Roinn Cumarsáide, Gníomhaithe ar son na hAeráide & Comhshaoil
Department of Communications, Climate Action & Environment

Draft Statutory Climate Change Adaptation Plan for the Electricity and Gas Networks Sector

Public Consultation

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Preface

The energy sector is essential to the functioning of a modern economy and is a key enabler to all other economic activities. Disruptions or reductions in the supply of energy can have significant negative impacts on the economy and the citizen. Adapting and future-proofing the efficient functioning of our energy system, so that we can continue to accrue the many benefits of energy to the economy and Irish society in general, is therefore essential.

A Climate Change Adaptation Plan for the Electricity and Gas Networks Sector was published in early 2018 in the context of the December 2012 National Climate Change Adaptation Framework (NCCAF). The high level Plan outlined initial research and analysis on the likely effects of Climate Change on the Irish Electricity and Gas Networks sectors and possible actions to develop resilience to climate change within the Electricity and Gas Networks Sector.

The Climate Action and Low Carbon Development Act, 2015 placed the development of National Climate Change Adaptation Frameworks and Sectoral Adaptation Plans on a statutory basis. As required under the Act, the first statutory National Climate Change Adaptation Framework was approved by Government in December 2017 and will be reviewed at least every 5 years after that.

Ireland's first statutory National Adaptation Framework (NAF) was published in January 2018. The NAF sets out the national strategy to reduce the vulnerability of the country to the negative effects of climate change and to avail of any positive impacts.

This statutory Climate Change Adaptation Plan for the Electricity and Gas Networks Sector is the first to be drafted under the new provisions set out in the Climate Action and Low Carbon Development Act 2015 and the National Adaptation Framework.

Purpose of this Consultation

A working group, led by DCCAE and involving key electricity and gas network stakeholders was established to scope out and develop this Plan using the Sectoral Planning Guidelines for Climate Change Adaptation.

The first draft statutory Climate Change Adaptation Plan for the Electricity and Gas Networks Sector, under the new provisions set out in the Climate Action and Low Carbon Development Act 2015 and the National Adaptation Framework is now being published for the purpose of public consultation. These representations will be considered before the final version of the plan is published and comes into operation.

It has been determined following appropriate screening that SEA and AA are not required for the statutory climate change adaption plan for the electricity and gas networks sector.

1. Introduction

Our climate is changing and the associated transformation could have critical implications for our planet and way of life. The impacts of climate change are now being observed across all continents and oceans (IPCC, 2014). While there is still a degree of uncertainty about the level and extent of the likely impacts, an exacerbation of existing societal and systems vulnerabilities is to be expected.

Changes in Ireland's climate are in-line with global trends and observations show that temperatures have increased by about 0.8°C over the period 1900-2012, an average of about 0.07°C per decade. The overall trend is upwards and consistent with global patterns of change, however with a high degree of climate variability and associated uncertainties in relation to extreme events.

The science in relation to the warming of the climate system is unequivocal (IPCC, 2013). Increasingly, there is a clearer understanding of how the risks of climate change can be reduced and managed through complementary strategies which focus on adaptation and mitigation (IPCC, 2014).

Climate change adaptation can be defined as the ability of a system to adjust to climate change (including climate variability and extremes), to minimise potential damage, to take advantage of opportunities, and to cope with the consequences.

By exploiting the opportunities and reducing the impacts posed by climate risks, successful adaptation can ultimately boost economic growth.

Infrastructure such as electricity and gas networks play an essential role in ensuring social and economic wellbeing. Risks to this infrastructure both from extreme weather events (such as flooding) and gradual climate change could have significant economic and social consequences and it is important therefore to future proof the efficient functioning of our energy system.

Electricity and gas networks have linked and mutual dependencies on each other and disruption to one network may have severe knock on effects on the functioning of the other. The preparation of this Adaptation Plan, and future iterations of the plan, helps identify these interdependencies and ensure that suitable adaptation measures are put in place.

Guidance and information on adaptation to climate change is provided by the United Nations Framework Convention on Climate Change (UNFCCC) and the EU Adaptation Strategy (2013). More recently, national guidance on climate change had been published by EPA research for the local authority sector (Gray, 2016).

1.1 Strategic Policy Focus

An overarching policy to build resilience to the impacts of climate change is being led by the EU Commission through an EU Adaptation Strategy which was adopted in April 2013 (http://ec.europa.eu/clima/publications/docs/eu_strategy_en.pdf).

This Strategy supports action by promoting greater coordination and information-sharing between Member States with the aim of ensuring that adaptation considerations are addressed in all relevant EU policies. It sets out a framework and mechanisms for developing preparedness in respect of current and future climate impacts across the EU.

The Strategy is accompanied by a generic set of adaptation planning guidelines which have been used by the EPA to guide the roll-out of sectoral plans as well as the development of guidelines for local authorities in Ireland.

Aligned to the EU strategy is Ireland's National Climate Change Adaptation Framework (NCCAF), referenced above, which was published by the Department of Environment, Community and Local Government in December 2012.

(http://www.environ.ie/en/Publications/Environment/ClimateChange/FileDownLoad,32076,en.pdf)

This Framework brings a strategic policy focus to climate change adaptation at local and national level through the development and implementation of sectoral and local adaptation action plans. The Framework identified the Department of Communications, Energy and Natural Resources (now the Department of Communications, Climate Action and Environment) as the lead Department charged with the development of a Sectoral Adaptation Plan for energy.

Subsequently, the Climate Action and Low Carbon Development Act, 2015 placed the development of National Climate Change Adaptation Frameworks and Sectoral Adaptation Plans on a statutory basis. As required under the Act, the first statutory National Climate Change Adaptation Framework was approved by Government in December 2017 and will be reviewed at least every 5 years after that. The Department of Communications, Climate Action and Environment (DCCAE) is responsible for developing the new framework.

Following approval of the statutory National Adaptation Framework, Section 6 of the Act requires the Government to request all relevant Government Ministers to prepare Sectoral Adaptation Plans covering the relevant sectors under their remit within a specified time period.

