great Island	31.5	31.76	19.37	12.38
ENNISCORTHY	Wexford	113.4	94.63	62.17	32.46
ARKLOW	Ballybeg	40	30.68	20.52	10.16
ENNISCORTHY	Wexford	40	20.61	11.94	8.67
ENNISCORTHY	Banoge	40	18.25	10.23	8.02
ARKLOW	Arklow	40	12.84	9.10	3.74

9 APPENDIX 6 - 38KV AND 110KV STATION LOADINGS

Athlone-Longford Scenario 1

38KV STATION NAME	PLANNING CAP	AREA	WP LOADING	WP+LCT LOADING
AGHAMORE	5	Longford	4.04	9.49
ATHLONE	20	Athlone	18.55	45.15
BALLINASLOE	9	Athlone	4.57	10.36
BALLYMAHON	9	Longford	6.62	14.02
BUSHFIELD	20	Athlone	6.71	14.90
CASTLEREA	9	Longford	4.82	9.60
CREAGH	9	Athlone	9.54	22.51
CURRA	5	Athlone	0.58	3.01
EDGEWORTHSTOWN	20	Longford	4.17	13.52
FINNEA	9	Longford	6.01	12.39
GARRYCASTLE	30	Athlone	12.19	22.04
GLEBE	20	Longford	6.18	16.26
GORT	9	Athlone	7.16	12.08
KILCOLGAN	10	Athlone	7.51	15.22
LONGFORD	20	Longford	12.67	24.67
LOUGHREA	9	Athlone	10.48	20.10
MOATE	10	Athlone	5.49	11.14
ROOSKY	5	Longford	2.59	6.64
ROSCOMMON	20	Longford	11.91	24.13

AREA	110KV STATION NAME	STATION CAPACITY	STATION LOADING WP&LCT	STATION WP LOADING	LCT LOADING
LONGFORD	Lanesborough	31.5	33.62	18.60	15.02
LONGFORD	Richmond	56.7	61.09	38.09	23.00
ATHLONE	Somerset	31.5	45.31	25.48	19.83
ATHLONE	Athlone	113.4	166.39	98.80	67.58

9 APPENDIX 6 - 38KV AND 110KV STATION LOADINGS

Ballina-Castlebar – Scenario 1

38KV STATION NAME	PLANNING CAP	AREA	WP LOADING	WP+LCT LOADING
ACHILL	5	Castlebar	2.62	7.74
ARDNAREE	20	Ballina	9.85	16.90
BALLINROBE	20	Castlebar	6.62	12.85
BANGOR ERRIS	5	Ballina	1.53	4.19
BELMULLET	5	Ballina	4.48	6.36
CARROWBEG	30	Castlebar	6.97	12.18
CHARLESTOWN	4.5	Ballina	5.81	9.87
CONG	9	Castlebar	5.06	8.54
CROSSMOLINA	5	Ballina	3.44	7.51
ENNISCRONE	10	Ballina	2.96	8.53
KILTIMAGH	5	Castlebar	2.16	4.18
KNOCKAPHUNTA	9	Castlebar	7.01	16.50
MOY	20	Ballina	16.55	27.03
NEWPORT	9	Castlebar	4.01	5.68
RAHANS	5	Ballina	0.88	3.42
SWINFORD	9	Ballina	7.15	14.64
TUBBERCURRY	5	Ballina	3.51	7.37
TURLOUGH ROAD	14	Castlebar	8.36	10.82
WESTPORT	20	Castlebar	5.76	11.30
WINDSOR	9	Castlebar	5.45	9.79

AREA	110KV STATION NAME	STATION CAPACITY	STATION LOADING WP&LCT	STATION WP LOADING	LCT LOADING
BALLINA	Bellacorick	10	1.84	1.38	0.46
BALLINA	Bellacorick	15	10.55	3.90	6.65
CASTLEBAR	Castlebar	56.7	55.93	29.40	26.53
CASTLEBAR	Carrowbeg	31.5	36.90	20.39	16.51
BALLINA	Tonroe	31.5	34.00	21.16	12.84
BALLINA	Moy	56.7	63.37	39.72	23.66

9 APPENDIX 6 - 38KV AND 110KV STATION LOADINGS

Bandon-Dunmanway – Scenario 2

38KV STATION NAME	PLANNING CAP	AREA	WP LOADING	WP+LCT LOADING
BALLYDEHOB	5	Dunmanway	3.68	7.03
BANTRY	9	Dunmanway	6.57	12.12
BEALNABLATH	15	Bandon	5.51	19.54
CASTLETOWNBERE	10	Dunmanway	2.79	7.27
CLONAKILTY	10	Bandon	8.45	15.89
CURRALEIGH	9	Bandon	8.61	25.48
DUNMANWAY	20	Dunmanway	7.55	4.68
ENNISKEANE	9	Dunmanway	4.30	11.10
GLENGARRIFF	5	Dunmanway	0.85	1.99
KILMONEY	15	Bandon	11.42	19.02
KINSALE	9	Bandon	10.45	35.68
KNOCKBROGAN	9	Bandon	6.13	15.79
LEE BRIDGE	15	Bandon	9.79	34.15
MACROOM	5	Bandon	3.74	13.63
ROSS CARBERY	9	Dunmanway	4.66	8.59
SKIBBEREEN	9	Dunmanway	8.57	15.00
TIMOLEAGUE	5	Bandon	4.85	7.91
WHITECHURCH	20	Bandon	14.17	42.27

AREA	110KV STATION NAME	STATION CAPACITY	STATION LOADING WP&LCT	STATION WP LOADING	LCT LOADING
BANDON	Bandon	56.7	90.02	36.07	53.95
BANDON	Macroom	31.5	47.78	15.05	32.73
BANDON	Bandon	20	8.41	6.49	1.91
DUNMANWAY	Dunmanway	113.4	51.20	32.51	18.68
DUNMANWAY	Ballylickey	63	21.38	12.06	9.32
BANDON	Garrow	15	0.01	0.01	0.00

9 APPENDIX 6 - 38KV AND 110KV STATION LOADINGS

Cavan Sligo Scenario 2

38KV STATION NAME	PLANNING CAP	AREA	WP LOADING	WP+LCT LOADING
AGHAGAD	9	Sligo	3.54	7.84
BAILIEBORO	24	Cavan	3.90	17.44
BALLAGHADERREEN	9	Sligo	5.31	12.06
BALLYBAY	9	Cavan	4.12	7.35
BALLYCONNELL	9	Cavan	4.01	9.33
BALLYJAMESDUFF	20	Cavan	6.18	9.92
BALLYMOTE	5	Sligo	3.64	6.90
BALLYTIVNAN	20	Sligo	7.22	15.09
BOYLE	9	Sligo	6.22	11.78
CARRICK ON SHANNON	9	Sligo	8.88	15.48
CARRICKMACROSS	20	Cavan	9.93	39.29
CARRIGALLEN	5	Sligo	2.80	5.19
CASTLEBLAYNEY	9	Cavan	4.82	25.22
CAVAN	20	Cavan	11.83	25.34
CLONES	9	Cavan	6.15	11.54
COLLOONEY	10	Sligo	7.49	13.42
CRANMORE	9	Sligo	7.52	12.14
DERRYCRAMPH	9	Cavan	7.38	12.02
DRUMBEAR	9	Cavan	7.68	13.19
EMYVALE	5	Cavan	4.06	7.27
ERRIGAL	20	Cavan	7.22	11.47
FINISKLIN	9	Sligo	5.45	9.93
GORTEEN	5	Sligo	2.48	4.38
KILLESHANDRA	9	Cavan	2.84	4.93
LISDRUM	5	Cavan	1.63	3.04
MANORHAMILTON	20	Sligo	5.36	10.59
MOHILL	9	Sligo	5.16	10.86
MULLAGH	14	Cavan	3.76	18.91
OAKFIELD	20	Sligo	8.83	16.58
SHERCOCK	9	Cavan	2.53	12.09
TELAYDON	15	Cavan	7.25	12.73
TULLYNAMALRA	9	Cavan	2.78	11.21
VIRGINIA	9	Cavan	3.24	12.90

9 APPENDIX 6 - 38KV AND 110KV STATION LOADINGS

Cavan Sligo Scenario 2

AREA	110KV STATION NAME	STATION CAPACITY	STATION LOADING WP&LCT	STATION WP LOADING	LCT LOADING
CAVAN	Lisdrum	56.7	43.58	33.92	9.67
CAVAN	Shankill	113.4	86.83	63.40	23.43
SLIGO	Carrick On Shannon	56.7	52.52	30.86	21.66
SLIGO	Sligo	113.4	92.49	61.24	31.25
SLIGO	Arigna	15	8.53	4.61	3.92
CAVAN	Gortawee	63	9.33	6.95	2.38

9 APPENDIX 6 - 38KV AND 110KV STATION LOADINGS

Cork City Scenario 2

38KV STATION NAME	PLANNING CAP	AREA	WP LOADING	WP+LCT LOADING
BALLINCOLLIG	40	Cork	8.10	22.32
BISHOPSTOWN	20	Cork	15.00	41.36
CARRIGALINE	9	Cork	11.90	33.44
COBH	9	Cork	9.37	29.51
DENNEHYS CROSS	30	Cork	10.61	24.87
DOUGLAS	20	Cork	15.72	27.78
FACTORY CROSS	20	Cork	3.07	5.51
FAIRHILL	10	Cork	7.20	21.37
KILBARRY	35	Cork	22.43	41.29
MAYFIELD	20	Cork	10.59	31.13
RINGASKIDDY 110KV	10	Cork	4.76	13.93
RIVERSTOWN	9	Cork	10.36	24.48
TOGHER	20	Cork	10.18	19.67

AREA	110KV STATION NAME	STATION CAPACITY	STATION LOADING WP&LCT	STATION WP LOADING	LCT LOADING
CORK	Kilbarry	113.4	249.71	109.35	140.36
CORK	Liberty Street	40	38.83	33.34	5.48
CORK	Castleview	63	44.42	40.00	4.43
CORK	Trabeg	56.7	91.34	34.64	56.70
CORK	Trabeg	40	32.73	23.40	9.34
CORK	Marina	40	28.00	21.80	6.21
CORK	Barnahely	56.7	52.89	23.51	29.38
CORK	Coolroe	40	12.46	8.75	3.72
CORK	Barnahely	60	9.28	9.28	0.00

9 APPENDIX 6 - 38KV AND 110KV STATION LOADINGS

Drogheda/Dundalk Scenario 2

38KV STATION NAME	PLANNING CAP	AREA	WP LOADING	WP+LCT LOADING
ABBEYLAND	20	Drogheda	13.89	32.59
ACADEMY STREET	20	Drogheda	18.06	53.44
BALLYBAILIE	5	Dundalk	5.00	15.17
BUSH	9	Dundalk	3.49	12.59
COES ROAD	9	Dundalk	4.64	13.18
DRYBRIDGE	30	Drogheda	8.40	30.00
DULEEK	9	Drogheda	7.11	22.33
DUNDALK	20	Dundalk	9.85	31.66
DUNLEER	9	Dundalk	7.75	22.73
JENKINSTOWN	9	Dundalk	4.12	16.20
JULIANSTOWN	9	Drogheda	8.30	26.73
KILSARAN	5	Dundalk	4.24	9.29
KINGSCOURT	18	Dundalk	8.46	24.64
LITTLE MILLS	5	Dundalk	3.38	9.55
MARSHES	30	Dundalk	11.22	33.02
MORNINGTON ROAD	20	Drogheda	9.37	26.08
RAMPARTS	20	Dundalk	8.02	20.51
RANDALSTOWN	5	Drogheda	7.83	16.24
RATHMULLAN	20	Drogheda	12.29	33.03
SLANE	15	Drogheda	4.77	15.99
STICKILLEN	9	Dundalk	6.80	20.07
TERMONFECKIN ROAD	9	Drogheda	8.08	27.05

AREA	110KV STATION NAME	STATION CAPACITY	STATION LOADING WP&LCT	STATION WP LOADING	LCT LOADING
DROGHEDA	Drybridge	113.4	233.30	97.07	136.23
DROGHEDA	Navan	113.4	184.19	74.51	109.68
DUNDALK	Dundalk	113.4	177.10	68.29	108.81
DUNDALK	Meath Hill	113.4	136.48	62.17	74.30

9 APPENDIX 6 - 38KV AND 110KV STATION LOADINGS

Dublin Central – Scenario 3

38KV STATION NAME	PLANNING CAP	AREA	WP LOADING	WP+LCT LOADING
BALLYBODEN	20	Dublin Central	12.57	34.70
BALLYMOUNT	20	Dublin Central	8.17	14.52
BEDFORD ROW	60	Dublin Central	37.24	58.19
CAMDEN ROW	15	Dublin Central	9.62	21.41
CLONTARF	10	Dublin Central	10.36	29.79
CRUMLIN	20	Dublin Central	7.80	25.74
DODDER ROAD	10	Dublin Central	7.10	16.03
DONNYBROOK	20	Dublin Central	6.71	21.76
DRUMCONDRA	20	Dublin Central	7.62	28.91
EAST WALL ROAD	20	Dublin Central	3.79	10.28
FAIRVIEW	15	Dublin Central	12.29	34.74
GARVILLE AVENUE	10	Dublin Central	9.71	22.68
GLASNEVIN	10	Dublin Central	5.13	17.94
GLOUCESTER PLACE	20	Dublin Central	13.43	36.49
GREENHILLS	10	Dublin Central	6.92	20.21
INCHICORE CENTRAL	20	Dublin Central	14.79	36.55
INCHICORE NORTH	10	Dublin Central	5.51	18.55
KIMMAGE	20	Dublin Central	14.15	41.06
KINGSBRIDGE	20	Dublin Central	6.09	24.20
LEESON STREET	20	Dublin Central	15.26	34.18
MARROWBONE LANE	15	Dublin Central	6.70	21.98
MERRION SQUARE	20	Dublin Central	9.68	16.35
NEWMARKET (DR)	10	Dublin Central	10.19	29.95
PEMBROKE	40	Dublin Central	22.84	62.21
PHIBSBORO	20	Dublin Central	12.24	32.20
SHERIFF STREET	20	Dublin Central	12.14	18.82
SOUTH KING STREET	20	Dublin Central	16.86	24.56
TEMPLEOGUE	20	Dublin Central	11.48	27.51
WATLING STREET	20	Dublin Central	7.33	19.67
WHITEHALL	10	Dublin Central	7.16	19.93

9 APPENDIX 6 - 38KV AND 110KV STATION LOADINGS

Dublin Central – Scenario 3

AREA	110KV STATION NAME	STATION CAPACITY	STATION LOADING WP&LCT	STATION WP LOADING	LCT LOADING
DUBLIN CENTRAL	Inchicore 220kv	113.4	284.67	127.86	156.81
DUBLIN CENTRAL	Wolfe Tone Street	40	65.93	48.40	17.53
DUBLIN CENTRAL	Milltown (dr)	40	59.16	23.53	35.63
DUBLIN CENTRAL	Harolds Cross	40	48.76	19.29	29.46
DUBLIN CENTRAL	North Quays	40	41.88	23.04	18.84
DUBLIN CENTRAL	Misery Hill	40	33.74	22.13	11.61
DUBLIN CENTRAL	Heuston Square	40	32.85	18.70	14.15
DUBLIN CENTRAL	Mesh: Blue	113.4	63.32	26.65	36.68
DUBLIN CENTRAL	Mesh: Green	113.4	59.16	23.53	35.63
DUBLIN CENTRAL	Trinity	40	19.17	16.67	2.50
DUBLIN CENTRAL	Ringsend	40	4.16	3.12	1.05
DUBLIN CENTRAL	Mesh: Brown	101.7	4.16	3.12	1.05

9 APPENDIX 6 - 38KV AND 110KV STATION LOADINGS

Dublin North – Scenario 2

38KV STATION NAME	PLANNING CAP	AREA	WP LOADING	WP+LCT LOADING
ASHBOURNE	25	Dublin North	11.98	21.85
BALBRIGGAN	20	Dublin North	14.19	48.79
BALGADDY	20	Dublin North	17.07	34.72
BALLYCOOLEN	30	Dublin North	15.00	27.18
BALLYMUN	20	Dublin North	7.61	17.64
CASTLEKNOCK	9	Dublin North	4.31	7.91
CELBRIDGE	20	Dublin North	16.07	25.35
CLONDALKIN	30	Dublin North	23.07	45.83
CLONSHAUGH	20	Dublin North	2.97	7.27
COLLINSTOWN	9	Dublin North	1.98	3.52
COOLMINE	20	Dublin North	19.47	36.92
COOLOCK	20	Dublin North	9.15	18.18
GLASMORE	20	Dublin North	22.44	75.60
GRANGE (DR)	20	Dublin North	23.11	44.25
HOWTH JUNCTION	20	Dublin North	13.46	23.98
KILCOCK	20	Dublin North	12.64	21.88
LEIXLIP	20	Dublin North	12.12	24.24
LIFFEY VALLEY	20	Dublin North	8.69	17.96
LOUGHSHINNY	20	Dublin North	19.11	48.06
LUCAN EAST	9	Dublin North	8.80	17.76
MALAHIDE	20	Dublin North	17.48	30.43
MERVILLE	20	Dublin North	9.35	18.03
MONEYCOOLEY	30	Dublin North	19.10	34.21
MOUNTGORRY	20	Dublin North	16.40	42.91
PALMERSTOWN	20	Dublin North	11.17	21.74
SANTRY	20	Dublin North	10.31	21.19
SEMPERIT	30	Dublin North	15.42	32.13
SUTTON	20	Dublin North	7.03	11.04
SWORDS	20	Dublin North	11.06	30.58
UNIDARE	20	Dublin North	5.93	11.80

9 APPENDIX 6 - 38KV AND 110KV STATION LOADINGS

Dublin North – Scenario 2

AREA	110KV STATION NAME	STATION CAPACITY	STATION LOADING WP&LCT	STATION WP LOADING	LCT LOADING
DUBLIN NORTH	Finglas	113.4	286.17	190.23	95.94
DUBLIN NORTH	Grange Castle	63	99.38	66.59	32.79
DUBLIN NORTH	Macetown	40	59.29	41.45	17.84
DUBLIN NORTH	Glasmore	113.4	245.95	94.11	151.84
DUBLIN NORTH	Cabra	40	47.07	32.97	14.10
DUBLIN NORTH	Griffinrath	113.4	129.37	87.13	42.23
DUBLIN NORTH	Poppintree	40	40.26	26.99	13.27
DUBLIN NORTH	Grange (dr)	113.4	113.22	70.51	42.70
DUBLIN NORTH	College Park	60	40.62	34.06	6.56
DUBLIN NORTH	Baltrasna	40	30.36	21.60	8.77
DUBLIN NORTH	Pelletstown	40	34.78	21.32	13.46
DUBLIN NORTH	Artane	40	34.24	18.14	16.11
DUBLIN NORTH	Fortunestown	40	24.53	17.77	6.75
DUBLIN NORTH	Kilmore	60	25.86	22.62	3.24
DUBLIN NORTH	Grange Castle	60	16.61	15.37	1.24
DUBLIN NORTH	Stephenstown	40	5.23	4.75	0.47

9 APPENDIX 6 - 38KV AND 110KV STATION LOADINGS

Dublin South – Scenario 1

38KV STATION NAME	PLANNING CAP	AREA	WP LOADING	WP+LCT LOADING
BALLINCLEA	10	Dublin South	5.22	9.43
BELFIELD	20	Dublin South	10.62	19.80
BELGARD	20	Dublin South	11.33	19.79
BLESSINGTON	9	Dublin South	10.25	21.42
BOGHALL ROAD	20	Dublin South	9.12	18.74
BRAY	20	Dublin South	12.45	25.04
BREWERY ROAD	20	Dublin South	9.93	18.05
CARRICKMINES	25	Dublin South	14.17	36.00
DEANSGRANGE	20	Dublin South	12.02	21.87
DUN LAOGHAIRE	20	Dublin South	11.76	19.32
DUNDRUM	20	Dublin South	17.20	33.87
GREYSTONES	20	Dublin South	14.39	29.94
JOHNSTOWN	20	Dublin South	10.89	25.27
KILCOOLE	9	Dublin South	8.68	15.95
LITTLE BRAY	20	Dublin South	11.53	27.19
LOUGHLINSTOWN	20	Dublin South	11.24	23.97
MONKSTOWN	20	Dublin South	14.75	26.92
MOUNT MERRION	20	Dublin South	15.54	27.41
NAAS	20	Dublin South	11.12	24.39
OLDBAWN	20	Dublin South	15.50	31.59
SAGGART	9	Dublin South	7.87	14.63
SALLINS	20	Dublin South	12.79	26.01
SALLYNOGGIN ROAD	20	Dublin South	13.66	29.56
SANDYFORD	20	Dublin South	17.06	33.35
TYMON	20	Dublin South	13.30	25.36
WHITESTOWN	20	Dublin South	9.32	20.31

9 APPENDIX 6 - 38KV AND 110KV STATION LOADINGS

Dublin South – Scenario 1

AREA	110KV STATION NAME	STATION CAPACITY	STATION LOADING WP&LCT	STATION WP LOADING	LCT LOADING
DUBLIN SOUTH	Taney	40	15.91	11.32	4.59
DUBLIN SOUTH	Citywest	40	12.77	11.81	0.96
DUBLIN SOUTH	Central Park	40	19.37	14.71	4.67
DUBLIN SOUTH	Monread	40	24.70	17.02	7.68
DUBLIN SOUTH	Cookstown	40	27.08	18.22	8.87
DUBLIN SOUTH	Pottery Road	40	26.44	18.95	7.49
DUBLIN SOUTH	Kilteel	56.7	46.69	29.71	16.98
DUBLIN SOUTH	Fassaroe	113.4	116.86	67.74	49.11
DUBLIN SOUTH	Cookstown	113.4	128.10	73.13	54.97
DUBLIN SOUTH	Blackrock	113.4	138.90	83.64	55.26
DUBLIN SOUTH	Carrickmines	113.4	160.65	93.00	67.65

9 APPENDIX 6 - 38KV AND 110KV STATION LOADINGS

Fermoy Scenario 2

38KV STATION NAME	PLANNING CAP	AREA	WP LOADING	WP+LCT LOADING
BUTTEVANT	3.6	Fermoy	4.94	18.75
CARRIGSHANE	9	Fermoy	5.78	18.84
CARRIGTOHILL	5	Fermoy	2.38	5.56
CASTLELYONS	9	Fermoy	4.59	18.31
CASTLETOWNROCHE	5	Fermoy	1.98	7.59
CLOONLOUGH	9	Fermoy	4.82	16.92
CLOYNE	5	Fermoy	3.89	15.96
COOLCARRON	5	Fermoy	4.64	13.54
CURRAGLASS	5	Fermoy	1.75	7.05
FERMOY NORTH	9	Fermoy	6.14	22.53
FOXHOLE	20	Fermoy	13.63	21.95
KILLACLOYNE	19	Fermoy	6.56	25.83
KILSHANNY	3.6	Fermoy	3.97	5.77
MALLOW	20	Fermoy	8.03	26.15
SCARTEEN	9	Fermoy	3.92	15.77

AREA	110KV STATION NAME	STATION CAPACITY	STATION LOADING WP&LCT	STATION WP LOADING	LCT LOADING
FERMOY	Midleton	31.5	60.63	28.99	31.64
FERMOY	Barrymore	31.5	78.35	27.98	50.37
FERMOY	Midleton	40	24.30	18.73	5.57
FERMOY	Mallow	56.7	68.26	25.03	43.22
FERMOY	Cow Cross	31.5	35.08	13.81	21.27

9 APPENDIX 6 - 38KV AND 110KV STATION LOADINGS

Galway Tuam – Scenario 2

38KV STATION NAME	PLANNING CAP	AREA	WP LOADING	WP+LCT LOADING
ATHENRY	10	Tuam	14.51	48.15
BALLYGAR	10	Tuam	3.20	10.68
BALLYHAUNIS	9	Tuam	6.17	12.94
CARRAROE	5	Galway	3.82	14.49
CLAREGALWAY	10	Galway	11.01	40.32
CLOON	20	Tuam	3.41	6.08
DALTON	20	Tuam	11.26	21.77
GLENAMADDY	5	Tuam	8.64	14.15
HEADFORD	5	Tuam	5.33	10.69
HEADFORD ROAD	20	Galway	11.26	26.48
MONEENAGHIESHA	20	Galway	6.60	20.04
ORANMORE	20	Galway	11.19	33.39
OUGHTERARD	9	Galway	4.56	17.89
PARKMORE	9	Galway	2.74	11.41
RECESS	5	Galway	1.47	7.30
SCREEB	5	Galway	3.72	7.94
TRIMMS LANE	20	Galway	11.83	27.69
TUAM NORTH	9	Tuam	7.86	14.03
TUAM SOUTH	5	Tuam	3.82	6.00

AREA	110KV STATION NAME	STATION CAPACITY	STATION LOADING WP&LCT	STATION WP LOADING	LCT LOADING
GALWAY	Salthill	63	96.74	54.80	41.94
GALWAY	Galway	113.4	233.67	95.64	138.03
GALWAY	Galway	40	39.98	31.25	8.73
TUAM	Cloon	55.35	45.12	28.75	16.37
TUAM	Dalton	94.5	47.14	30.50	16.64
GALWAY	Screeb	31.5	7.94	4.16	3.79

9 APPENDIX 6 - 38KV AND 110KV STATION LOADINGS

Killarney Tralee – Scenario 1

38KV STATION NAME	PLANNING CAP	AREA	WP LOADING	WP+LCT LOADING
BALLYARD	9	Tralee	5.81	12.90
BALLYBEGGAN	18	Tralee	11.64	24.34
BALLYBUNION	19	Tralee	4.06	8.98
BALLYRICKARD	18	Tralee	9.44	22.16
CASTLEISLAND	9	Tralee	6.95	14.75
CAUSEWAY	9	Tralee	7.49	13.70
CLOONBANNIN	10	Killarney	3.83	7.32
COOLCORCORAN	18	Killarney	12.30	28.42
DINGLE	10	Tralee	4.94	13.88
GURRANEBANE	9	Killarney	8.07	21.89
INCH	9	Tralee	2.39	7.39
KANTURK	9	Killarney	9.26	16.16
KENMARE	10	Killarney	2.98	8.61
KILFLYNN	10	Tralee	3.16	8.00
KILGARVAN	5	Killarney	1.76	4.03
MILLTOWN (SR)	20	Killarney	10.32	23.77
NEWMARKET (SR)	9	Killarney	2.93	4.87
RATHMORE	10	Killarney	5.47	12.35
SMEARLA	20	Tralee	9.20	21.40
WOODFORD	9	Killarney	7.50	17.65

AREA	110KV STATION NAME	STATION CAPACITY	STATION LOADING WP&LCT	STATION WP LOADING	LCT LOADING
TRALEE	Cloghboola	63	0.10	0.10	0.00
TRALEE	Trien	119.7	43.41	22.63	20.77
KILLARNEY	Glenlara	63	28.35	17.27	11.08
TRALEE	Tralee	113.4	95.85	56.02	39.83
KILLARNEY	Knockearagh	56.7	71.06	41.51	29.55
KILLARNEY	Oughtragh	31.5	66.94	29.01	37.93

9 APPENDIX 6 - 38KV AND 110KV STATION LOADINGS

Kilkenny-Portlaoise Scenario 1

38KV STATION NAME	PLANNING CAP	AREA	WP LOADING	WP+LCT LOADING
BAGENALSTOWN	9	Kilkenny	8.43	17.63
BALLYRAGGET	5	Kilkenny	5.36	9.22
BALTINGLASS	9	Portlaoise	10.68	19.24
CALLAN	9	Kilkenny	6.84	12.05
CASTLECOMER	9	Kilkenny	7.24	12.34
GORESBRIDGE	9	Kilkenny	4.34	11.04
GRAIGUE	20	Kilkenny	9.84	23.80
GRAIGUENAMANAGH	3.6	Kilkenny	4.24	7.23
KILCULLEN	19	Portlaoise	12.13	22.83
MCDONAGH	20	Kilkenny	9.39	17.14
MOUNTMELLICK	9	Portlaoise	6.40	11.63
PALLAS	9	Portlaoise	8.45	21.39
POLLERTON	20	Kilkenny	14.86	32.16
PORTARLINGTON	14	Portlaoise	7.81	22.09
PORTLAOISE	20	Portlaoise	18.47	18.97
PURCELLS INCH	15	Kilkenny	2.91	5.26
ROSEHILL	20	Kilkenny	12.41	23.73
TALBOTS INCH	9	Kilkenny	5.81	13.29

AREA	110KV STATION NAME	STATION CAPACITY	STATION LOADING WP&LCT	STATION WP LOADING	LCT LOADING
KILKENNY	Stratford	31.5	19.24	11.86	7.38
PORTLAOISE	Athy	40	38.31	22.83	15.48
PORTLAOISE	Portlaoise 110kv	56.7	62.80	33.49	29.32
KILKENNY	Kilkenny	113.4	109.83	71.30	38.53
KILKENNY	Carlow	113.4	118.42	72.28	46.15

9 APPENDIX 6 - 38KV AND 110KV STATION LOADINGS

Letterkenny-Killybegs – Scenario 1

38KV STATION NAME	PLANNING CAP	AREA	WP LOADING	WP+LCT LOADING
BALLYMACARRY	5	Letterkenny	2.32	5.02
BALLYRAINE	9	Letterkenny	8.17	14.39
BALLYSHANNON	9	Killybegs	5.72	11.57
BUNCRANA	9	Letterkenny	7.96	19.40
BUNDORAN	9	Killybegs	4.14	11.69
CARNDONAGH	9	Letterkenny	6.84	18.22
CONVOY	5	Letterkenny	3.45	7.74
CREESLOUGH	5	Killybegs	2.30	8.89
CULLION	9	Letterkenny	10.99	20.61
DERRYBEG	9	Killybegs	4.61	15.51
DONEGAL	9	Killybegs	8.73	17.60
DUNGLOE	5	Killybegs	3.75	11.58
GLENTIES	5	Killybegs	3.09	9.00
GORTLEE	9	Letterkenny	6.73	16.05
GWEEDORE	5	Letterkenny	2.55	6.46
KILCAR	5	Killybegs	2.49	7.44
KILLYBEGS	30	Killybegs	4.45	11.53
MILFORD (NR)	9	Letterkenny	9.82	24.07
MOVILLE	9	Letterkenny	4.50	12.31
NEWTOWNCUNNINGHAM	9	Letterkenny	5.84	11.45
ROSSGEIR	9	Letterkenny	6.49	12.98
STRANORLAR	20	Letterkenny	8.15	18.62

AREA	110KV STATION NAME	STATION CAPACITY	STATION LOADING WP&LCT	STATION WP LOADING	LCT LOADING
KILLYBEGS	Binbane	176.4	55.05	24.13	30.92
LETTERKENNY	Trillick	63	54.96	23.30	31.66
KILLYBEGS	Cathaleens Fall	31.5	40.86	21.42	19.44
LETTERKENNY	Letterkenny	113.4	141.27	77.65	63.61

9 APPENDIX 6 - 38KV AND 110KV STATION LOADINGS

Limerick-Ennis Scenario 2

38KV STATION NAME	PLANNING CAP	AREA	WP LOADING	WP+LCT LOADING
BALLINACURRA	15	Limerick	9.96	16.73
CAHERDAVIN	20	Limerick	12.98	27.30
CAHIRCALLA	9	Ennis	9.45	15.02
CASTLETROY	9	Limerick	6.61	15.04
CORBALLY	9	Limerick	12.04	23.73
CRANNY	2	Ennis	1.03	1.72
CRATLOE	9	Limerick	10.03	23.02
DOCK ROAD	9	Limerick	6.38	9.71
DRUMLINE	9	Limerick	3.76	11.26
DRUMQUIN	5	Ennis	3.87	7.42
ENNIS NORTH	9	Ennis	8.09	16.01
ENNISTYMON	9	Ennis	7.91	15.72
GARRYOWEN	30	Limerick	14.19	23.46
GILLOGUE	9	Limerick	8.68	19.57
KILKEE	5	Ennis	2.53	6.50
KILRUSH	9	Ennis	6.20	10.48
MILLTOWN MALBAY	5	Ennis	2.84	6.63
MOYLISH	9	Limerick	6.25	17.36
PATRICKSWELL	9	Limerick	10.16	17.88
RAHEEN	20	Limerick	12.22	25.14
RINEANNA	20	Limerick	11.46	21.86
ROCHES STREET	20	Limerick	11.69	17.21
SCARIFF	5	Ennis	3.06	5.80
SHANNON	20	Limerick	7.40	10.66
TULLA	5	Ennis	5.05	9.13

AREA	110KV STATION NAME	STATION CAPACITY	STATION LOADING WP&LCT	STATION WP LOADING	LCT LOADING
ENNIS	Ennis	56.7	82.92	52.61	30.31
LIMERICK	Limerick	113.4	122.39	87.92	34.47
LIMERICK	Ardnacrusha	126	204.40	88.35	116.05
LIMERICK	Drumline	56.7	43.79	38.21	5.58
LIMERICK	Singland	40	27.96	20.94	7.02
LIMERICK	Ahane	15	9.61	6.61	3.01
ENNIS	Tullabrack	31.5	23.61	12.00	11.61
ENNIS	Ennis	40	21.51	14.62	6.89

9 APPENDIX 6 - 38KV AND 110KV STATION LOADINGS

Mullingar-Tullamore Scenario 2

38KV STATION NAME	PLANNING CAP	AREA	WP LOADING	WP+LCT LOADING
ATHBOY	10	Mullingar	5.05	16.32
ATHGARVAN	20	TULLAMORE	9.08	29.91
BALLINDERRY	20	Mullingar	14.58	45.27
BANAGHER	5	TULLAMORE	3.59	6.41
BLAKE	9	TULLAMORE	6.95	22.26
CLARA	20	TULLAMORE	12.08	21.00
CLONMINCH	20	TULLAMORE	15.17	25.43
DELVIN	3.2	Mullingar	4.36	17.83
EDENDERRY	20	TULLAMORE	16.12	46.89
KELLS	9	Mullingar	6.32	18.19
KILDARE	30	TULLAMORE	15.95	47.32
LLOYD	9	Mullingar	1.53	5.17
LOUGHANALLA	9	Mullingar	4.88	16.26
LUMCLOON	9	TULLAMORE	5.55	10.11
MORRISTOWN	9	TULLAMORE	9.53	31.33
NEWBROOK	5	Mullingar	3.78	12.56
OLDCASTLE	10	Mullingar	3.59	13.71
SRAH	19	TULLAMORE	6.67	13.82
TRIM	14	Mullingar	13.45	42.24

AREA	110KV STATION NAME	STATION CAPACITY	STATION LOADING WP&LCT	STATION WP LOADING	LCT LOADING
MULLINGAR	Mullingar	56.7	105.63	37.51	68.12
MULLINGAR	Dunfirth	20	17.94	12.63	5.31
MULLINGAR	Mullingar	40	25.94	19.53	6.41

9 APPENDIX 6 - 38KV AND 110KV STATION LOADINGS

Roscrea – Scenario 2

38KV STATION NAME	PLANNING CAP	AREA	WP LOADING	WP+LCT LOADING
BALLYCROSSAUN	9	Roscrea	6.42	11.14
BIRDHILL	20	Roscrea	13.50	44.48
BIRR	20	Roscrea	11.41	22.49
BLANCHFIELD	46.5	Roscrea	0.00	0.00
DALLOW	10	Roscrea	0.00	0.00
KYLEERAGH	15	Roscrea	11.96	17.46
MOUNTRATH	9	Roscrea	5.70	22.16
NENAGH	30	Roscrea	9.16	14.62
RATHDOWNEY	5	Roscrea	3.49	5.96
ROSCREA	20	Roscrea	11.66	22.59
TOOMEVARA	5	Roscrea	3.52	5.79

AREA	110KV STATION NAME	STATION CAPACITY	STATION LOADING WP&LCT	STATION WP LOADING	LCT LOADING
ROSCREA	Ikerrin	31.5	44.91	33.56	11.35
ROSCREA	Nenagh	31.5	32.08	22.97	9.11
ROSCREA	Dallow	31.5	28.90	19.73	9.17

9 APPENDIX 6 - 38KV AND 110KV STATION LOADINGS

Tipperary-NewcastleWest – Scenario 2

38KV STATION NAME	PLANNING CAP	AREA	WP LOADING	WP+LCT LOADING
ABBEYFEALE	15	Newcastlewest	6.13	12.27
BRUFF	10	Newcastlewest	6.77	12.26
CAPPAMORE	19	Tipperary	9.96	33.90
CASHEL	20	Tipperary	7.79	12.26
CHARLEVILLE	25	Newcastlewest	5.33	10.23
CHURCHTOWN	20	Newcastlewest	4.92	12.79
FOYNES	9	Newcastlewest	3.92	13.77
GARRANACANTY	20	Tipperary	11.08	17.80
GARRYSPILLANE	5	Tipperary	4.28	7.22
GLENGOOLE	15	Tipperary	10.88	14.49
HOLYCROSS ROAD	9	Tipperary	9.71	15.40
KILMALLOCK	5	Newcastlewest	4.63	8.00
KILROSS ROAD	5	Tipperary	4.15	8.34
KYLETAUN	9	Newcastlewest	10.99	37.85
LOUGHTAGALLA	9	Tipperary	8.03	12.19
MILFORD (MWR)	15	Newcastlewest	3.92	7.37
MULTEEN	10	Tipperary	0.00	0.00
NEWCASTLEWEST	9	Newcastlewest	7.32	27.20
RATHGOGGIN	9	Newcastlewest	2.92	4.39
TEMPLEMORE	20	Tipperary	6.56	10.56