1.2 Energy Sector Approach

The energy sector is essential to the functioning of the modern economy and is a key enabler to all other economic activities. Disruptions or reductions in the supply of energy can have significant negative impacts on the commercial and social heart of the country. The impacts of such disruptions will be highly dependent on scale and duration.

While it is acknowledged that the energy sector can be a contributory element to climate change, the sector is also at risk from climate change impacts with potential consequences for both energy resources and the sustainability of the infrastructure.

Adapting and future-proofing the efficient functioning of our energy system, so that we can continue to accrue the many benefits of energy to the economy and Irish society in general, is therefore essential.

Climate change is a dual process, represented by both gradual changes (e.g. temperature) and recurring extreme events (such as storms or flooding), which bring with them both short and long term impacts. Temperature changes may lead to increased energy demand over time (e.g. for heating and cooling); other gradual changes such as increased or more frequent rainfall may increase wear and tear on infrastructure. Extreme weather events may have immediate impacts such as electricity blackouts with associated social and economic consequences. These impacts must be taken account of in how the energy system operates.

The statutory Climate Change Adaptation Plan for the Electricity and Gas Networks Sector is the first to be drafted under the new provisions set out in the Climate Action and Low Carbon Development Act 2015 and the National Adaptation Framework. It aims to identify the potential impacts of climate change on energy infrastructure, assess the associated risks and set out an action plan for adapting to those impacts.

The Plan focusses on the energy networks (electricity and gas), specifically electricity generation and electricity and gas transmission and distribution infrastructures and interconnectors. Future iterations of this Plan may also need to look at the resilience of energy resources to climate change impacts as well as the increased resilience required from electricity networks supporting increased electrification of heat and transport. For example, changes in weather patterns over the medium to long term might impact negatively on the generation of electricity from wind – with storm track changes or heavy winds causing the shut-down of wind turbines. In 2017, 81% of the electricity fuel mix in Ireland as a percentage of demand was generated by natural gas (51.0%) and renewables (30.0%) (mostly wind) – Energy in Ireland 2017 Report.

1.3 Methodology

The approach to adaptation planning for the electricity and gas networks sector has followed the six step approach as outlined in the Sectoral Planning Guidelines for Climate Change Adaptation as published in May 2018. These Guidelines were developed to support the drafting of the 12 sectoral adaptation plans identified by the National Adaptation Framework. The Guidelines were developed to ensure they are flexible enough to be applied across all 12 sectors and provide a consistent and coherent approach for Government Departments and Agencies ensuring that appropriate adaptation plans are developed which will remain relevant until they need to be reviewed.

The Sectoral Planning Guidelines provides for a 6 step planning cycle as set out below.

Step 1: Preparing the Ground: In order to have an effective adaptation plan put in place it is essential to have the correct team in place. This includes establishing a Sectoral Adaptation Team (SAT) identifying stakeholders and their roles, and securing required human, technical and financial resources. The SAT oversees and undertakes the adaptation planning process. The SAT will be broken down into a Core Team which will co-ordinate and oversee the adaptation planning process and a Planning Team which will ensure a broad spectrum of relevant knowledge, know-how and technical expertise is considered in the development of the adaptation plan.

Step 2: Climate Impact Screening: Climate Impact Screening establishes a broad overview of sectoral vulnerability and consequences of current and future climate impacts using information that will allow for prioritisation of the most urgent climate impacts and vulnerabilities to be analysed further.

Step 3: Prioritisation: Having identified the most urgent climate impacts and vulnerabilities, prioritisation will highlight those changes and impacts that will have the greatest consequence within the sector. Prioritisation can be assessed using criteria such as timing of impact, magnitude of impact, and the relevance of the impact to activities within the sector and their priorities and objectives.

Step 4: Priority Impact Assessment: Once the potential climate impacts and vulnerabilities have been identified and prioritised, a more detailed exercise is carried out to assess possible outcomes (impacts and consequences) based on multiple time horizons and on multiple emission levels that can provide for identification and assessment of adaptation options. In addition the impact assessment should ensure that the resilience of Irish Energy networks in relation to expected climate change is of similar or higher performance than that of competing EU countries, so that Ireland is not at a competitive disadvantage in terms of Energy Security for industry.

Step 5: Develop your plan: After completing the priority impact assessment, an understanding of vulnerabilities, the relative priorities and where and when the sector will aim its adaptation efforts will have all been established. The Plan will consist of establishing goals, sequencing objectives, and identifying and prioritising actions to implement the plan. The Plan will also contain the risks, barriers and enablers to implementing the adaptation options.

Step 6: Implement, Evaluate and Review: The overall Plan and measures contained within will require on-going tracking and evaluation of progress to ensure effectiveness and efficiency. In the long term, there will be recurring National Adaptation Frameworks and sectoral plans as provided for in the Climate Action and Low Carbon Development Act 2015.

1.4 Mitigation and Adaptation Interactions

The focus of climate change mitigation actions is to reduce the greenhouse gas (GHG) emissions which are driving climate change. The aim of the first National Mitigation Plan, approved by Government in June 2017, is to provide the roadmap to achieve the 2050 national mitigation objective of transitioning to a competitive, low-carbon, climate-resilient and environmentally sustainable economy by 2050 and, in doing so, identify policies and measures to meet intermediate targets, to 2020 and 2030, agreed at EU level. It sets out the context for the objective, clarifies the level of greenhouse gas mitigation ambition envisaged, and the proposed process to pursue and achieve the overall objective.

Low carbon measures for the energy sector are being developed within the context of the Mitigation Plan, including energy efficiency measures to reduce the amount of energy used and measures to encourage increased use of renewable energy. DCCAE is committed to identifying measures that will deliver tangible and sustainable mitigation results, allowing for the phased development of a low carbon energy sector for Ireland by 2050.

Mitigation measures which lead to increased consumption from one energy resource/infrastructure may reduce consumption from another. For instance, the widespread adoption of new technologies such as electric vehicles and heat pumps on the demand side which reduce Greenhouse Gases (GHG) is likely to increase the demand for electricity and hence the demand on electricity networks. However it will not increase GHG overall as GHG from power generation is controlled at an EU level under the Emissions Trading Scheme which 'caps' GHG from Generation within the EU and encourages use of Renewables. Nevertheless, supporting this extra load may require extra network reinforcement which in turn may both contribute to the need for extra network resilience to climate change events as well as providing opportunities for increased climate change adaptation as reinforcement is carried out.