AREA	110KV STATION NAME	STATION CAPACITY	STATION LOADING WP&LCT	STATION WP LOADING	LCT LOADING
NEWCASTLEWEST	Tipperary	31.5	33.36	21.48	11.88
NEWCASTLEWEST	Rathkeale	54	91.60	30.48	61.13
TIPPERARY	Thurles	56.7	42.08	29.91	12.17
NEWCASTLEWEST	Charleville	94.5	29.99	21.04	8.95

9 APPENDIX 6 - 38KV AND 110KV STATION LOADINGS

Waterford –Clonmel Scenario 1

38KV STATION NAME	PLANNING CAP	AREA	WP LOADING	WP+LCT LOADING
ARDFINNAN	10	Clonmel	3.61	6.65
ARDGEEHA	20	Clonmel	6.18	13.14
BALLYHALE	10	Waterford	5.21	10.88
BELVIEW	30	Waterford	2.47	9.78
CAHIR	20	Clonmel	10.41	14.65
COLLIGAN	20	Clonmel	8.42	16.57
CREGG ROAD	3.6	Clonmel	2.46	5.67
DEERPARK	9	Clonmel	11.37	16.99
GRANAGH	9	Waterford	6.85	13.31
GRANGE (SR)	9	Waterford	7.96	17.98
KILCARAGH	9	Waterford	8.26	16.60
KILCLOHER	5	Clonmel	3.74	6.19
KILMACTHOMAS	9	Waterford	4.40	9.06
KILMEADEN	5	Waterford	2.44	3.73
LAWLESSTOWN	20	Clonmel	9.98	19.27
LISMORE	5	Clonmel	4.90	7.76
MANOR STREET	20	Waterford	13.23	25.74
MOUNT MISERY	20	Waterford	4.97	14.29
PORTLAW	3.6	Waterford	3.08	4.20
ROSBERCON	20	Waterford	6.27	11.27
SPA ROAD	9	Clonmel	6.26	11.49
SPRINGS	20	Clonmel	5.74	11.02
TRAMORE	20	Waterford	13.83	28.98
TYCOR	9	Waterford	7.89	15.18
WATERFORD	9	Waterford	3.74	7.12
WATERFORD IND EST	30	Waterford	8.05	21.24

AREA	110KV STATION NAME	STATION CAPACITY	STATION LOADING WP&LCT	STATION WP LOADING	LCT LOADING
WATERFORD	Killoteran	40	17.18	16.81	0.37
CLONMEL	Doon	56.7	43.91	27.14	16.77
CLONMEL	Cahir	56.7	41.08	27.56	13.52
CLONMEL	Ballydine	31.5	22.66	15.36	7.30
WATERFORD	Waterford	113.4	96.69	63.53	33.16
CLONMEL	Dungarvan	56.7	76.59	48.42	28.16
WATERFORD	Butlerstown	56.7	92.73	52.74	39.99

9 APPENDIX 7 – GEOGRAPHICAL REPRESENTATION OF STUDIES AND ESTIMATED LOAD PROFILES

The PSS load flow study results were used to generate a dashboard showing the level of loading forecast in a station by 2030. A geographic element was also added to this dashboard showing the MV/LV substations that are fed from the station that is loaded beyond current rating. In the future, the intention is to use this dashboard to help identify the potential areas that flexibility services can be sourced from, i.e. if a customer/aggregator has a connection in the area indicated they can bid in to provide a service to address the constraint on the network.

The pictures below show a sample of maps selected across the country. Where feasible a station close to a large town or significant landmark is displayed to give an impression for the look and feel of this data.

Also shown for each of the stations that are loaded beyond current rating are 2 load profiles[36] shown as box plots. The box plot shows how the load is distributed for each of hour of the day across a full year. 50% of the load is contained in the box with 25% being contained in the "whiskers". The top and bottom of the whiskers show the max and min load for that time.

The first is the 2020 load profile. A second profile was generated by adding in forecast EV and HP load. This load was estimated using results from the Dingle Project – where households were on day-night tariffs and therefore EV charging was primarily at night-time. (see graph below Figure A7.1) As can be seen from the load profiles with LCT, the peak load, even with EV charging in the night hours, is forecast to be higher in comparison to the 2020 evening peak at 7pm.. Other caveats are listed below.

The dataset used for EV's is from charging transactions for 15 households in the Dingle area that have home charging installed.

1. **7 months of spring-summer period within progressively loosening lockdown conditions**
2. **Rural area of unknown demographic and occupational properties**
3. **Only one public charger in town, privately accessible charger will be the norm here**
4. **Max 7kW residential chargers are installed for home charging**
5. **Current composition of EV battery capacity roughly between 30-70kWh capacity**
6. **All households are on day/night tariff – charging scheduled from 11pm onwards**

The estimated EV charge profile is as below. This shows that while the majority of charging takes place 10pm – 6am there is still a probability the EV will need to charge outside these hours.

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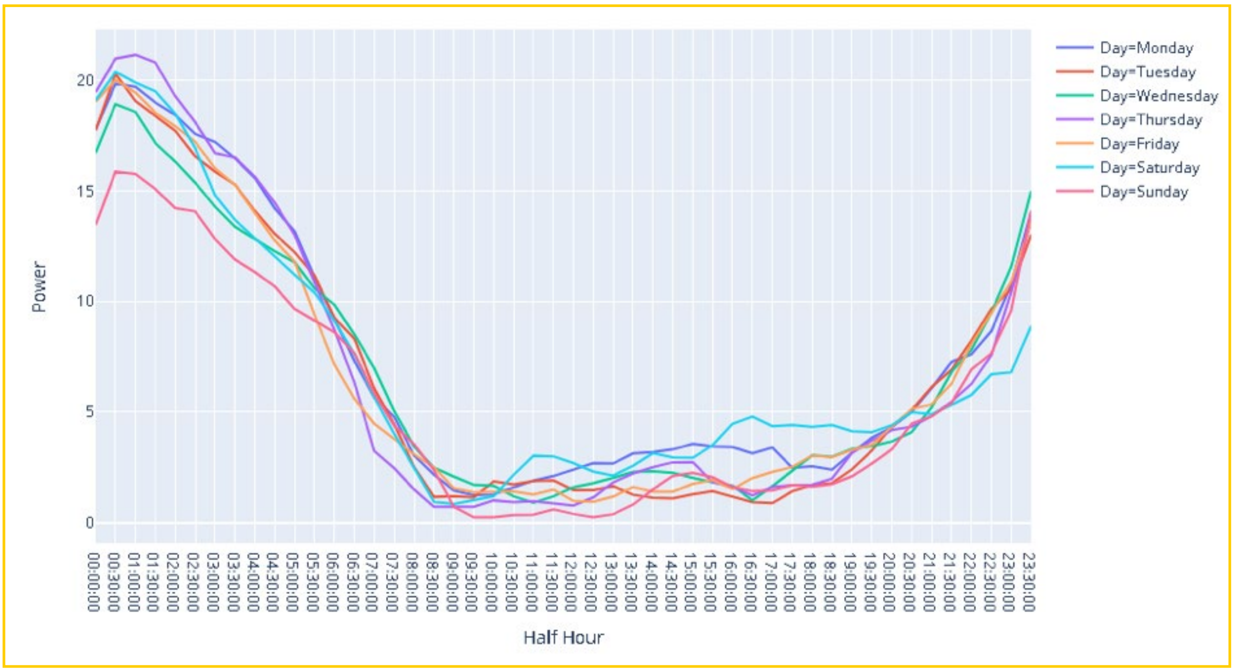
[36] Load profiles are not available for all stations but are published where available

9 APPENDIX 7 – GEOGRAPHICAL REPRESENTATION OF STUDIES AND ESTIMATED LOAD PROFILES

FIGURE A7.1 **EV CHARGE PROFILE**



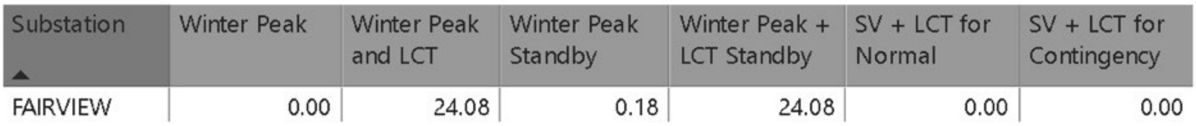
With regard to Heat Pumps, only the data from 2 households was usable

1. **Less than 3 months of data available, all of which occurred during the summer months**
2. **Heat pump was only for hot water usage, seldomly used for home heating purposes due to the weather**
3. **Even the hot water usage will not take into account of the seasonal behaviour changes.**
4. **Data is only from 2 household, making this analysis very biassed towards these individual households in terms of their usage patterns and building energy performance.**

9 APPENDIX 7 – GEOGRAPHICAL REPRESENTATION OF STUDIES AND ESTIMATED LOAD PROFILES

FAIRVIEW 38KV/MV – DUBLIN CENTRAL AREA

FIGURE A7.2 **STATION LOADING 2030**



Substation ▲	Winter Peak	Winter Peak and LCT	Winter Peak Standby	Winter Peak + LCT Standby	SV + LCT for Normal	SV + LCT for Contingency
FAIRVIEW	0.00	24.08	0.18	24.08	0.00	0.00

FIGURE A7.3 **STATION FEEDING AREA**

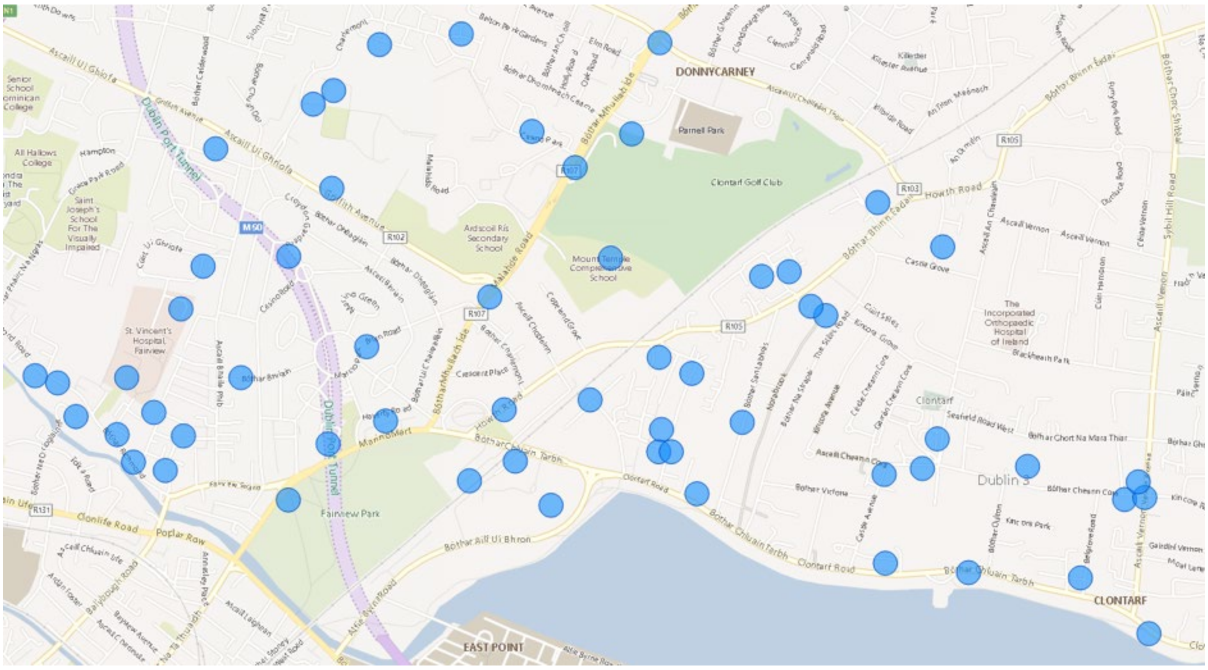
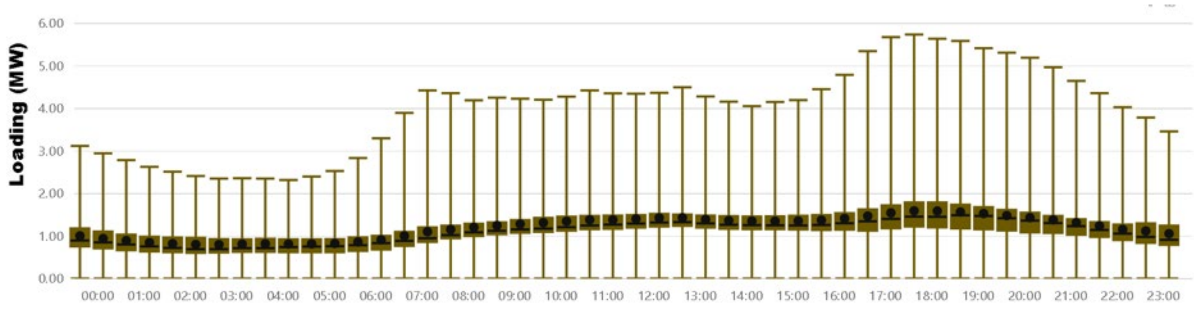


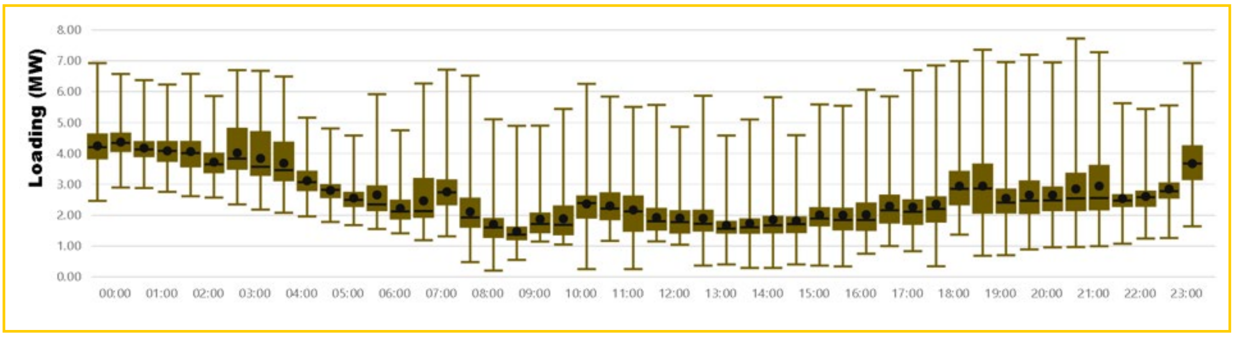
FIGURE A7.4 **STATION LOAD PROFILE 2020**



9 APPENDIX 7 – GEOGRAPHICAL REPRESENTATION OF STUDIES AND ESTIMATED LOAD PROFILES

FAIRVIEW 38KV/MV – DUBLIN CENTRAL AREA continued

FIGURE A7.5 **STATION LOAD PROFILE WITH LCT IN 2030– PRIMARILY NIGHT TIME EV CHARGING**



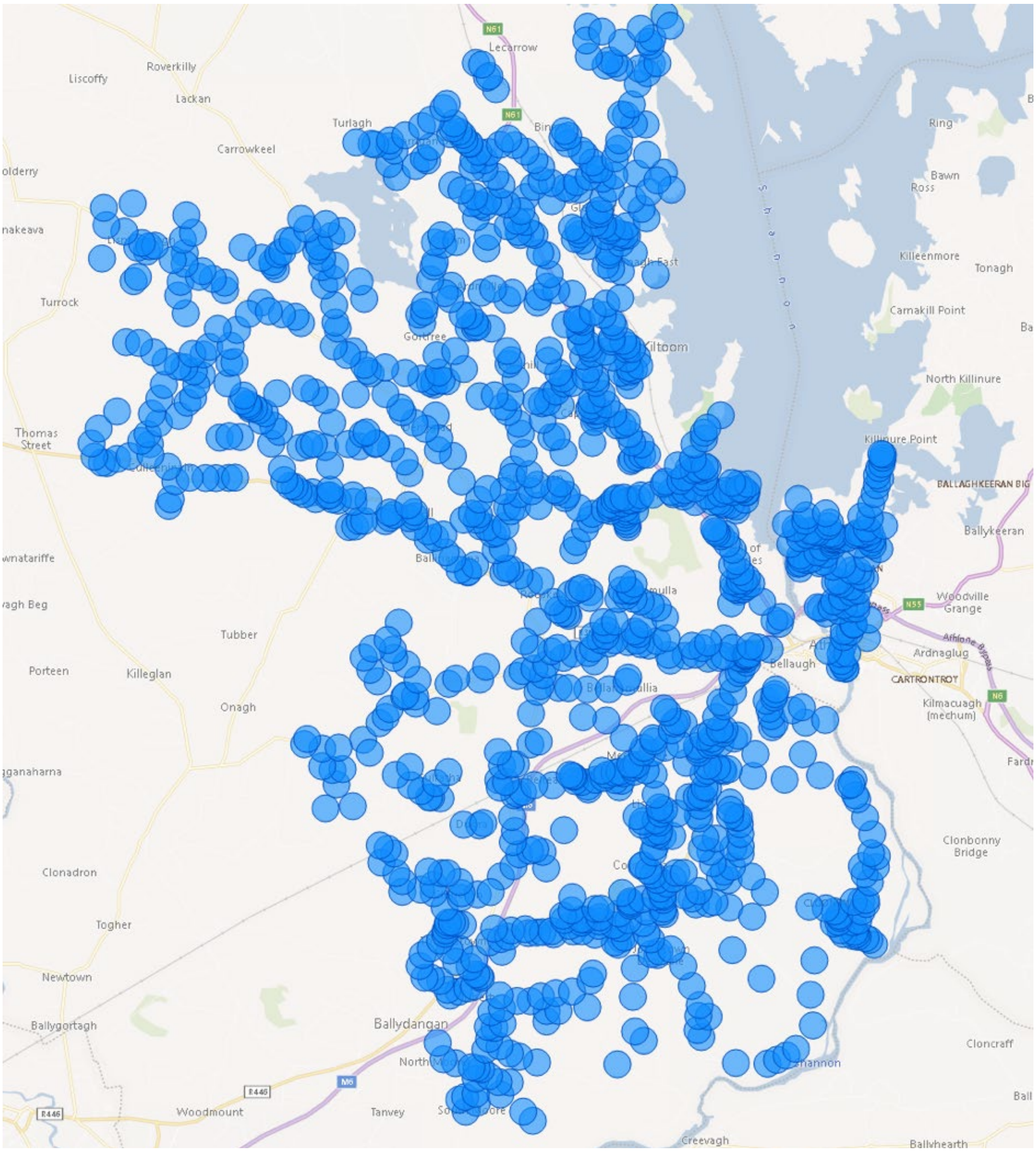
9 APPENDIX 7 – GEOGRAPHICAL REPRESENTATION OF STUDIES AND ESTIMATED LOAD PROFILES

ATHLONE 38KV/MV – ATHLONE AREA

FIGURE A7.6 **STATION LOADING 2030**

Substation	Winter Peak	Winter Peak and LCT	Winter Peak Standby	Winter Peak + LCT Standby	SV + LCT for Normal	SV + LCT for Contingency
ATHLONE	1.47	27.58	7.43	27.58	0.00	0.65

FIGURE A7.7 **STATION FEEDING AREA**



9 APPENDIX 7 – GEOGRAPHICAL REPRESENTATION OF STUDIES AND ESTIMATED LOAD PROFILES

ATHLONE 38KV/MV – ATHLONE AREA continued

FIGURE A7.8 **STATION LOAD PROFILE 2020**

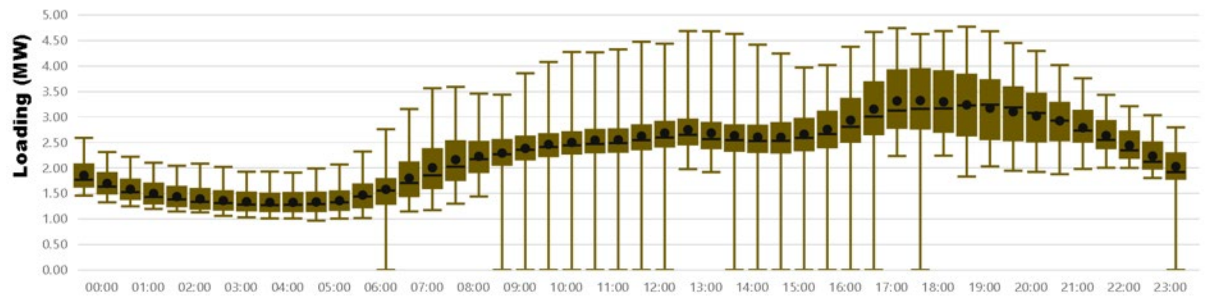
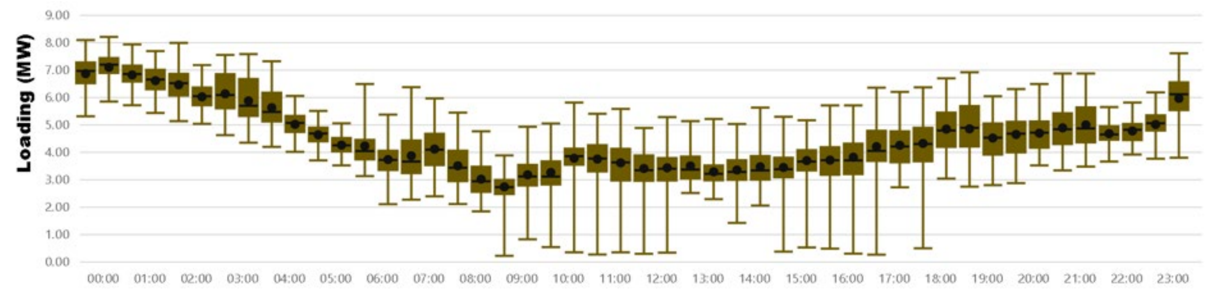


FIGURE A7.9 **STATION LOAD PROFILE WITH LCT IN 2030 – PRIMARILY NIGHT TIME EV CHARGING**



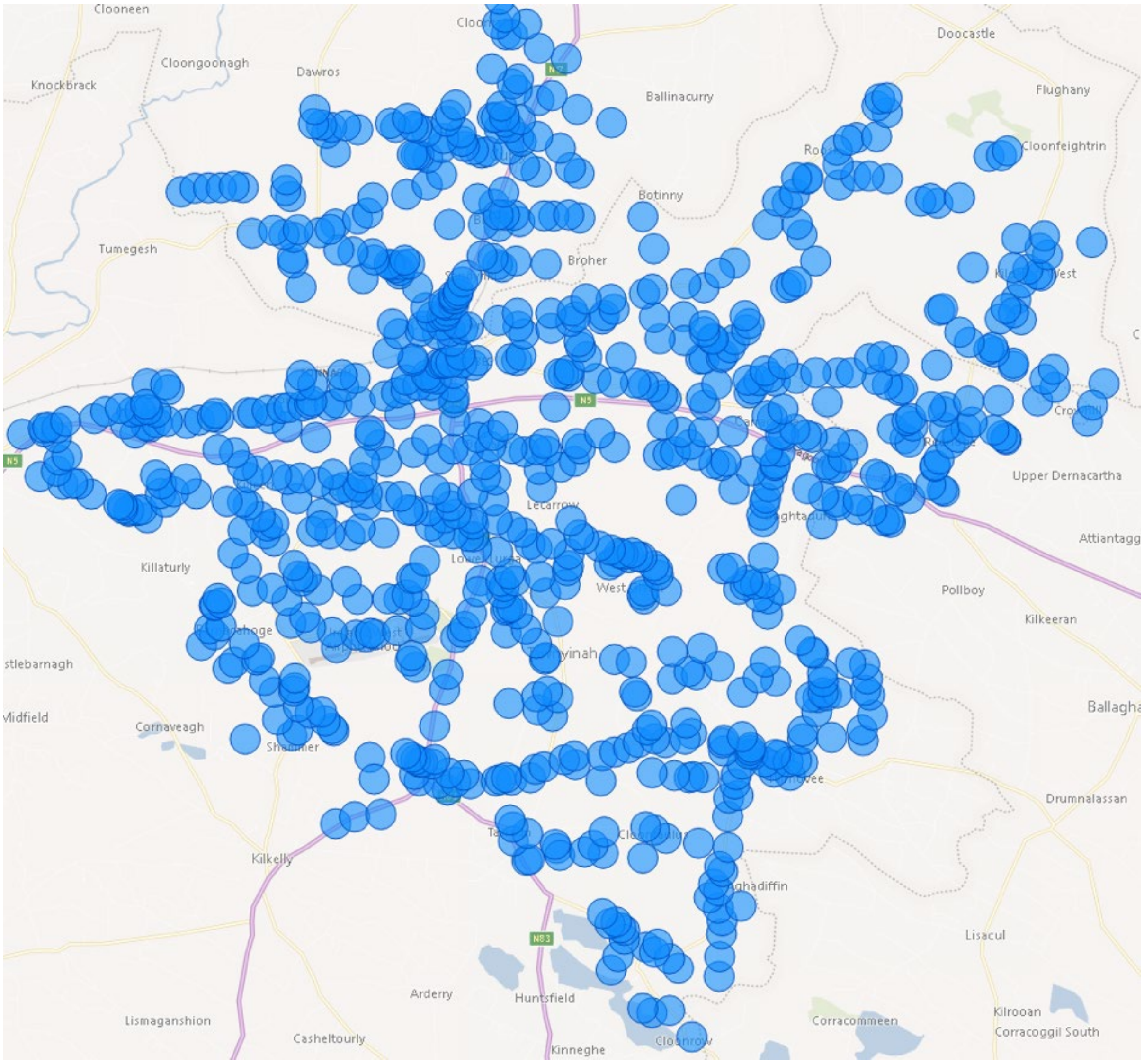
9 APPENDIX 7 – GEOGRAPHICAL REPRESENTATION OF STUDIES AND ESTIMATED LOAD PROFILES

CHARLESTOWN 38KV/MV – BALLINA AREA

FIGURE A7.10 **STATION LOADING 2030**

Substation	Winter Peak	Winter Peak and LCT	Winter Peak Standby	Winter Peak + LCT Standby	SV + LCT for Normal	SV + LCT for Contingency
CHARLESTOWN	0.00	5.40	0.59	5.40	0.00	0.00

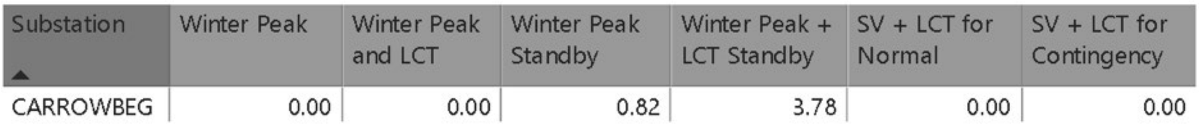
FIGURE A7.11 **STATION FEEDING AREA**



9 APPENDIX 7 – GEOGRAPHICAL REPRESENTATION OF STUDIES AND ESTIMATED LOAD PROFILES

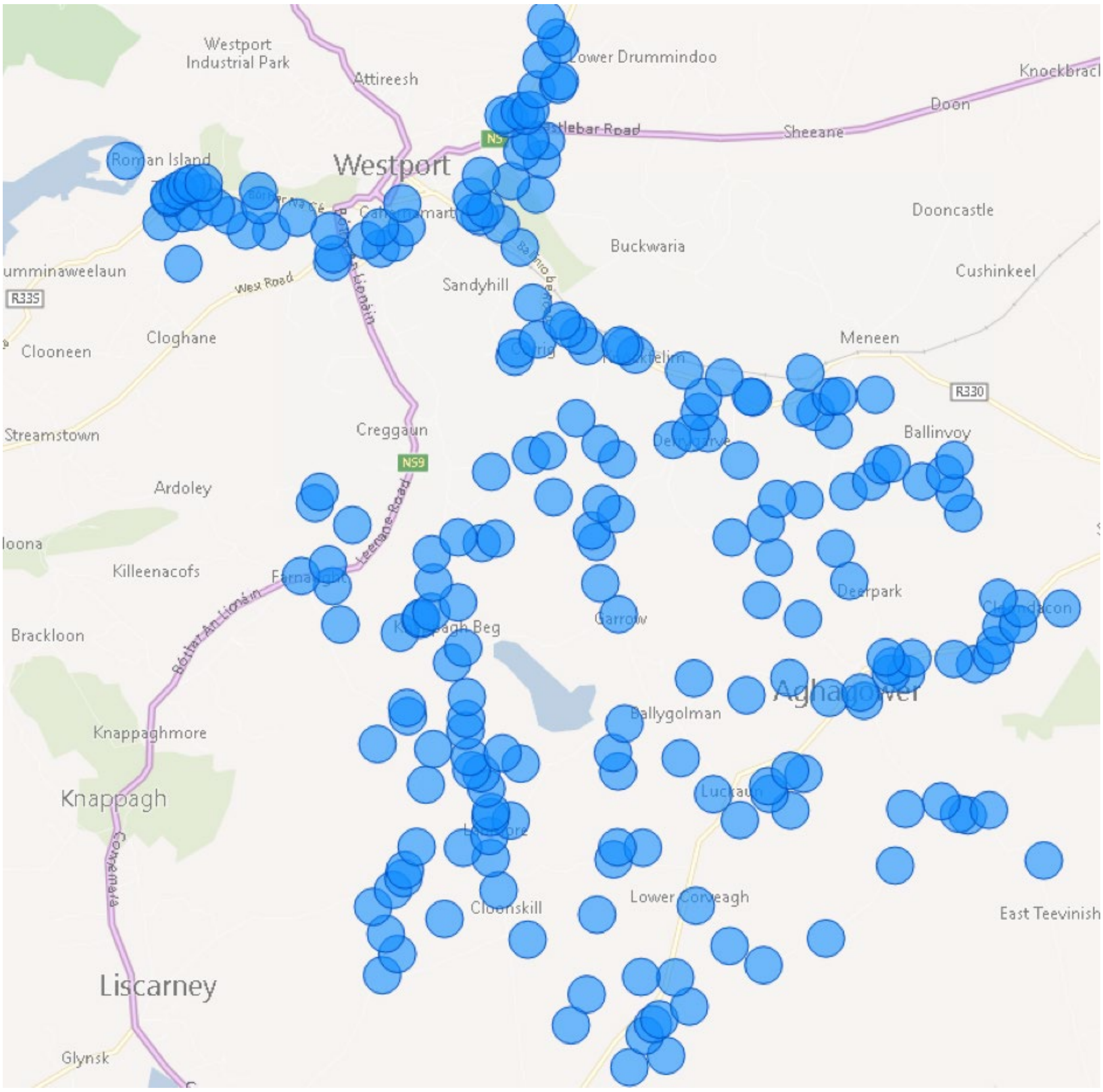
CARROWBEG 38KV/MV – CASTLEBAR AREA

FIGURE A7.12 **STATION LOADING 2030**



Substation ▲	Winter Peak	Winter Peak and LCT	Winter Peak Standby	Winter Peak + LCT Standby	SV + LCT for Normal	SV + LCT for Contingency
CARROWBEG	0.00	0.00	0.82	3.78	0.00	0.00

FIGURE A7.13 **STATION FEEDING AREA**



9 APPENDIX 7 – GEOGRAPHICAL REPRESENTATION OF STUDIES AND ESTIMATED LOAD PROFILES

ATHLONE 38KV/MV – ATHLONE AREA continued

FIGURE A7.14 **STATION LOAD PROFILE 2020**

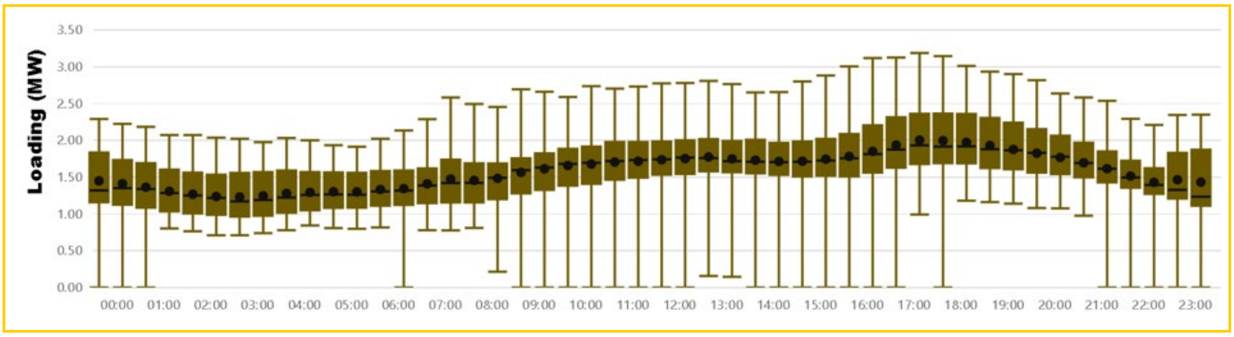
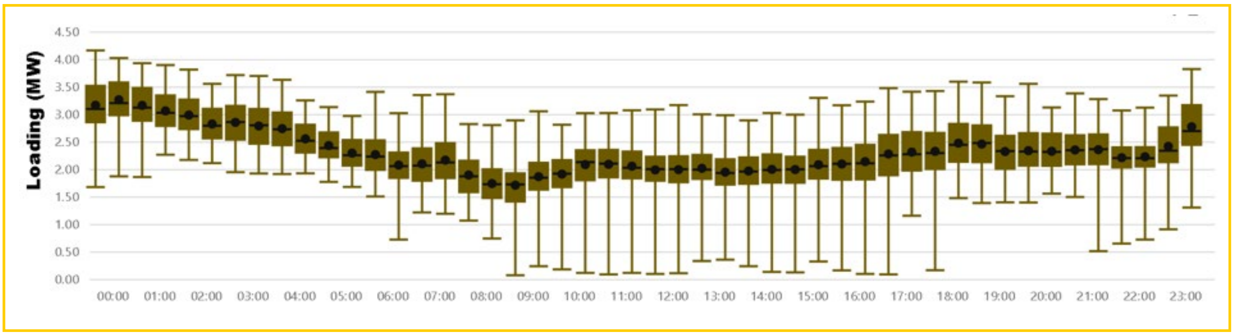


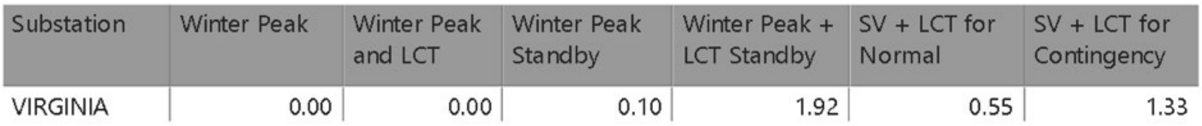
FIGURE A7.15 **STATION LOAD PROFILE WITH LCT IN 2030 – PRIMARILY NIGHT TIME EV CHARGING**



9 APPENDIX 7 – GEOGRAPHICAL REPRESENTATION OF STUDIES AND ESTIMATED LOAD PROFILES

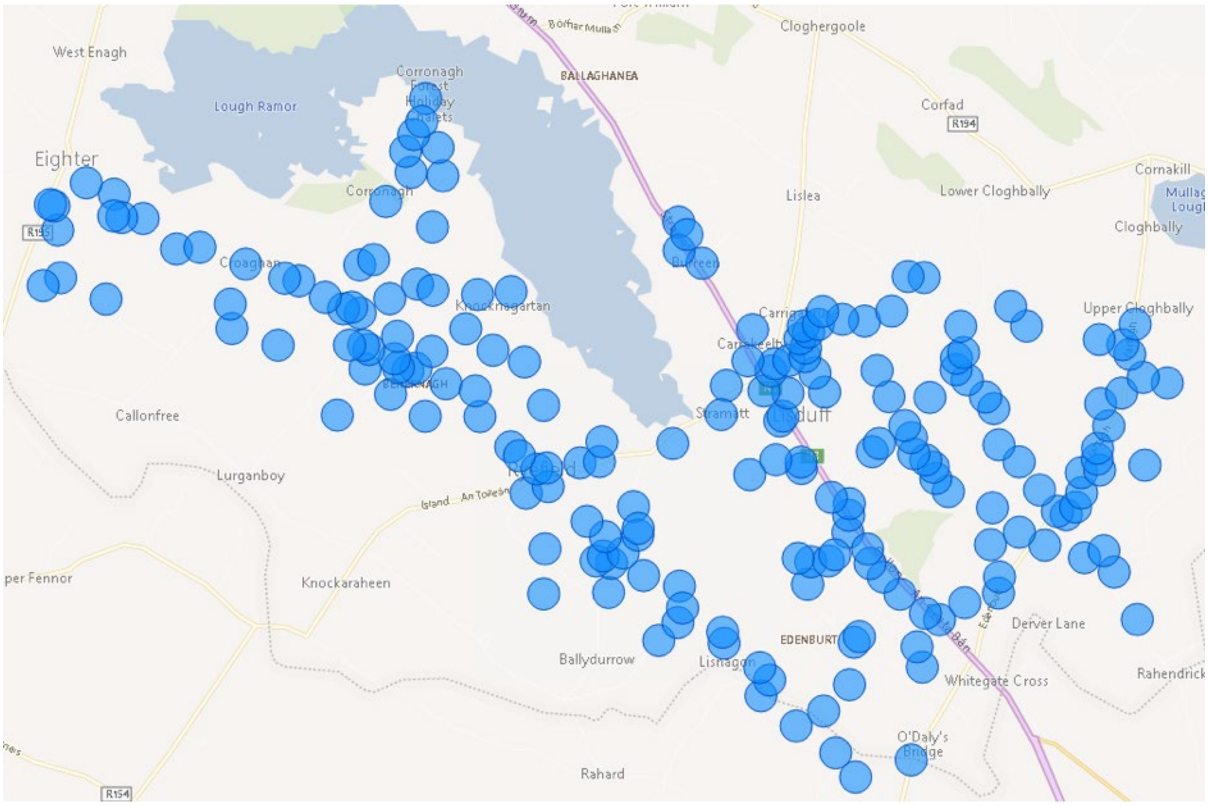
VIRGINIA 38KV/MV – CAVAN AREA

FIGURE A7.16 **STATION LOADING 2030**



Substation	Winter Peak	Winter Peak and LCT	Winter Peak Standby	Winter Peak + LCT Standby	SV + LCT for Normal	SV + LCT for Contingency
VIRGINIA	0.00	0.00	0.10	1.92	0.55	1.33