Meanwhile on the supply side, the growing penetration of intermittent energy sources such as wind and photovoltaics (PV) (and possibly wave energy systems in the future) is being managed by the electricity Transmission System Operator (TSO) to ensure that the stability and secure operation of the electricity network is maintained.

Smart grid technologies and enhanced interconnection to European electricity systems are also likely to emerge as major components of our evolving electricity network with more consumers self-generating electricity.

Energy related climate adaptation actions and plans must ensure that our evolving energy system remains sufficiently robust to deal with the likely consequences of climate change.

It is important to reflect on the interaction (synergies and co-benefits) between mitigation planning and adaptation planning. It is clearly a 'least regrets' option that if mitigation activities succeed in limiting the rise in global temperatures, less adaptation will be needed to deal with the consequences of climate change. However, due to the slow response time of the climate system, changes are projected to continue and increase over the coming decades. Even if GHG emissions came to an end, some changes, such as sea-level rise, are projected to continue up to and beyond the end of this century.

The critical issue is that **adaptation** to climate change within Ireland is fully within Ireland's control, whereas the impact of **mitigation** depends on global response, even with Ireland making its full contribution.

1.5 Electric Vehicles

The benefits of electric vehicles (EVs) are well known by now as is the role they can play in reducing emissions in the transport sector. Their use displaces imported oil products with electricity which can be produced from a much broader range of indigenous commodities, including gas and renewable electricity. Also, as EVs are a means of storing electricity, they may also have a role, if incentivised, in balancing the grid at off peak times or when there is an excess of renewable electricity available (e.g. at night when demand is low).

EirGrid's 'Tomorrow's Energy Scenarios 2017' describes possible uptake figures for EVs and the associated increase in overall electricity demand, captured as part of a public consultation on future energy scenarios for Ireland[1]. The use of smart charging will likely play an important role in mitigating and managing the impacts of EV penetration on the transmission system peak demand.

The long-term impact of electricity demand and generation technologies, including EVs, on the transmission system is detailed in EirGrid's 'Tomorrow's Energy Scenarios System Needs Assessment' report[2] The impact on the distribution system has been examined by

1 http://www.eirgridgroup.com/site-files/library/eirgrid/eirgrid-tomorrows-energy-scenarios-report-2017.pdf

2 http://www.eirgridgroup.com/site-files/library/EirGrid/TES-2017-System-Needs-Assessment-Final.pdf

ESB Networks, informing the development of structural and smart network solutions to ensure the efficient and safe accommodation of growing EV uptake.

The primary impact on the distribution system is the increased load at local level – particularly in urban areas where the distribution system was designed based on an average use across homes. Though the introduction of multiple EVs charging at the same time can significantly increase the capacity needed on a local distribution network, as could the extra load created through the electrification of heat, ESB Networks has been developing solutions to help keep the cost of any reinforcements low by adopting a “smart grid reinforcement” strategy, with a balance of smart-grid and structural solutions.

It is important to note that the Distribution System only needs reinforcement when the loads on it exceed its peak capacity. Increasing the volume of energy through the network has little cost. This means that where peak capacity is to be exceeded there is a choice between adding Network reinforcement or changing when the peak loads are used, so that a choice between whichever is the more economical option can be made.

Accordingly, in order to accommodate this additional load on existing networks, some targeted local reinforcements to the distribution network are likely to be required. The extent will depend on the level and pace of uptake of EVs in each local area. A further key measure that will minimise the impact on the electricity system is encouraging the majority of charging to take place at times of low demand – e.g. at night via home charging. This could be aided by the introduction of smart meters/connection policies which could provide the potential for a greater financial incentive for charging at off-peak times.

The Smart Meter Upgrade is a meter replacement programme which will result in the upgrade of over 2 million meters to modern, smart-ready technology. The rollout of this significant energy infrastructure project will occur on a phased basis, commencing with an initial delivery of 250,000 meters across the latter half of 2019 and 2020 and approximately 500,000 meters in each of the four subsequent years. By 2020 almost three quarters of a million of existing meters will be more than 40 years old and in need of replacement.

The national installation of smart meters is a key enabler of Ireland's transition to a low carbon energy system that will help deliver on our climate action goals. Smart meters will support greater uptake of electric vehicles and micro-generation. There will be no need for estimated bills with smart meters. Accurate energy usage information across the day will enable consumers to be more efficient in their use of electricity and save money (e.g. by using appliances off-peak). This will, in turn, reduce the need for less efficient and more costly generation at peak times and support the increase in renewable power on the electricity system.

1.6 Natural Gas in Transport

To date, the use of natural gas in Irish transport has been very limited, but outside of Ireland it is a well-established transport fuel, with almost half a million natural gas-fuelled vehicles in use in the EU and over 20 million worldwide.

Natural gas can be deployed for all types of road transport vehicles but is particularly suited to larger vehicles such as buses, vans and trucks and therefore represents a viable alternative to diesel for the freight sector. It is a cost-effective and feasible solution to reduce carbon, in tandem with providing tangible benefits to air quality by decreasing levels of dangerous pollutants such as NOX, SOX and Particulate Matter (PM). In addition, as biomethane has identical properties as natural gas, it can also be used in natural gas vehicles in any quantity (unlike most liquid biofuels which need to be blended in small quantities with fossil fuels).

Typically, natural gas is usually deployed in transport as Compressed Natural Gas (CNG) where natural gas which has been compressed to fit into a vehicle's fuel tank or less commonly as Liquefied Natural Gas (LNG) that has been cooled down to liquid form. CNG refuelling stations typically draw from the gas grid – however, in some cases they can be standalone drawing their supply from biomethane production facilities.

In the longer term electric alternatives are also likely to become available.

1.7 Causeway Project

Gas Networks Ireland is rolling out its "Causeway Project" consisting of a network of 14 CNG stations around Ireland's motorway network and a biomethane grid injection facility.

A public CNG refuelling facility has been constructed at the Topaz Dublin Port service station this is due to come into operation shortly.

This will be followed by key strategic locations on the motorway network. A renewable gas injection facility in Co. Kildare is scheduled to be commissioned and operating early this year. In the longer term, Gas Networks Ireland is proposing to develop a 70-station CNG fuelling network, co-located in existing forecourts, on major routes and/or close to urban centres and further renewable gas injection points.

https://www.gasnetworks.ie/business/natural-gas-in-transport/the-causeway-project/

1.8 Delivering a Secure, Sustainable Electricity System (DS3)

DS3 (Delivering a Secure, Sustainable Electricity System) was set up by EirGrid and SONI in response to overcoming the challenges presented by Ireland's renewable electricity target of 40% for 2020. Its aim is to meet the challenges of operating the electricity system in a secure manner, while achieving the 2020 renewable electricity targets through facilitating large quantities of variable renewable generation such as onshore wind. The DS3 programme is built on three pillars: System Performance, System Policies and System Tools.

Ireland now has one of the highest percentages of electricity generated from wind power in the EU. A key enabler of this was to improve and monitor the performance of individual power plants, for example by their adherence to the grid code. Standards of compliance for wind farms have been added to the grid code, to reflect the changing power sources within Ireland. Furthermore, enhanced System Services have been designed and implemented to reward technologies which help support the power system at times of high variable renewable generation. Many technologies have developed or enhanced their capability in order to provide these System Services – this includes conventional generation, such as coal or gas, wind generation, battery energy storage, and demand side response.

Wind and solar generation are non-synchronous generators of electricity. This means they do not offer System Services with the same resilience as that provided by conventional generation, like gas or coal, due to their synchronous nature. These services help support the system in times of threat to the security of electricity supply, such as when there are faults on the system. EirGrid have developed a metric known as SNSP (System Non-Synchronous Penetration) which is a real-time measure of the percentage of generation that comes from non-synchronous sources, such as wind. EirGrid has already enabled the provision of a world-leading 65% of electricity from renewable sources, and is aiming for up to 75% over the coming years. Operational tools such as WSAT (Wind Security Assessment Tool) and the Wind Dispatch Tool assist with this, by providing information to the control centre in real time, to aid decision-making. Further tools are under development to enable EirGrid to move from a limit of 65% SNSP to 75% SNSP.

In order to best utilise the enhanced performance of technologies on the system and new support tools in the electricity Control Centre, new operational policies are needed. These provide guidance and structure to the Control Centre operators and the wider electricity industry on how the electricity system will perform in real-time. Introducing new and enhanced operational policies are key enablers for the DS3 programme to address the various factors that influence the SNSP limit. These policies also help to collate various system performance metrics, in order to accurately report to industry and the general public on the progress being made on integrating renewables into the power system.

The successful implementation of DS3 will facilitate Ireland in achieving its 2020 renewable electricity target and it will mean the country is less reliant on fossil fuel generation for electricity supply. This will decrease Ireland's carbon and greenhouse gas emissions and help to mitigate the impact of climate change.

EirGrid are currently examining the next steps required to go beyond 40% renewable electricity and pushing the boundaries of electricity system operation further beyond 75% SNSP. This will be central to meeting Ireland's renewable energy targets in 2030 and further into the future.

All of the above indicates the increasing reliance on electricity in Ireland's energy mix, the vulnerability to disruption due to the impact of climate change on the Transmission and Distribution Networks which distribute the power and consequently the need for Climate Adaptation measures.

1.9 Onshore/Offshore Wind

Ireland has significant onshore wind along with enormous potential for offshore energy developments.

However greater reliance on wind will also mean that climate change affecting wind may also affect generation from both Onshore and Offshore resources. This is because very high wind speeds would require shutdown of wind turbines or, in the opposite case of no wind, due to extensive areas of high pressure, the lack of wind would also limit wind generation.

In addition, disruption to the wind farms grid connection due to weather effects could also impact on wind generation, but this would only be significant nationally if the wind farms were very large or if a large amount of wind farm connections were lost during a storm.

Diversity with sources of generation is an important factor in delivering energy security and will mitigate any direct impacts of weather on wind generation. Engineering design should ensure that any risks from the effects of climate change are addressed for the specific grid connection.

1.10 Utility Scale Storage (Battery Storage and co-location of renewable projects with storage utility)

It is possible that additional electricity storage will be required as we transition to a low carbon society. Batteries are significant in cost and overall costs increase as the storage capacity gets larger.

In the short term at least it is likely that battery investment will be seeking to avail of system services income rather than seeking to capitalise on day/ night energy price spreads. Significant battery storage may be required to complement the levels of solar PV and wind in the future. There are a range of potential benefits in co-locating storage with renewables, which include:

- maximising generation output and managing intermittency;
- enabling projects to avoid grid constraints issues;
- improved frequency response; and
- savings in costs associated with sharing infrastructure;

Use of hybrid electricity generation sites (multiple technologies such as wind, solar, storage, thermal at a single connection) to increase generation resilience by diversifying generation sources could assist Climate Adaptation, and it may be possible to minimise the associated costs by sharing the one grid connection, as seen in other neighbouring European nations.

Along with improved Climate Adaptation this could not only facilitate increased and timelier penetration of renewables but potentially also reduce the overall cost to the consumer.

1.11 Solar (Microgen) & Large Scale Solar:

Both Microgen and Large Scale Solar use the same technology to generate electricity from the sun, and the price of solar panels is still decreasing.

While solar has seen significant penetration across Europe there may be a number of differing factors impacting penetration in Ireland. Firstly, the capacity factors which can be expected are likely to be quite low in Ireland compared to many other sunnier jurisdictions and this will impact upon the per unit price. Secondly, the building regulations in warmer climates will drive a significant amount of solar PV development on new buildings. Thirdly, retrofitting solar has been heavily and very generously subsidised in Great Britain, for example, at domestic level which has driven rapid penetration.