FIGURE A7.17 **STATION FEEDING AREA**



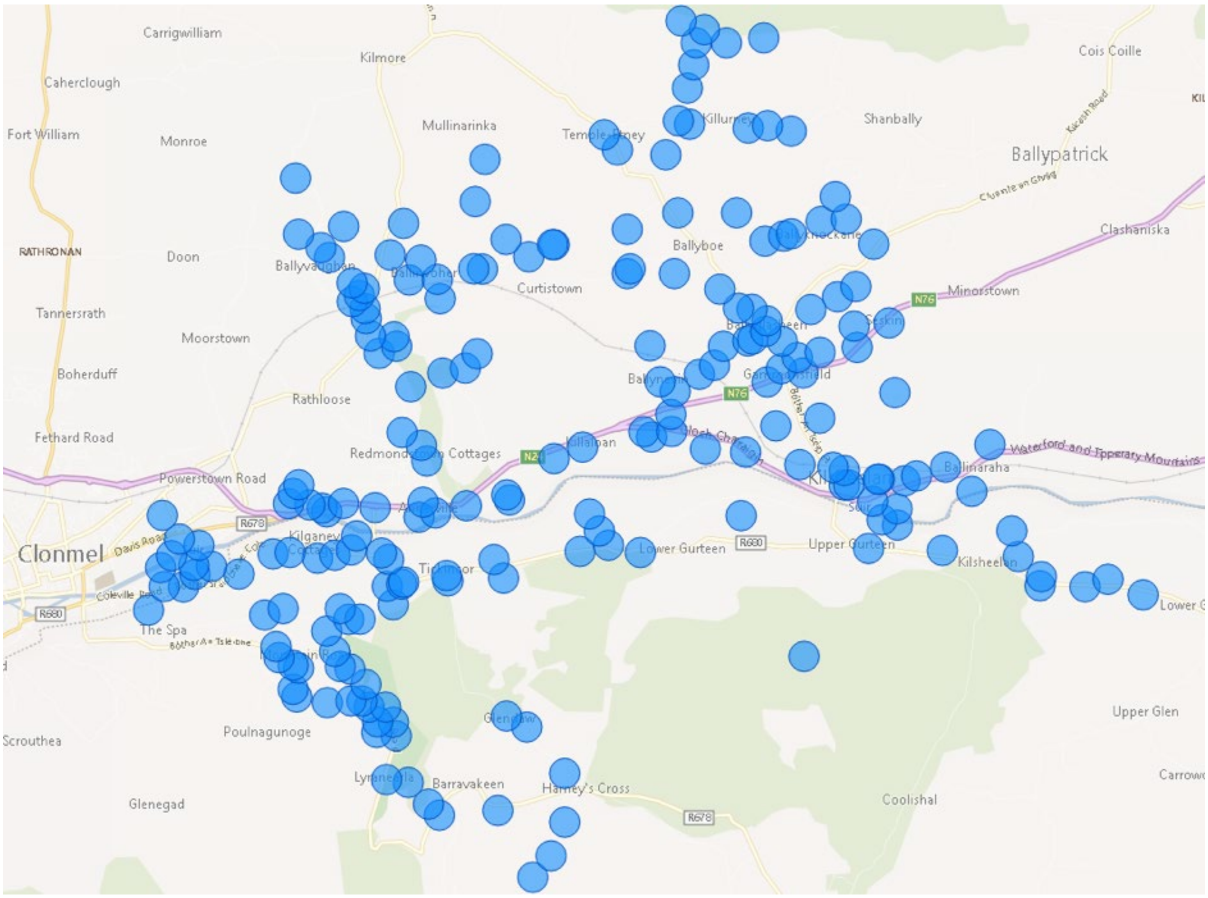
9 APPENDIX 7 – GEOGRAPHICAL REPRESENTATION OF STUDIES AND ESTIMATED LOAD PROFILES

SPA ROAD 38KV/MV – CLONMEL AREA

FIGURE A7.18 **STATION LOADING 2030**

Substation	Winter Peak	Winter Peak and LCT	Winter Peak Standby	Winter Peak + LCT Standby	SV + LCT for Normal	SV + LCT for Contingency
SPA ROAD	0.70	2.11	2.66	4.94	0.00	1.10

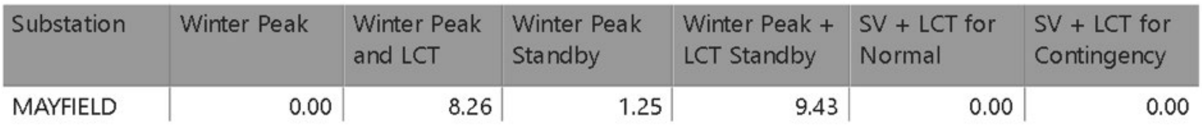
FIGURE A7.19 **STATION FEEDING AREA**



9 APPENDIX 7 – GEOGRAPHICAL REPRESENTATION OF STUDIES AND ESTIMATED LOAD PROFILES

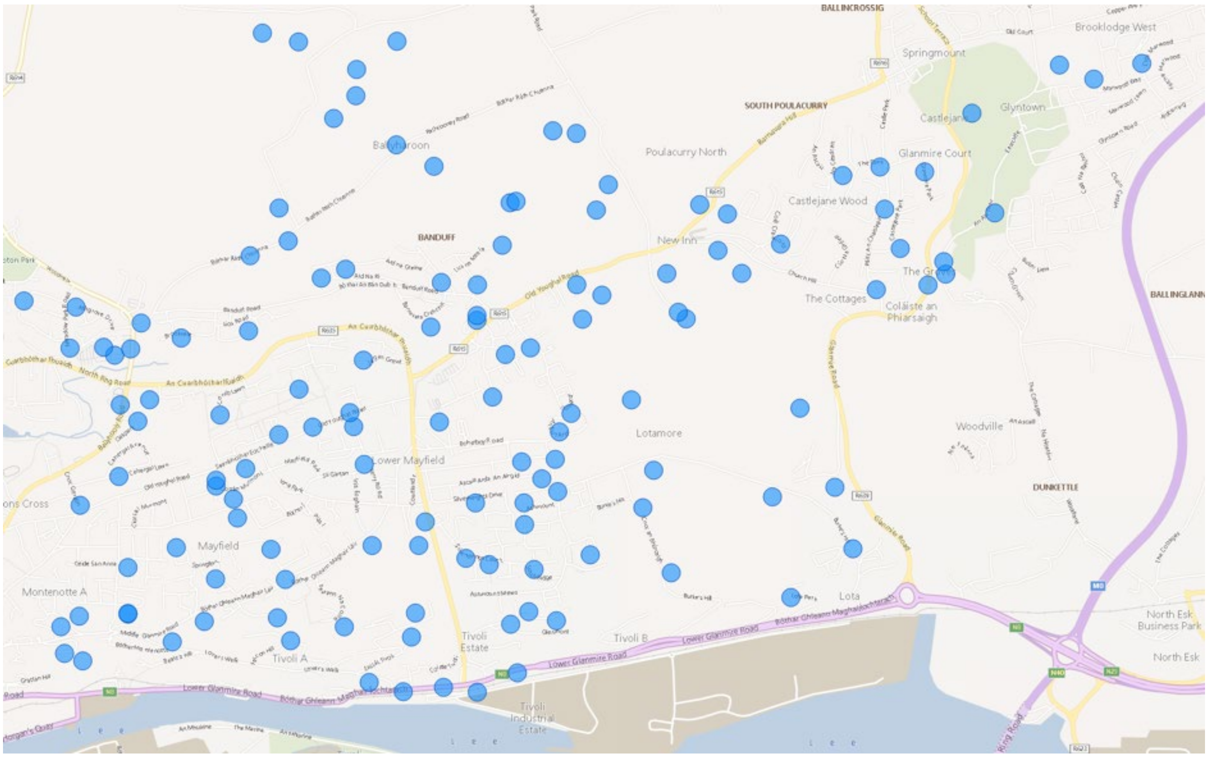
MAYFIELD 38KV/MV – CORK CITY AREA

FIGURE A7.20 **STATION LOADING 2030**



Substation	Winter Peak	Winter Peak and LCT	Winter Peak Standby	Winter Peak + LCT Standby	SV + LCT for Normal	SV + LCT for Contingency
MAYFIELD	0.00	8.26	1.25	9.43	0.00	0.00

FIGURE A7.21 **STATION FEEDING AREA**



9 APPENDIX 7 – GEOGRAPHICAL REPRESENTATION OF STUDIES AND ESTIMATED LOAD PROFILES

MAYFIELD 38KV/MV – CORK CITY AREA

FIGURE A7.22 **STATION LOAD PROFILE 2020**

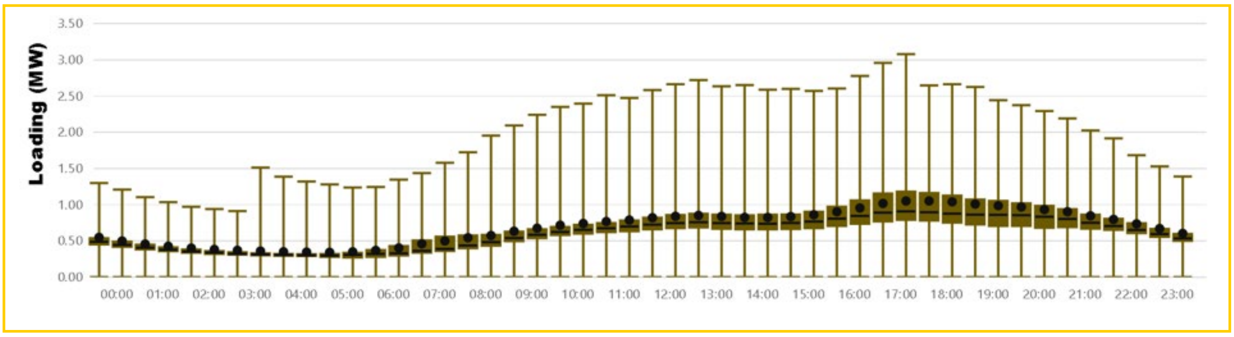
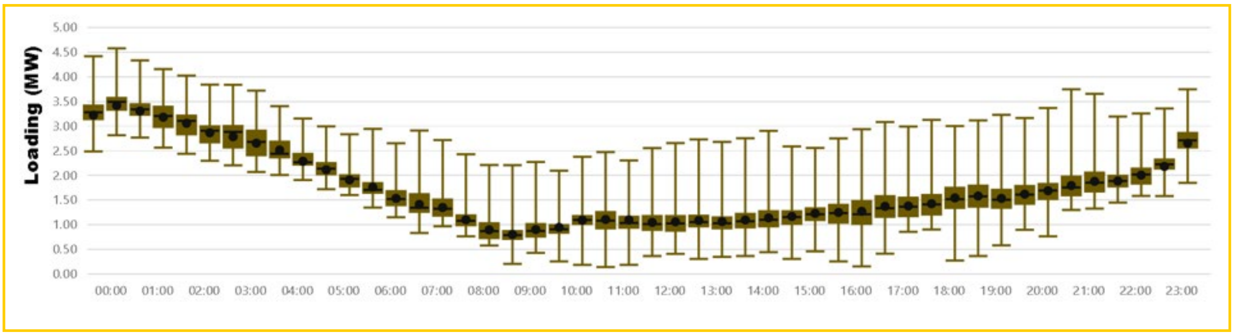


FIGURE A7.23 **STATION LOAD PROFILE WITH LCT IN 2030 – PRIMARILY NIGHT TIME EV CHARGING**



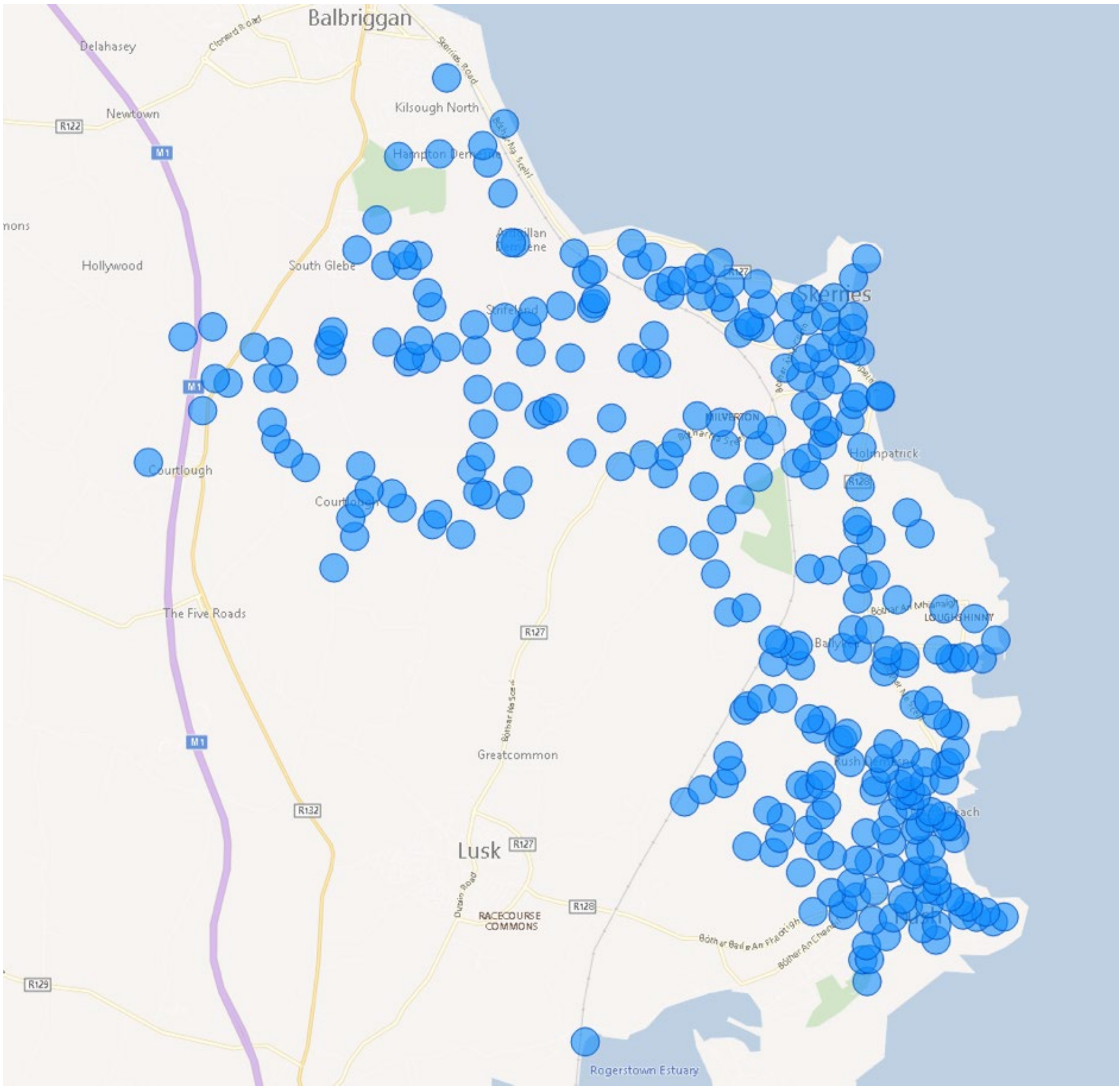
9 APPENDIX 7 – GEOGRAPHICAL REPRESENTATION OF STUDIES AND ESTIMATED LOAD PROFILES

LOUGHSHINNY 38KV/MV – DUBLIN NORTH AREA

FIGURE A7.24 **STATION LOADING 2030**

Substation	Winter Peak	Winter Peak and LCT	Winter Peak Standby	Winter Peak + LCT Standby	SV + LCT for Normal	SV + LCT for Contingency
LOUGHSHINNY	1.92	21.92	7.06	21.92	2.51	1.44

FIGURE A7.25 **STATION FEEDING AREA**



9 APPENDIX 7 – GEOGRAPHICAL REPRESENTATION OF STUDIES AND ESTIMATED LOAD PROFILES

LOUGHSHINNY 38KV/MV – DUBLIN NORTH AREA

FIGURE A7.26 **STATION LOAD PROFILE 2020**

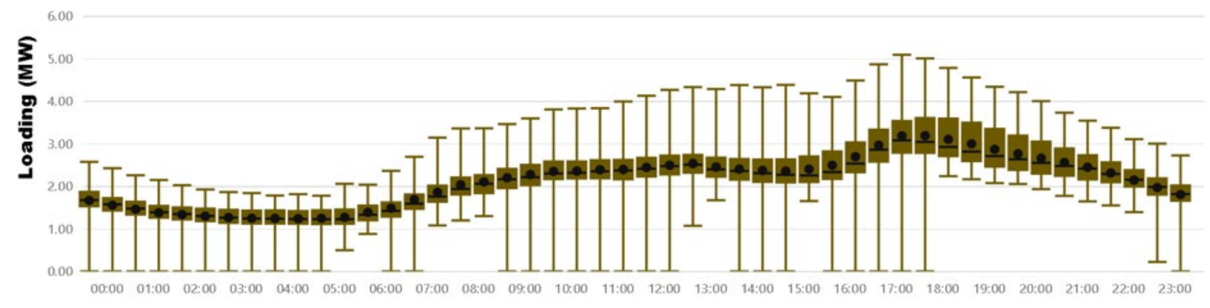
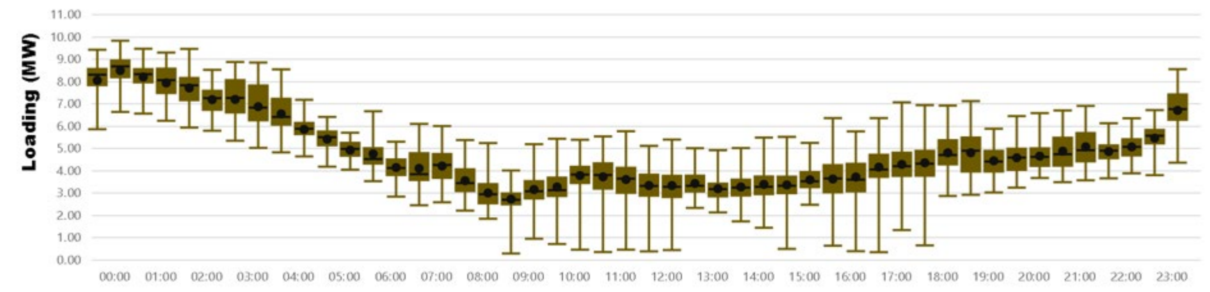