Accordingly the most likely route for Solar development in Ireland in the shorter term is on sites co-located with wind generation with any potential for a wider deployment coming later. If the market and regulatory issues around hybrid units can be addressed there should be significant potential to install solar at existing wind farm sites to take advantage of largely non coincidental generation. Solar PV may also be installed at wind sites where full repowering is not possible and continued wind based operations is not an option.

Hence the impact of Solar will be to assist in Climate Change Adaptation as it increases the renewable technology diversity. It is less likely that both wind and solar would be unavailable due to the impact of one type of weather event.

1.12 Heat-pumps

From a resilience perspective, and similar to the transition to electric vehicles, the electrification of heat via heat pumps will increase demand on the electricity grid, and the volume can be expected to grow due to active support at the domestic/residential level via the SEAI's Better Energy Homes scheme.

It is expected that the greatest concentration, and network impact, of Heat Pumps will initially occur in new housing and apartment developments where the insulation levels required by Part L Building Regulations make Heat Pumps economically viable, as even a small Heat Pump can provide the heating required. Furthermore the extra capacity required for such

Heat Pump Housing developments can be incorporated at low cost, along with provision for Electric Vehicles.

In existing housing developments Heat Pumps are economically viable if the insulation level is increased, with substantial increases being required in older homes. This means that the penetration of Heat Pumps in older existing housing stock will be slow unless there is a large scale insulation upgrade program. Accordingly this means that the impact of Heat Pumps on existing residential estates will be much lower than that of Electric Vehicles.

1.13 Biomethane Production

Biomethane is a renewable gaseous fuel, produced from sustainable feedstocks that can be used as a direct substitute for natural gas. The typical production process involves anaerobically digesting biodegradable feedstocks and upgrading the resulting biogas to grid-standard biomethane. Biomethane can then be injected into the natural gas grid via an injection point. Feedstocks typically used for biomethane production include food and agricultural wastes. These feedstocks are generally available in Ireland, therefore an increase in biomethane production offers the potential to reduce exposure to external gas market shocks and increase energy security. In addition to reducing emissions in the energy area, the use of certain feedstocks, such as livestock manure and food wastes, has the extra benefit of reducing emissions in the sectors producing these particular waste streams.

A biomethane network would include the following additional infrastructure:

i) Feedstock transport networks (likely road networks)

ii) Anaerobic Digestion facilities (likely to be combined with biogas-to-biomethane upgrading infrastructure)

iii) Biomethane transport networks (road or pipeline)

iv) Grid Injection facilities (likely to be operated by TSO/DSO)

The increased diversity of Generation provided by BioMethane, and the fact that such generation is available regardless of weather conditions, make this beneficial in adapting to climate change.

1.14 Renewable Electricity Support Scheme (RESS)

In July 2018 Government approved the proposed Renewable Electricity Support Scheme (RESS) which is now subject to the EU State Aid approval process. Key elements of the Scheme include:

- It is designed to deliver Ireland's contribution towards an EU-wide renewable energy target of 32%, out to 2030, within a competitive auction based, cost effective framework.
- It is designed under the EU State Aid Guidelines 2014-2020.
- It will be characterised by a series of auctions, run throughout the lifetime of the scheme.
- The new scheme is framed within the context of the European Union's Clean Energy Package, in particular the recast Renewable Energy Directive and the development of Ireland's draft National Energy and Climate Plan (NECP), and Ireland's effort to meet its 2020 renewable energy targets;
- The RESS will deliver a broader range of policy objectives including:
    - the provision of pathways and supports for communities to participate in, and own renewable energy projects;
    - broadening the renewable electricity technology mix (the diversity of technologies); and
    - increasing energy security, energy sustainability and ensuring the cost effectiveness of energy policy.

The Scheme will provide for a renewable electricity (RES-E) ambition of at least 55% by 2030 which is set out in the draft National Energy and Climate Plan.

1.15 Renewable Energy Directive (RED) II and NECP Current Measures to Address Vulnerabilities

As part of the vulnerability assessment of the electricity and gas networks sector it is important to recognise existing measures and resilience, such as planning legislation, Government-led emergency planning and business continuity plans at the network company level.

The future impacts on energy infrastructure from climate change will most likely arise from disruptions to services or damage to energy infrastructure caused by increased storm events, rising sea levels and increased incidents of flooding. The energy network companies have participated in the development of this Climate Change Adaptation Plan and will have a key role to play in carrying out any actions defined within this Plan. In parallel, they continue to build on their experience of severe weather events, available climate data, research and future modelling, and adapt and update their mitigation and response plans to minimise the impact of both current and future weather related events. Co-benefits with emergency planning will be a complementary outcome of this Plan.

The overall strategy for Networks is then to:

(a) Develop mitigation plans for assets which form part of the Critical National Infrastructure and are likely to be affected by severe climate related events such as flooding and wind e.g. flood barriers at HV Stations and greater Timber Cutting;
(b) Improve automatic restoration of supply to customers in the event of existing networks through better networks automation and control;
(c) Increase resilience of networks through advanced maintenance and selective ‘hardening’ of specific assets when carrying out network reinforcement e.g. for EV and electrification of heat;
(d) Ensure faster repair of circuits through use of Smart Analytics to identify the most significant faults whose repair will restore supply fastest to the greatest number of customers, in the overall context of the DCCAE Government Emergency Plan;
(e) Provide increased network resilience to specific identified critical locations of economic activity.

1.16 Planning Legislation

Planning legislation can offer resilience. The Planning and Development Act, 2000 sets out the detail for regional planning guidelines, development plans and local area plans as well as the basic framework for the development management and consent system. Among other things, it provides the statutory basis for protecting our natural and cultural heritage and carrying out Environmental Impact Assessments.

Environmental Impact Assessment (EIA) is the process by which the anticipated effects on the environment of a proposed development or project are measured. If the likely effects are significant, design measures and/or other relevant mitigation measures can be taken to reduce or avoid those effects. In recent years, measures have been taken to integrate climate change, including adaptation, into the EIA.

In practical terms, changes may be required which allow the heights of critical assets to be increased so that they are mounted a meter or so above expected flood levels.

The EU Commission issued 'Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment' which aims to help Member States improve how climate change, both mitigation and adaptation, are integrated in Environmental Impact Assessments (EIAs).

Guidance is available to support the planning system and documents which are particularly relevant to climate change adaptation include: The Planning System and Flood Risk Management – Guidelines for Planning Authorities (OPW-DEHLG, 2009).

1.17 Government Emergency Planning

In 2001, a range of Government structures was put in place to support emergency planning in Ireland. A key objective was to improve co-ordination across the various existing national emergency plans.

The Government Task Force on Emergency Planning (GTFEP) directs and oversees the emergency planning activities of all Government departments and public authorities in Ireland. The Minister for Defence chairs the GTFEP, which includes Ministers, senior officials of Government departments, senior officers of the Defence Forces, An Garda Síochána and officials of other key public authorities which have a lead or support role in Government Emergency Planning.

The Office of Emergency Planning (OEP) provides a key support role to the GTFEP. Under the remit of the Minister for Defence, the OEP is responsible for the co-ordination and oversight of emergency planning. The OEP also chairs the various subgroups of the GTFEP, including the National Framework Subgroup. This Subgroup comprises officials representing all Government departments and public authorities with lead or principal support roles and responsibilities for the range of emergency/incident types. As part of the work of the GTF, a review of the existing national-level structures and processes was initiated and this has culminated in the production of the "Strategic Emergency Management (SEM): National Structures and Framework" document. This framework sets out the national arrangements for the delivery of effective emergency management which outlines the structures for coordinating a "whole of Government" approach.

The most common emergencies that arise are unexpected events which require a rapid response from the emergency services, particularly fire services and An Garda Síochána. In the context of climate change adaptation, severe weather and flooding could be constituted as an 'emergency' depending on the scale of the event and the associated impacts.

1.18 Emergency Planning – Energy

As above, the Emergency Planning Framework in Ireland is based on a Lead Government Department concept. The Strategic Emergency Planning Guidelines identifies the lead Government Department in a range of potential emergency scenarios. DCCAE is the Lead Department for energy related emergencies (e.g. Energy Supply Emergency (Electricity/Gas), Oil Supply Emergency) and supports other Lead Departments for emergencies as appropriate.

In the event of a major energy network related incident occurring, the immediate response will be from the energy network companies, ESB Networks, Gas Networks Ireland, EirGrid, all of whom have emergency plans in place.

Emergency plans involve the restoration of supply but also effective communications with customers, which are considered by customers as equally important.

The role of DCCAE in these situations is to oversee and co-ordinate a national level emergency response, where a national response is required. In such cases, the Department would be supported by other Government Departments and relevant agencies, including the Commission for Regulation of Utilities (CRU), Transmission System Operators and the Distribution System Operators. The National Emergency Coordination Centre is activated in the event of a national emergency or a crisis requiring a national response.

CRU is a member of Gas Electricity Emergency Planning (GEEP) group which includes the networks operators & DCCAE. The group meets bi-annually to discuss matters related to Emergency preparedness/storm updates, long term resilience of the system, summer/winter outlooks etc. The group also reviews the operation of the network operators during recent weather events.

1.19 Energy Network Company Measures

Work on adapting to our changing climate is already underway – either through a process of specific adaptation measures or through continuous strengthening and maintenance works which are not necessarily identified under the framework of adaptation.

The Transmission and Distribution network companies also take account of climate change considerations and legal environmental obligations when seeking planning permissions for projects. In addition, the energy network companies have well developed business continuity and emergency plans to ensure an effective response to a range of events. These are built into everyday operations as well as future plans.

While these plans do not, of themselves, constitute climate change adaptation, there are strong linkages and overlap in these areas.

The following sections reflect a summary of current practice across the energy sector.

1.20 Electricity

Eirgrid

The electricity transmission system is designed and operated to comply with relevant international, European and national standards. All transmission equipment on the current grid is procured to IEC / CENELEC Standards in accordance with current Irish climate conditions and estimates of future conditions where adverse increases may be relevant. Irish engineers have been prominent in the CIGRE[3] organisation where standards and operational experiences are monitored, so a good understanding of international standards and practices has been developed.

In 2013, EirGrid undertook a Climate Change Risk Assessment of the Irish Transmission System. This work was informed by a detailed evaluation of the latest climate change science and Irish climate and climate change data, together with international climate change adaptation research and literature. Recommendations for climate change adaptation were identified and these were categorised into initiatives that either build adaptive capacity or deliver adaptation actions.

3 Founded in 1921, CIGRE, the Council on Large Electric Systems, is an international non-profit Association for promoting collaboration with experts from all around the world by sharing knowledge and joining forces to improve electric power systems of today and tomorrow.

These recommendations are being implemented. For example, building adaptive capacity included working with the DCCAE and other organisations to promote collaborative understanding of the issues associated with, and risks to, the transmission system. A key recommendation with adaptation actions is that risk should be quantified at a specific asset level, i.e. with respect to specific stations or lines. EirGrid has identified that the main risk to the transmission system is from flooding. During 2018, using a Geographical Information Systems (GIS) approach, relevant climate data was analysed having regard to the spatial location of the transmission system to identify infrastructure that may be vulnerable from climate change impacts. Detailed risk assessment at the specific transmission asset level is currently underway.

EirGrid's current Business Continuity Plan provides an effective response in the event of an incident that seriously disrupts EirGrid's normal operating conditions for an indefinite period of time.

There are two EirGrid functions which are critical for the purposes of Business Continuity – the National Control Centre (NCC) or power system control function and the data feeds to the wholesale market, the Single Electricity Market. These activities are extremely time critical and the failure to restore the function satisfactorily in a short period of time would have significant impacts.

Resilience of the power system is of vital importance. The core NCC functions are tested on a regular basis ensuring that the recovery of the NCC function occurs within the planned timeframe and in such a way that the power supply continues to operate in a safe and secure manner.

Each business within the EirGrid Group has its own individual Business Continuity Plan (BCP).

In managing the power system, EirGrid is committed to keeping key stakeholders, including the CRU and DCCAE, informed of key incidents and events on the system, including times where there is a serious risk to security of supply. Where a situation develops or an incident occurs, EirGrid informs designated contacts as soon as practical, providing up to date information, and ensures that these contacts are kept briefed with updates as the situation changes.