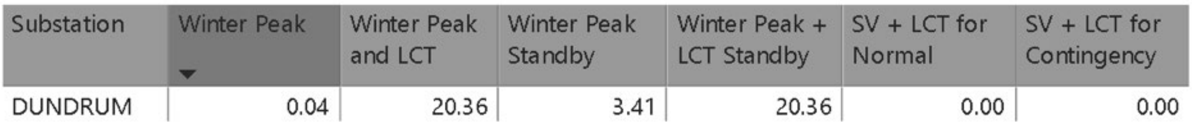
FIGURE A7.27 **STATION LOAD PROFILE WITH LCT IN 2030 – PRIMARILY NIGHT TIME EV CHARGING**



9 APPENDIX 7 – GEOGRAPHICAL REPRESENTATION OF STUDIES AND ESTIMATED LOAD PROFILES

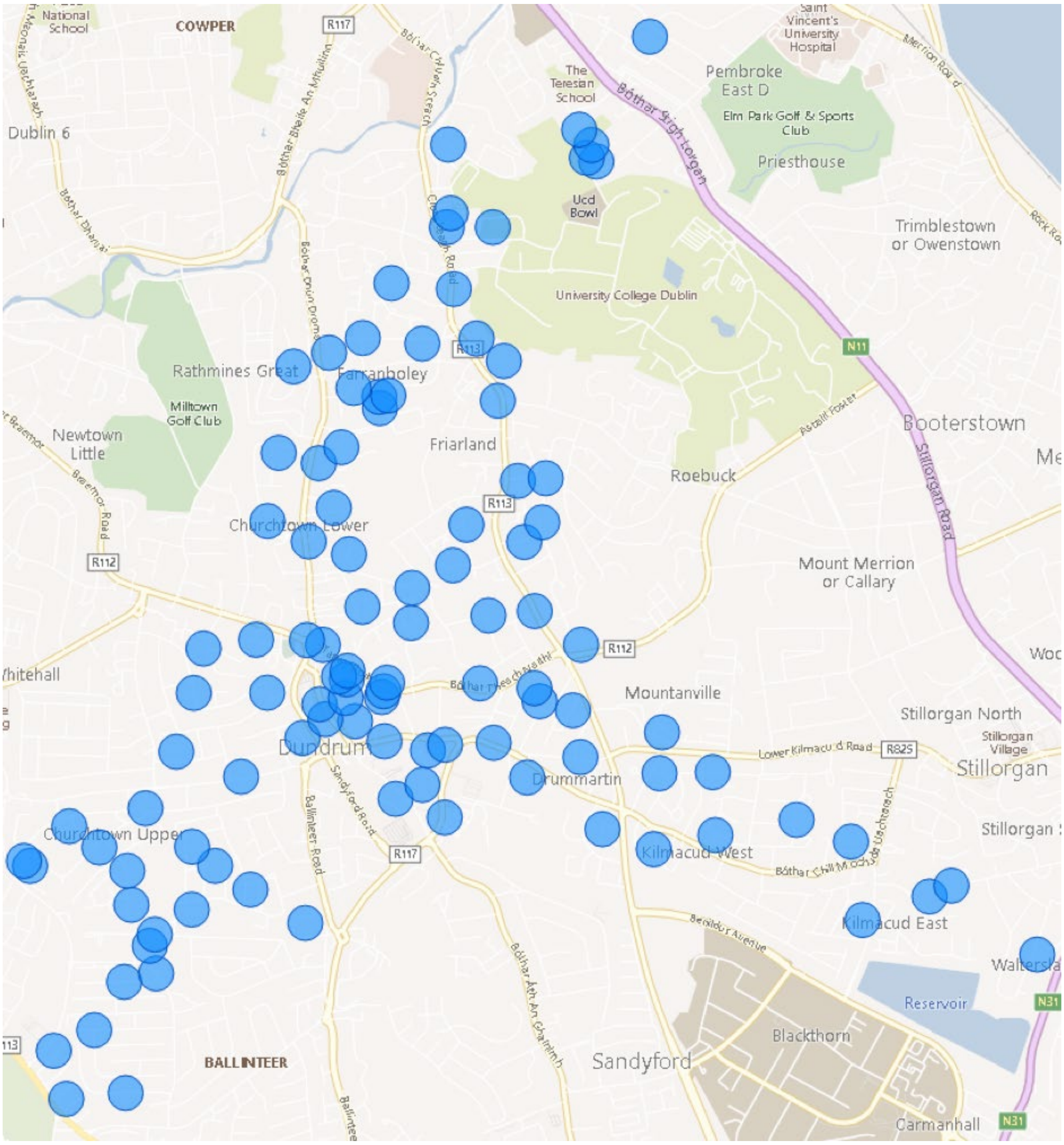
DUNDRUM 38KV/MV – DUBLIN SOUTH AREA

FIGURE A7.28 **STATION LOADING 2030**



Substation	Winter Peak	Winter Peak and LCT	Winter Peak Standby	Winter Peak + LCT Standby	SV + LCT for Normal	SV + LCT for Contingency
DUNDRUM	0.04	20.36	3.41	20.36	0.00	0.00

FIGURE A7.29 **STATION FEEDING AREA**



9 APPENDIX 7 – GEOGRAPHICAL REPRESENTATION OF STUDIES AND ESTIMATED LOAD PROFILES

DUNDRUM 38KV/MV – DUBLIN SOUTH AREA

FIGURE A7.30 **STATION LOAD PROFILE 2020**

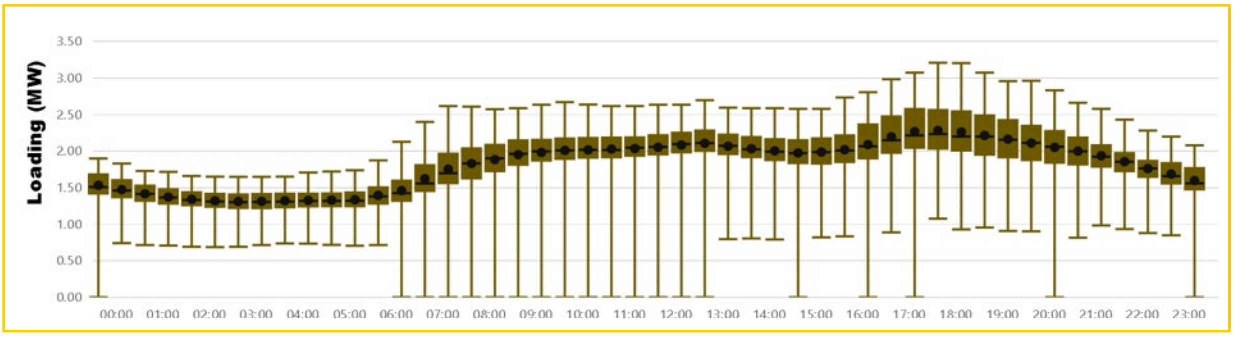
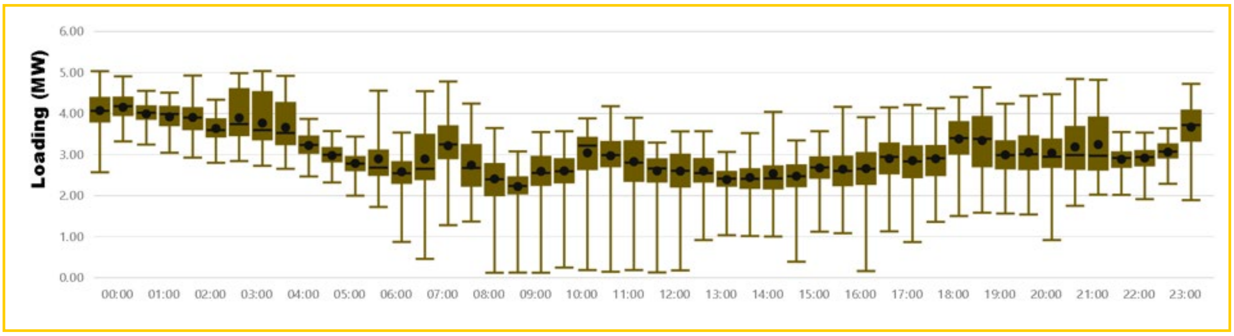


FIGURE A7.31 **STATION LOAD PROFILE WITH LCT IN 2030 – PRIMARILY NIGHT TIME EV CHARGING**



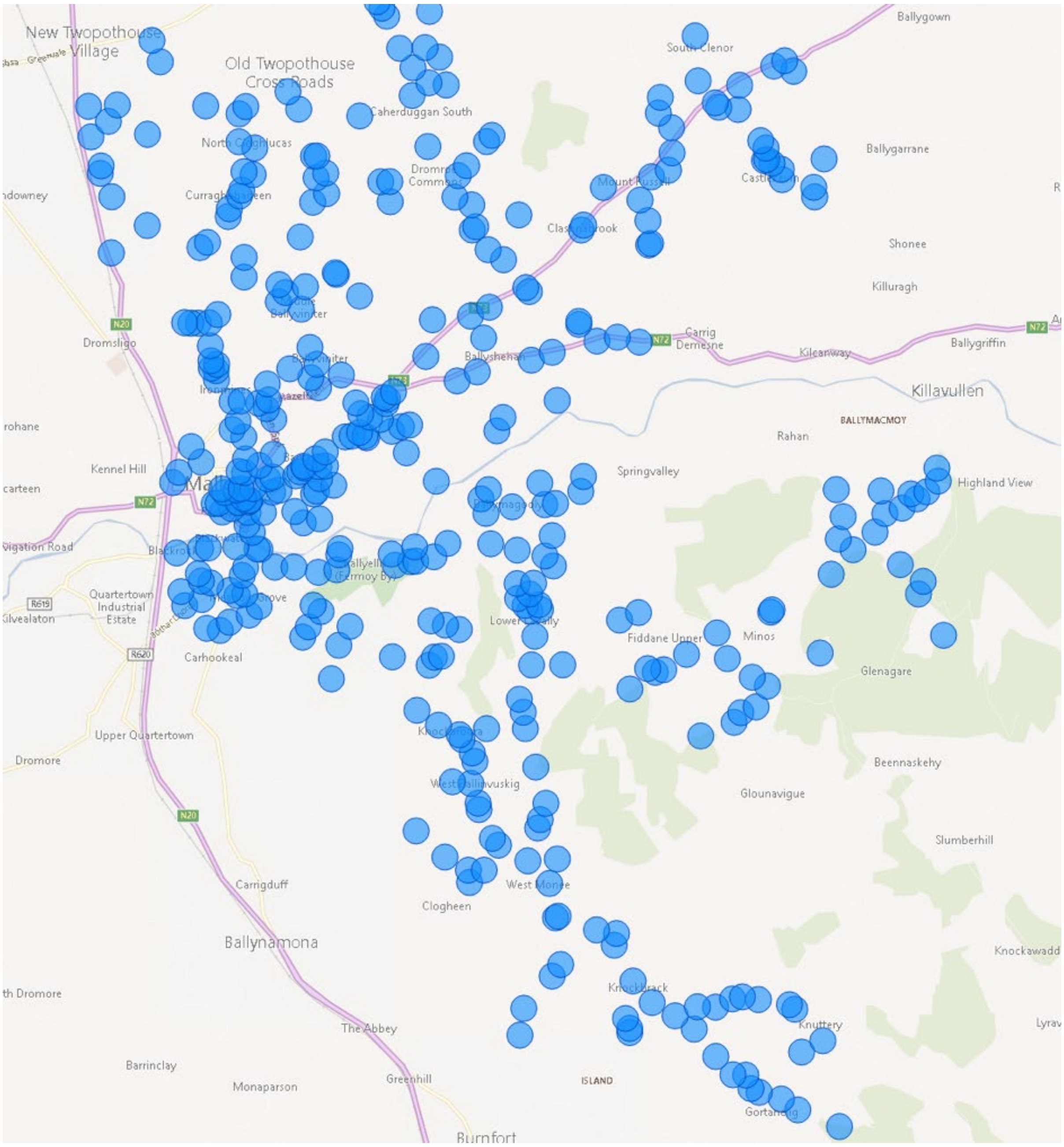
9 APPENDIX 7 – GEOGRAPHICAL REPRESENTATION OF STUDIES AND ESTIMATED LOAD PROFILES

MALLOW 38KV/MV – FERMOY AREA

FIGURE A7.32 **STATION LOADING 2030**

Substation	Winter Peak	Winter Peak and LCT	Winter Peak Standby	Winter Peak + LCT Standby	SV + LCT for Normal	SV + LCT for Contingency
MALLOW	0.00	7.92	1.79	14.71	0.00	0.00

FIGURE A7.33 **STATION FEEDING AREA**



9 APPENDIX 7 – GEOGRAPHICAL REPRESENTATION OF STUDIES AND ESTIMATED LOAD PROFILES

MALLOW 38KV/MV – FERMOY AREA

FIGURE A7.34 **STATION LOAD PROFILE 2020**

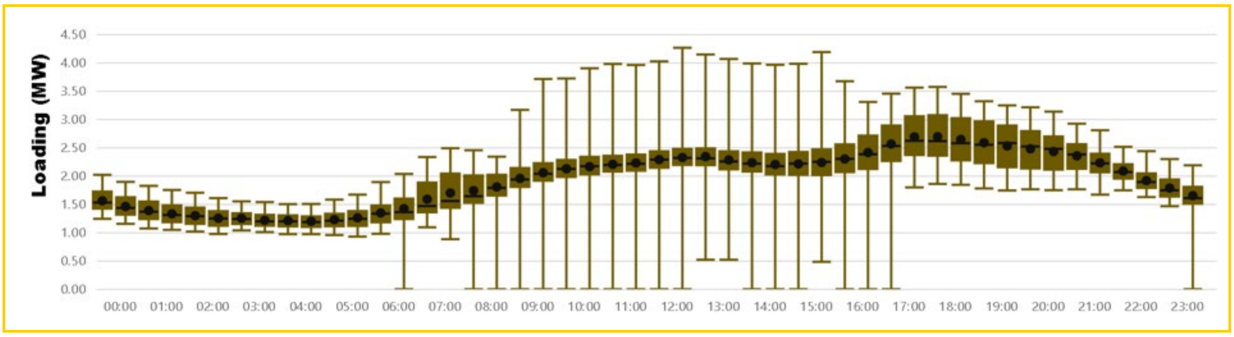
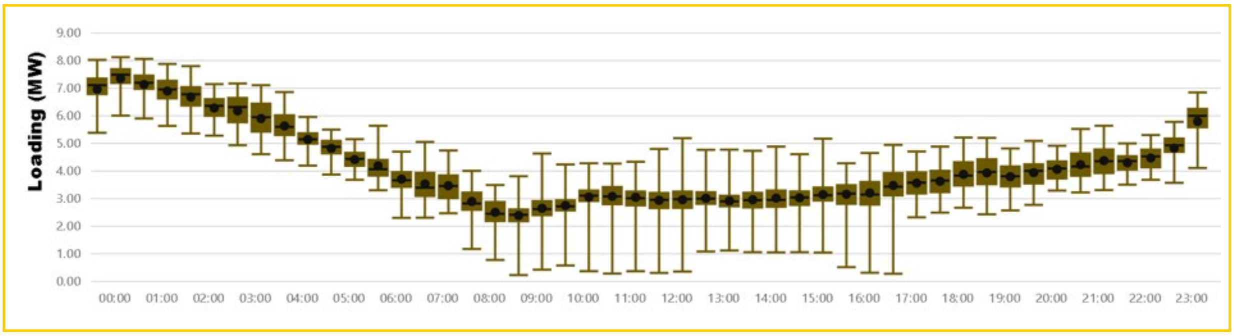


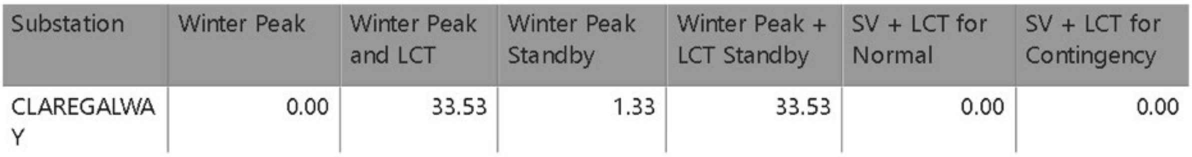
FIGURE A7.35 **STATION LOAD PROFILE WITH LCT IN 2030 – PRIMARILY NIGHT TIME EV CHARGING**



9 APPENDIX 7 – GEOGRAPHICAL REPRESENTATION OF STUDIES AND ESTIMATED LOAD PROFILES

CLAREGALWAY 38KV/MV – GALWAY AREA

FIGURE A7.36 **STATION LOADING 2030**



Substation	Winter Peak	Winter Peak and LCT	Winter Peak Standby	Winter Peak + LCT Standby	SV + LCT for Normal	SV + LCT for Contingency
CLAREGALWAY	0.00	33.53	1.33	33.53	0.00	0.00