ESB Generation and Trading

ESB Generation & Trading (GT) maintains a Crisis Management Plan setting out an integrated framework for managing crisis situations, ensuring that the needs of all internal and external stakeholders are recognised and responded to in a timely and professional manner. The plan and associated emergency procedures set out the methods and structures for responding to and managing crises such as severe flooding, serious contamination to the environment and major disruption to ESB's business. Coordination during such events is managed by the senior management Crisis Management Team.

ESB Networks

ESB Networks - ESB has a formal Crisis Management Policy and Action Plan which provides for an Emergency Communications Plan to be activated in the event of a crisis. In addition, liaison with DCCAE who are the lead Department for energy related emergencies takes place as appropriate during large scale incidents.

The Action Plan involves the mobilisation of all necessary ESB staff and contractors and their deployment on a national basis as required. Extensive existing network automation is also used to restore supplies using alternative networks around areas where faults have occurred, and a National Operations Centre (with satellite backups) ensures effective management of network operation.

Keeping the public well informed and regularly updated on events and being able to respond to customer queries is critical both for safety and confidence, and the Emergency Communications Plan has the following objectives:

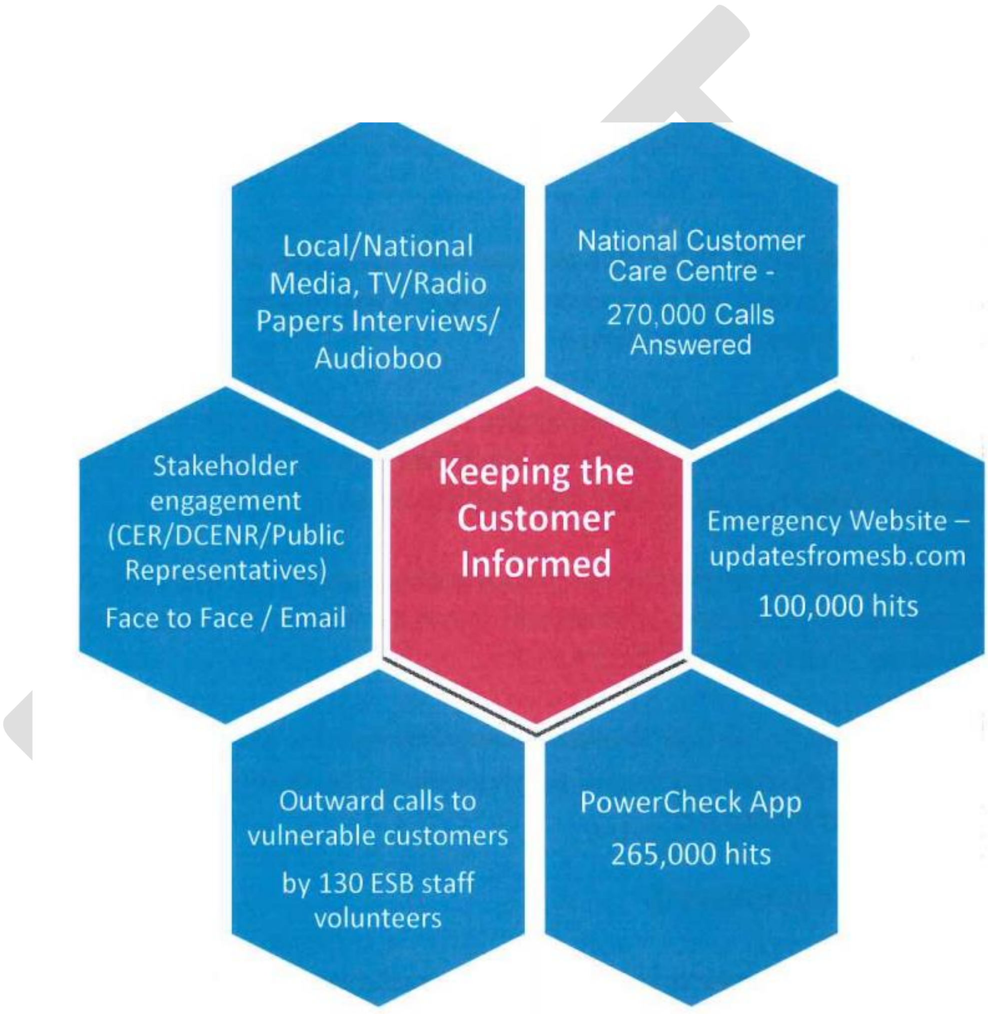
- Maintain confidence by keeping the public well informed
- Ensure safety by highlighting potential risks and hazards
- Provide timely information over all available channels, not only traditional Call Centres but also over Social Media and Online Channels including 'PowerApp' which provides details of outages and restoration times over mobile phones.

A number of media channels ensure information is readily available and accessible including: ESB Networks Customer Care Centre; a sophisticated IVR system which can provide specific information on outages and estimated restoration times to customers; 'Powercheck' which provides real time details of outages and restoration times; ESB

Networks Twitter account providing information and updates to customers. @ESBnetworks; print and broadcast media - local radio is particularly important.

These are summarized in Figure 1 as used in Storm Darwin (2014).

Figure 1 – Media channels used by ESB Networks in Storm Darwin (2014)



1.21 Gas

Gas Networks Ireland

Gas Networks Ireland has a Business Continuity Plan which provides a response in the event of an incident that affects normal business operations to an extent where they cannot be completed to expectations. This Business Continuity Plan details all levels of the response for the on-going operation of the company's critical processes in the event of a disaster.

The Severe Weather Contingency Plan is part of the Business Continuity Plan. The purpose of this plan is to set out a framework for managing severe weather situations affecting networks and to ensure that the needs of all internal and external stakeholders are recognised and responded to in a timely and professional manner. The Plan is primarily focussed on snow/ice/cold (winter weather events) but the structure and principles can be applied to other events such as high winds and/or flooding as required.