FIGURE A7.37 **STATION FEEDING AREA**

9 APPENDIX 7 – GEOGRAPHICAL REPRESENTATION OF STUDIES AND ESTIMATED LOAD PROFILES

CLAREGALWAY 38KV/MV – GALWAY AREA

FIGURE A7.38 **STATION LOAD PROFILE 2020**

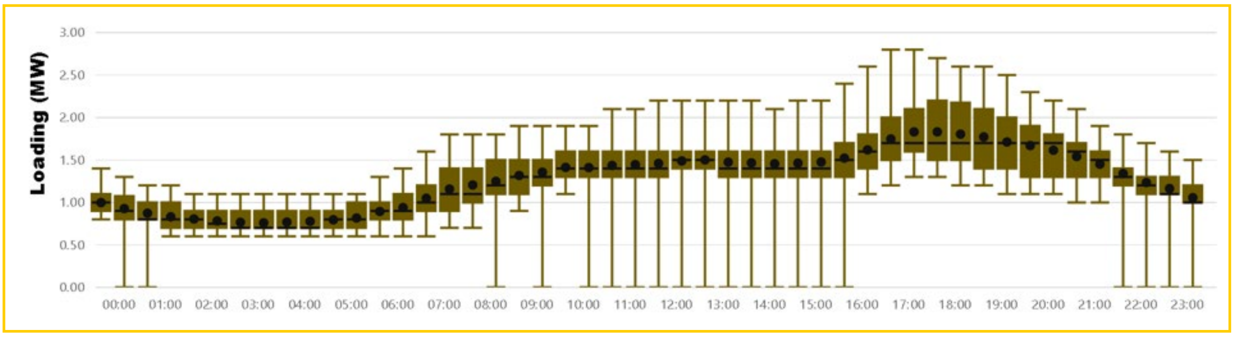
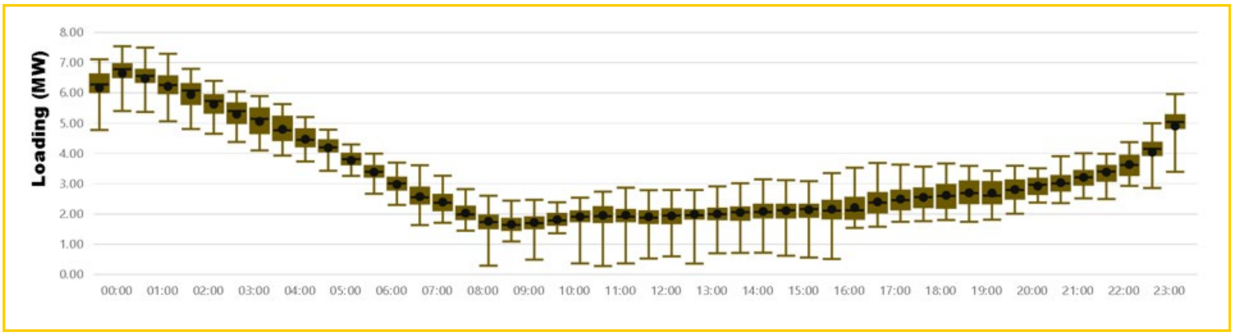


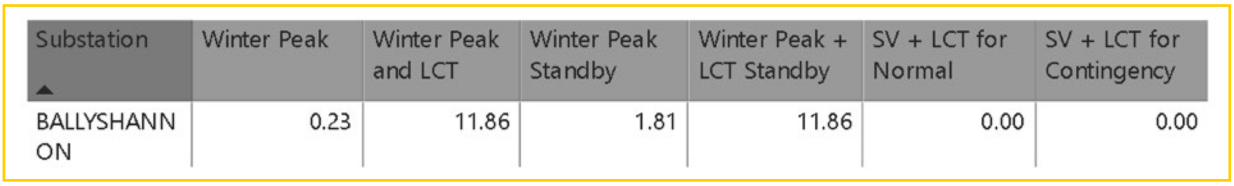
FIGURE A7.39 **STATION LOAD PROFILE WITH LCT IN 2030 – PRIMARILY NIGHT TIME EV CHARGING**



9 APPENDIX 7 – GEOGRAPHICAL REPRESENTATION OF STUDIES AND ESTIMATED LOAD PROFILES

BALLYSHANNON 38KV/MV – KILLYBEGS AREA

FIGURE A7.40 **STATION LOADING 2030**



Substation	Winter Peak	Winter Peak and LCT	Winter Peak Standby	Winter Peak + LCT Standby	SV + LCT for Normal	SV + LCT for Contingency
BALLYSHANNON	0.23	11.86	1.81	11.86	0.00	0.00

FIGURE A7.41 **STATION FEEDING AREA**

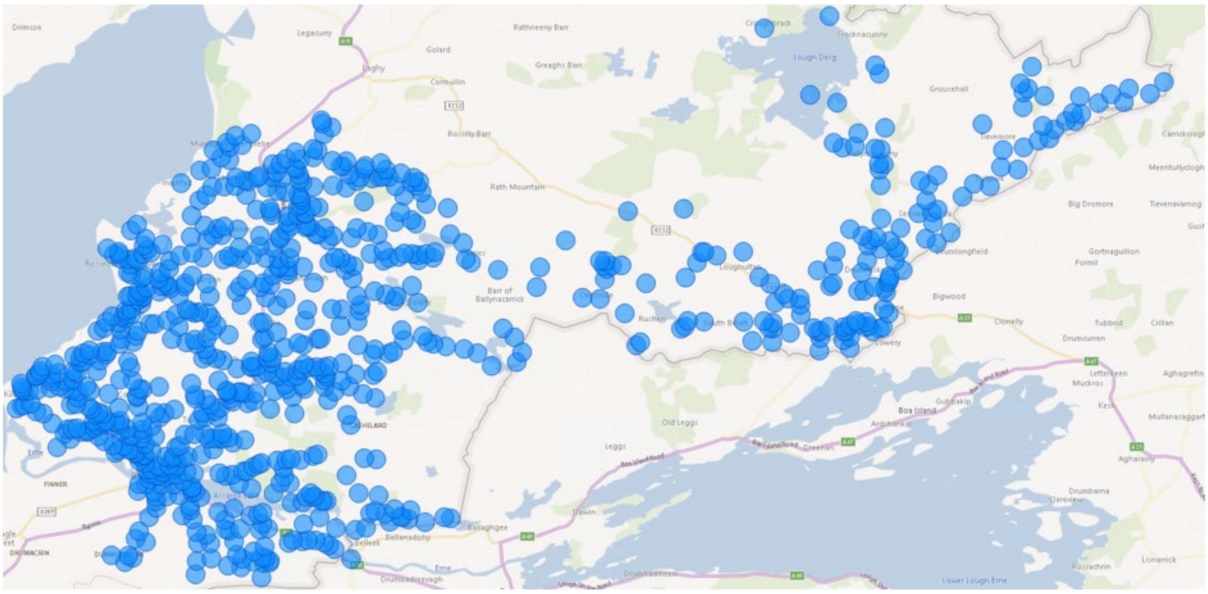


FIGURE A7.42 **STATION LOAD PROFILE 2020**

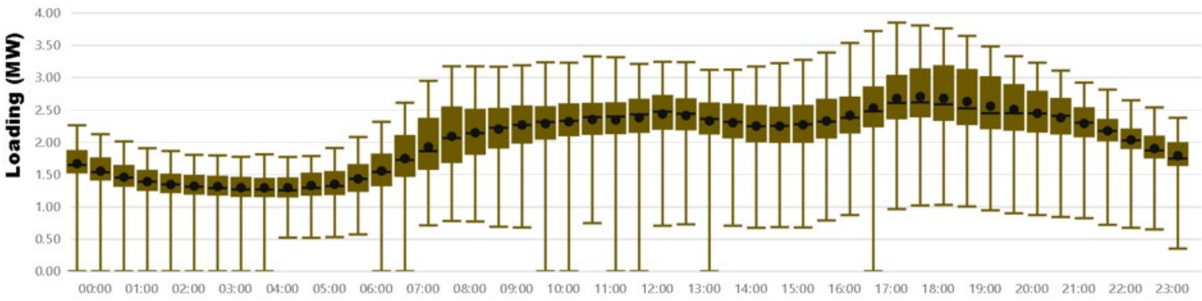
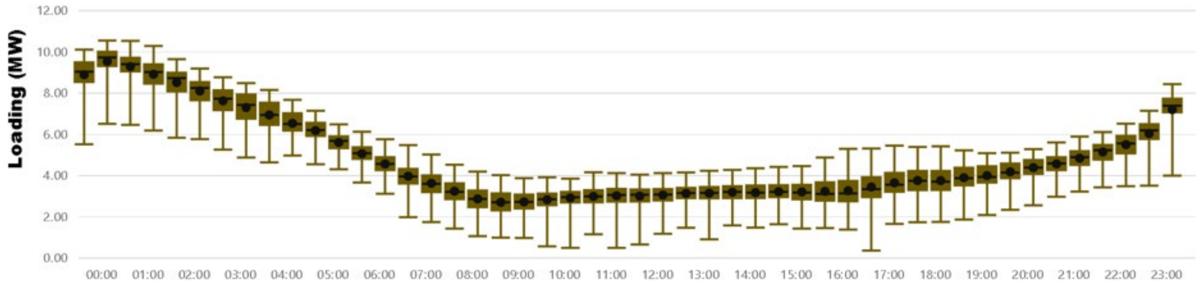


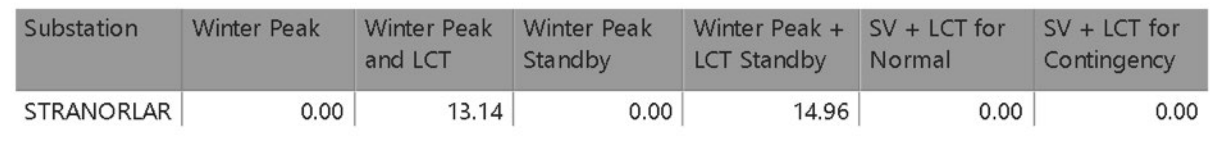
FIGURE A7.43 **STATION LOAD PROFILE WITH LCT IN 2030 – PRIMARILY NIGHT TIME EV CHARGING**



9 APPENDIX 7 – GEOGRAPHICAL REPRESENTATION OF STUDIES AND ESTIMATED LOAD PROFILES

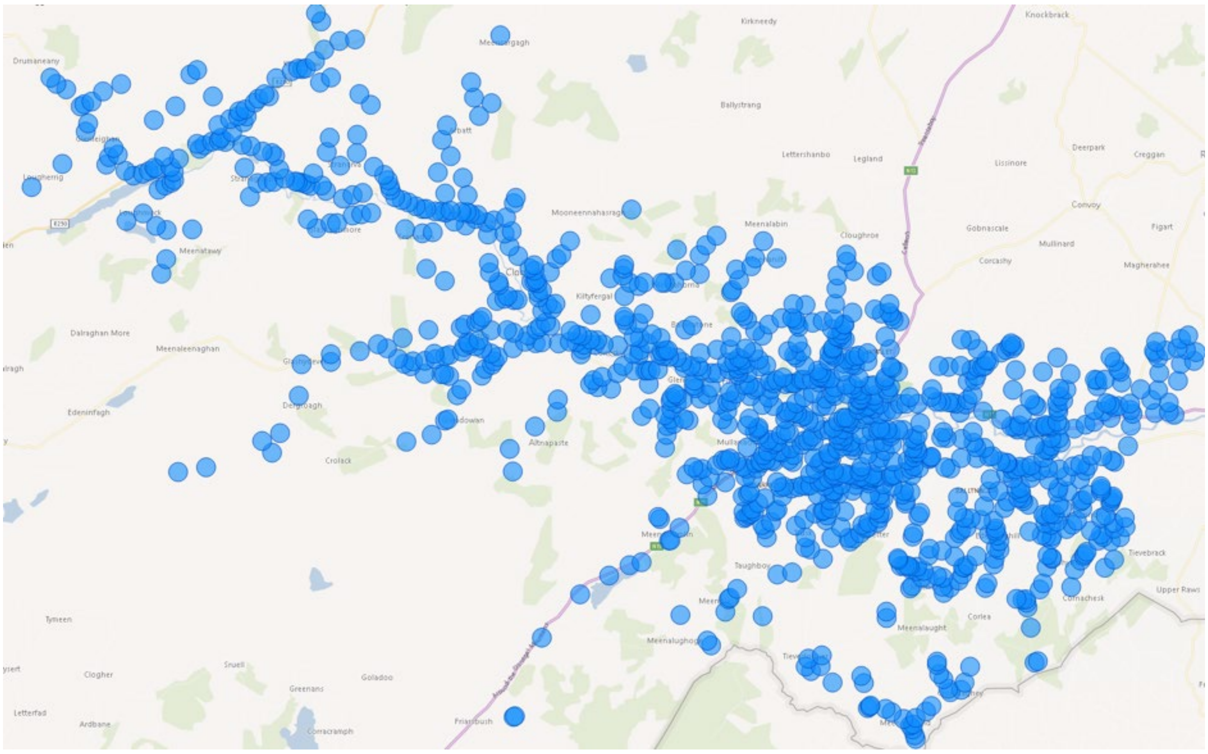
STRANORLAR 38KV/MV – LETTERKENNY AREA

FIGURE A7.44 **STATION LOADING 2030**



Substation	Winter Peak	Winter Peak and LCT	Winter Peak Standby	Winter Peak + LCT Standby	SV + LCT for Normal	SV + LCT for Contingency
STRANORLAR	0.00	13.14	0.00	14.96	0.00	0.00

FIGURE A7.45 **STATION FEEDING AREA**



9 APPENDIX 7 – GEOGRAPHICAL REPRESENTATION OF STUDIES AND ESTIMATED LOAD PROFILES

STRANORLAR 38KV/MV – LETTERKENNY AREA

FIGURE A7.46 **STATION LOAD PROFILE 2020**

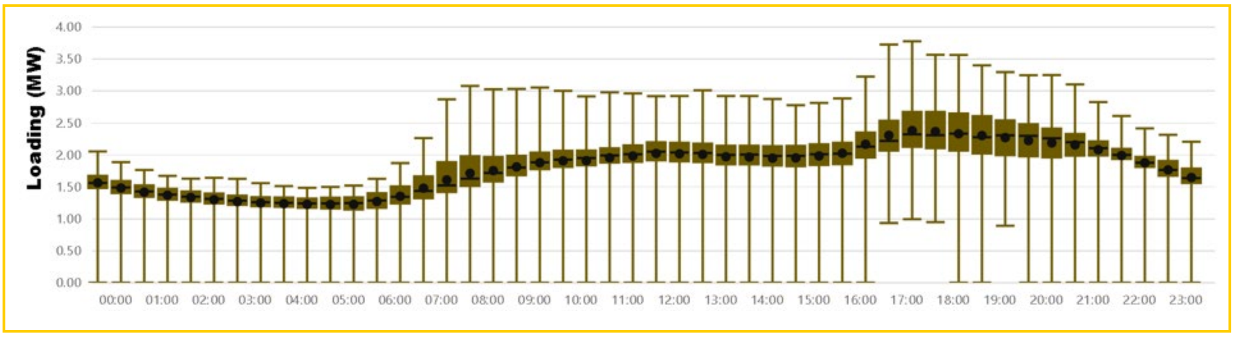
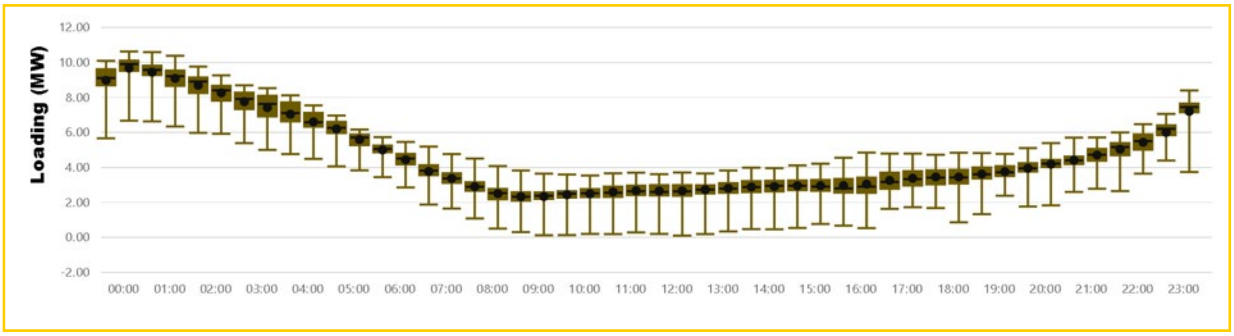


FIGURE A7.47 **STATION LOAD PROFILE WITH LCT IN 2030 – PRIMARILY NIGHT TIME EV CHARGING**



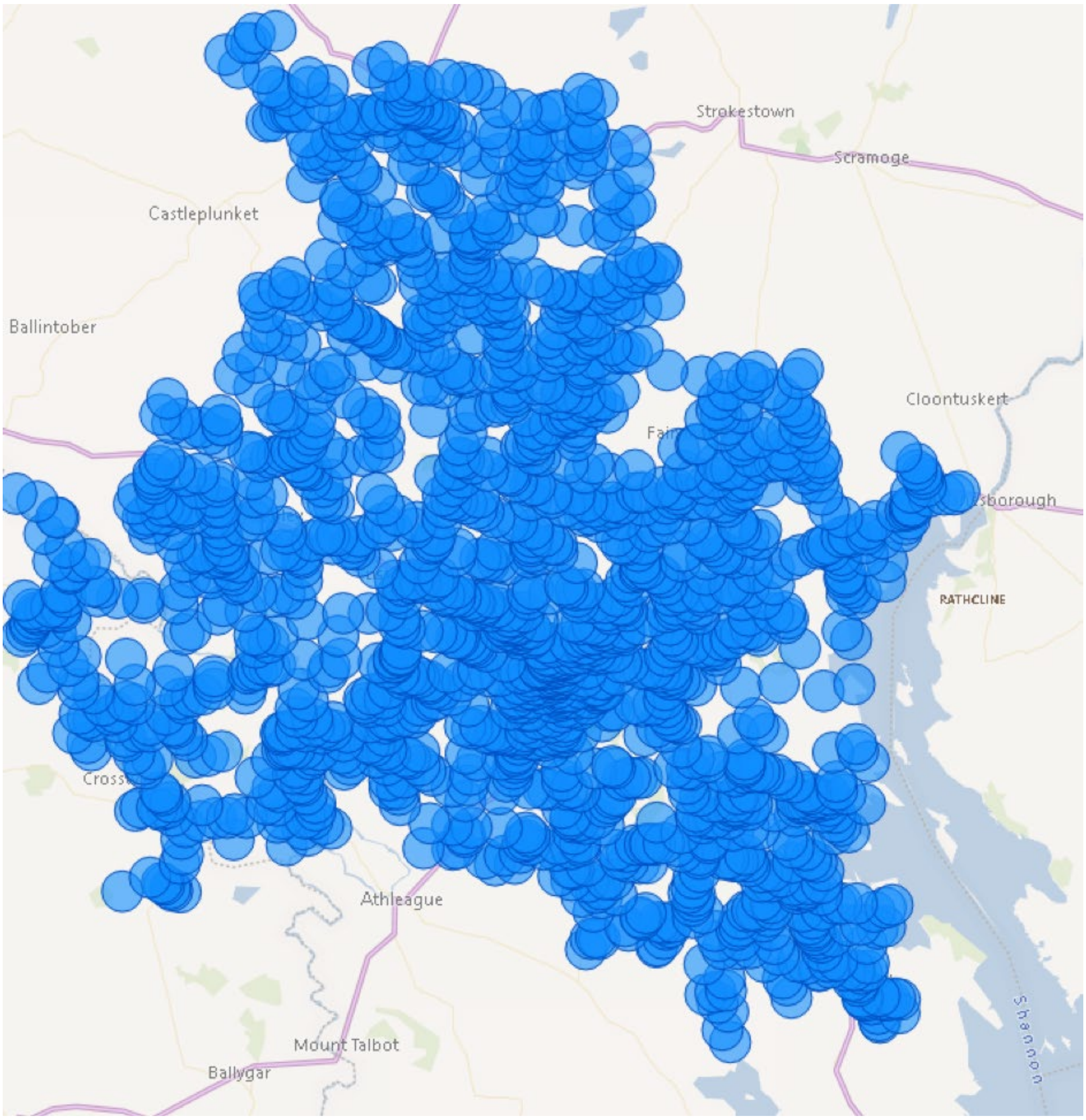
9 APPENDIX 7 – GEOGRAPHICAL REPRESENTATION OF STUDIES AND ESTIMATED LOAD PROFILES

ROSCOMMON 38KV/MV – LONGFORD AREA

FIGURE A7.48 **STATION LOADING 2030**

Substation	Winter Peak	Winter Peak and LCT	Winter Peak Standby	Winter Peak + LCT Standby	SV + LCT for Normal	SV + LCT for Contingency
ROSCOMMON	0.00	5.43	1.87	7.09	0.00	0.00

FIGURE A7.49 **STATION FEEDING AREA**



9 APPENDIX 7 – GEOGRAPHICAL REPRESENTATION OF STUDIES AND ESTIMATED LOAD PROFILES

ROSCOMMON 38KV/MV – LONGFORD AREA

FIGURE A7.50 **STATION LOAD PROFILE 2020**

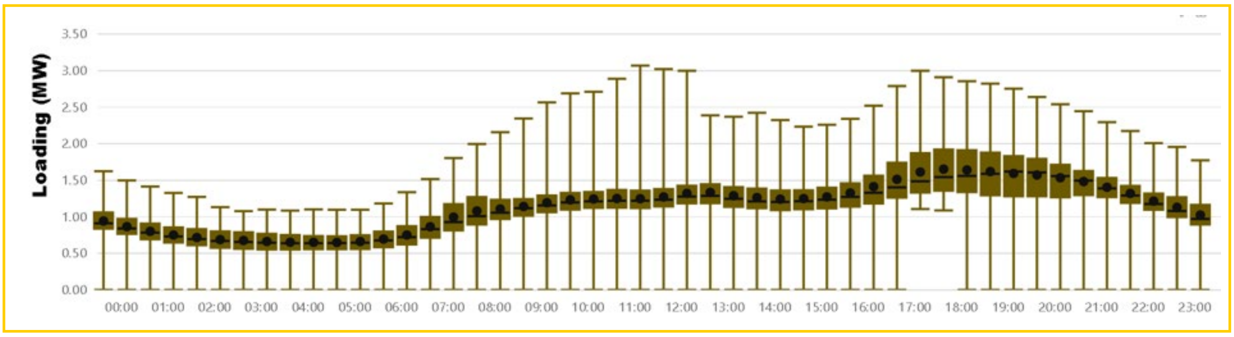
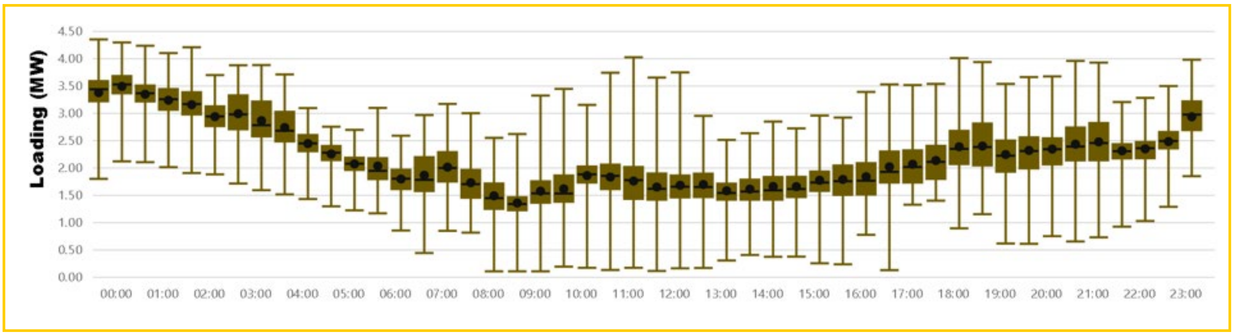


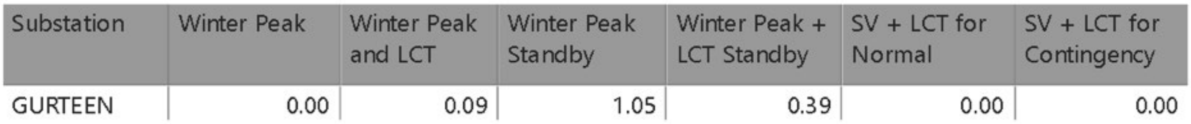
FIGURE A7.51 **STATION LOAD PROFILE WITH LCT IN 2030 – PRIMARILY NIGHT TIME EV CHARGING**



9 APPENDIX 7 – GEOGRAPHICAL REPRESENTATION OF STUDIES AND ESTIMATED LOAD PROFILES

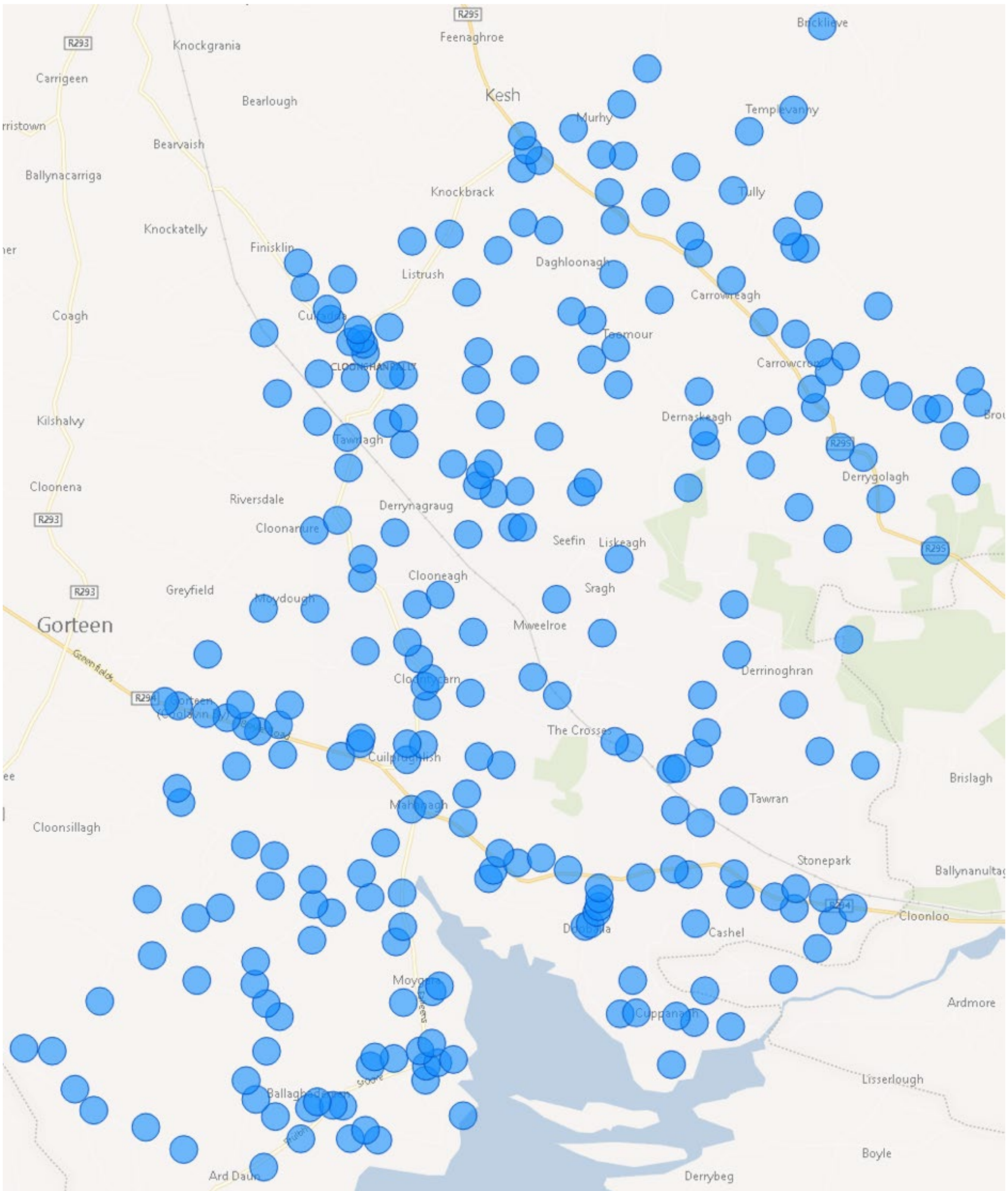
GURTEEN 38KV/MV – SLIGO AREA

FIGURE A7.52 **STATION LOADING 2030**



Substation	Winter Peak	Winter Peak and LCT	Winter Peak Standby	Winter Peak + LCT Standby	SV + LCT for Normal	SV + LCT for Contingency
GURTEEN	0.00	0.09	1.05	0.39	0.00	0.00

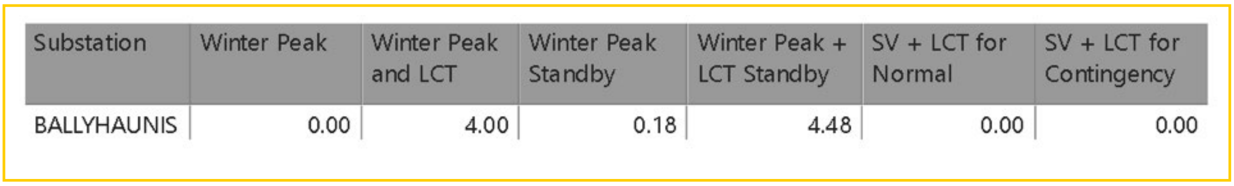
FIGURE A7.53 **STATION FEEDING AREA**



9 APPENDIX 7 – GEOGRAPHICAL REPRESENTATION OF STUDIES AND ESTIMATED LOAD PROFILES

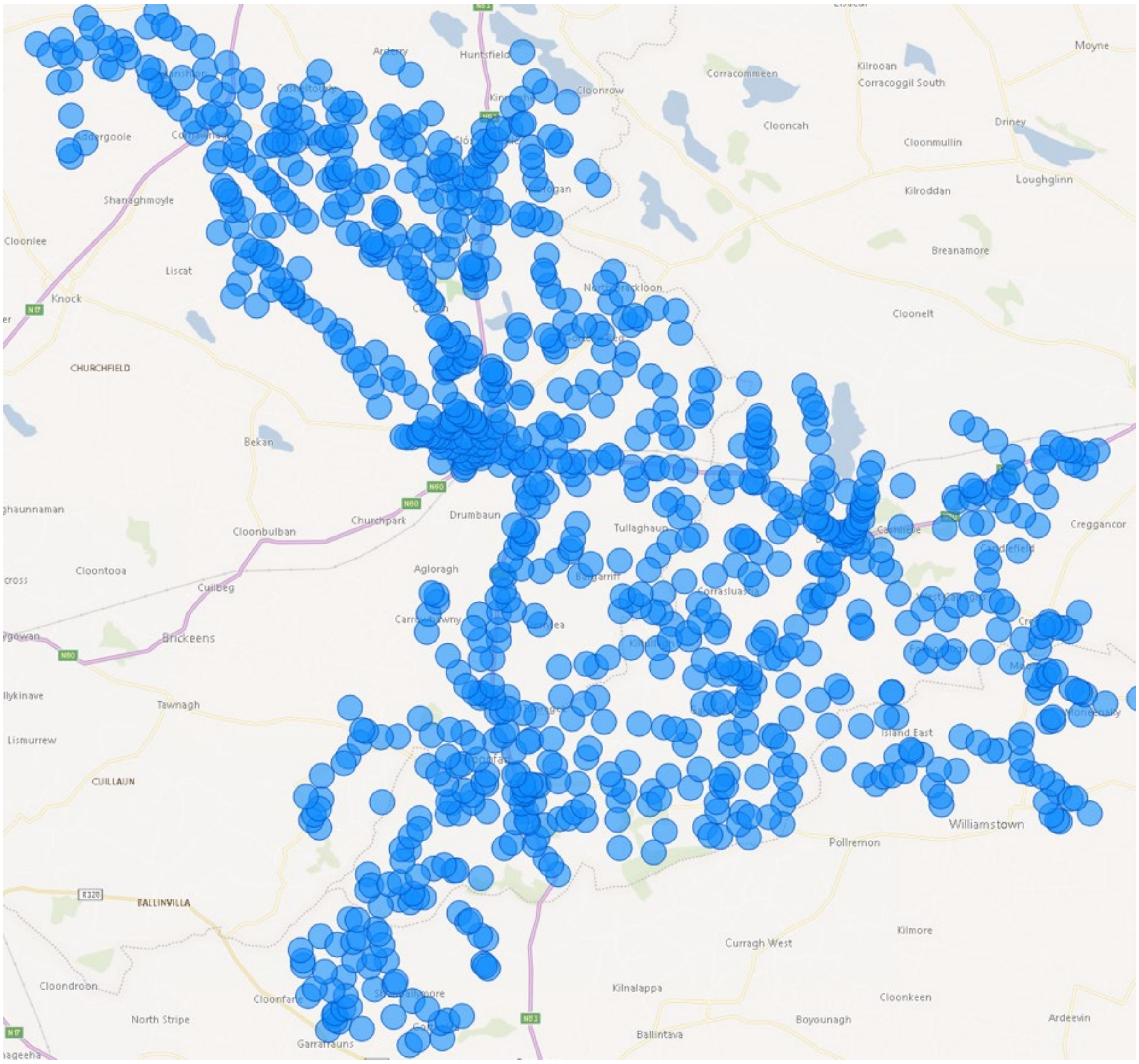
BALLYHAUNIS 38KV/MV – TUAM AREA

FIGURE A7.54 **STATION LOADING 2030**



Substation	Winter Peak	Winter Peak and LCT	Winter Peak Standby	Winter Peak + LCT Standby	SV + LCT for Normal	SV + LCT for Contingency
BALLYHAUNIS	0.00	4.00	0.18	4.48	0.00	0.00

FIGURE A7.55 **STATION FEEDING AREA**



9 APPENDIX 7 – GEOGRAPHICAL REPRESENTATION OF STUDIES AND ESTIMATED LOAD PROFILES

BALLYHAUNIS 38KV/MV – TUAM AREA

FIGURE A7.56 **STATION LOAD PROFILE 2020**

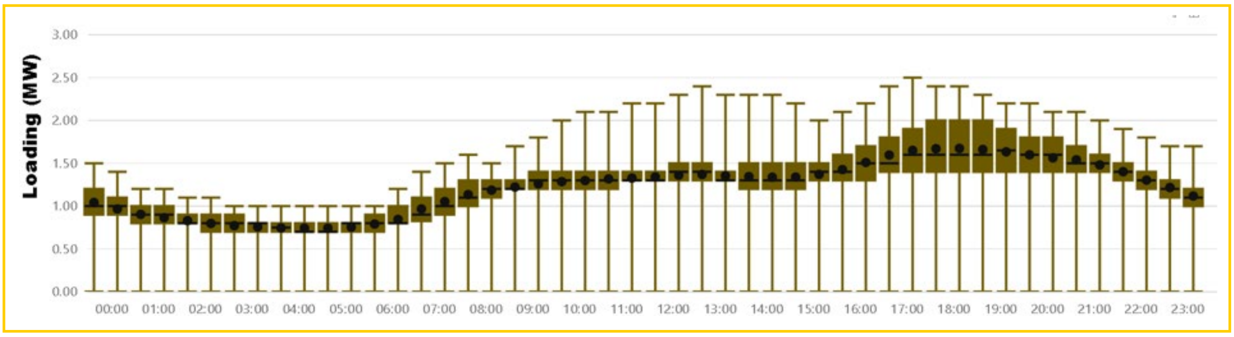
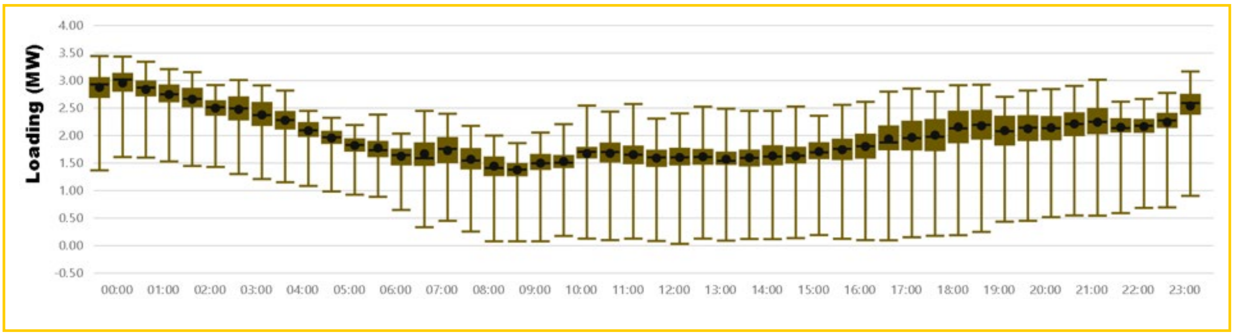


FIGURE A7.57 **STATION LOAD PROFILE WITH LCT IN 2030 – PRIMARILY NIGHT TIME EV CHARGING**



9 APPENDIX 7 – GEOGRAPHICAL REPRESENTATION OF STUDIES AND ESTIMATED LOAD PROFILES

BALLYHALE 38KV/MV – WATERFORD AREA

FIGURE A7.58 **STATION LOADING 2030**

Substation	Winter Peak	Winter Peak and LCT	Winter Peak Standby	Winter Peak + LCT Standby	SV + LCT for Normal	SV + LCT for Contingency
KILCARRAGH	0.00	7.98	0.69	7.98	0.00	0.00

FIGURE A7.59 **STATION FEEDING AREA**