Gas infrastructure is designed and operated to meet the requirements of the relevant Irish and European Standards. These standards set out the requirements to ensure assets are designed and operated safely and effectively. Included is a requirement that infrastructure is resilient to weather events and climate change. The National Standards Authority of Ireland (NSAI) is currently participating in a European review of standards to ensure that Climate Change has been appropriately covered in standards relating to gas infrastructure.

2. Preparing the Ground

A stakeholder team, led by the DCCAE and involving key electricity and gas network stakeholders was established to scope out and develop this Plan. The following organisations were represented on the team and/or made contributions to the development of the Plan:

- Department of Communications, Climate Action and Environment (DCCAE) www.dccae.gov.ie
- EirGrid www.eirgridgroup.com
- ESB Networks www.esbnetworks.ie
- ESB Generation & Trading www.esb.ie
- Gas Networks Ireland www.gasnetworks.ie
- Commission for Regulation of Utilities www.cru.ie
- Sustainable Energy Authority of Ireland www.seai.ie
- Electricity Association of Ireland www.eaireland.com
- Irish Wind Energy Association www.iwea.com

In addition to establishing a group of relevant energy networks stakeholders with relevant experience and expertise, the energy sector of DCCAE engaged with other sectors within DCCAE and local authorities currently involved in developing adaptive strategies, through representation on a National Climate Change Steering Group chaired by DCCAE. Such collaboration seeks to secure a cohesive approach to the multi-layered adaptive strategy for Ireland.

2.1 Climate Change Trends in Ireland

Climate change is happening in Ireland. The scale and rate of change is consistent with regional and global trends (Dwyer, 2013). These changes are projected to continue and increase over the coming decades (Gleeson, 2013). These include:

- Temperatures have increased by about 0.8°C over the period 1900-2012 - an average of about 0.07°C per decade;
    - The temperature has varied over the period, with colder than normal episodes in the early part of the twentieth century and some cold years in the 1960s and ’70s

    - ❖ Higher temperatures were recorded from the early 1930s to 1960 and from the late 1980s to the present

- Changes in precipitation patterns / increased frequency of extreme events;
- On-going sea level rise; and
- Changes in wind energy content.

A changing climate leads to changes in the frequency, intensity, spatial extent, duration and timing of extreme weather and climate events, and can result in unprecedented extreme weather and climate events (IPCC, 2012). Changes in weather extremes are projected to disrupt most natural and managed systems and regions.

In particular, extreme weather events which may lead to breakdown of infrastructure networks and critical services such as electricity, water supply, transport and health & emergency services are expected.

Table 1 - A summary of the State of knowledge on Climate Change impacts for Ireland. (EPA, 2017)

	OBSERVED IMPACTS	**PROJECTED IMPACTS**
TEMPERATURE	Temperatures have increased by 0.8ºC since 1990; an average of 0.075ºC per decade. The number of warm days (over 20°C) has increased while the number of cold days (below 0°C) has decreased.	Projections indicate an increase in average temperatures across all seasons (0.9-1.7°C). The number of warm days is expected to increase and heat waves are expected to occur more frequently.
PRECIPITATION	An increase in average annual national rainfall of approximately 60mm or 5% in the period 1981-2010, compared to the 30 year period 1961-1990.	Significant reductions are expected in average levels of annual spring and summer rainfall. Projections indicate a

	The largest increases are observed over the west of the country.	substantial increase in the frequency of heavy precipitation events in Winter and Autumn (approx. 20%)
WIND SPEED AND STORMS	No long-term change in average wind speed or direction can be determined with confidence. The number and intensity of storms in the North Atlantic has increased by approximately 3 storms per decade since 1950.	Projections indicate an overall decrease in wind speed and an increase in extreme wind speeds, particularly during Winter. The number of very intense storms is projected to increase over the North Atlantic region.
SEA LEVEL AND SEA SURFACE TEMPERATURE	Historically, sea level has not been measured with the necessary accuracy to determine sea level changes around Ireland. However, measurements from Newlyn, in southwest England, show a sea level rise of 1.7cm per decade since 1916. These measurements are considered to be representative of the situation in the south of Ireland, Sea surface temperatures have increased by 0.85°C since 1950, with 2007 the warmest year in Irish coastal records.	Sea levels will continue to rise for all coastal areas, by up to 0.8 m by 2100. The south of Ireland will likely feel the impacts of these rises first. Sea surface temperatures are projected to continue warming for the coming decade. For the Irish Sea, projections indicate a warming of 1.9°C by the end of the century.

Met Éireann (2013) set out projections for the future of the Irish climate and some key results are as follows:

- Warming is enhanced for the extremes (i.e. hot or cold days) with highest daytime temperatures projected to rise by up to 2 degrees in summer and lowest night-time temperatures to rise by up to 2-3 degrees in winter.
- In relation to observed warming, the strongest signals are in winter and summer.
- The frequency of heavy precipitation events during winter shows notable increases of up to 20%.
- The models predict an overall increase (0 to 8%) in the energy content of the wind for the future winter months and a decrease (4-14%) during the summer months;
- A small decrease in mean wave heights is expected around Ireland by the end of the century, while in winter and spring, storm wave heights are likely to increase.
- Average sea level rise of about 43cm is projected in the North Atlantic. Local effects around Ireland will lead to an additional sea level increase of about 7cm in the Irish Sea. It is likely that all Irish coastal waters will experience a similar sea level rise.
- Warmer climate with more rainfall will likely lead to greater vegetation growth in general (which may have a potential impact on nearby power lines).

Met Éireann and the national universities provide information on projected climate trends for Ireland. A summary of the state of knowledge was published by EPA in 2017. Key reports may be accessed as follows:

(a) https://www.epa.ie/pubs/reports/research/climate/EPA%20RR%20223_web.pdf

(b) www.climateireland.ie and

(c) Ireland's Climate: The Road Ahead at http://www.met.ie/publications/IrelandsWeather-13092013.pdf

Despite the above, the information that is currently available in respect of climate trends is still at a high level and tells us little about local or regional area projections, which is critical for determining risks for the energy sector.

Future modelling for the energy sector in relation to climate risk will be important as we progress to more focused actions in subsequent Adaptation Plans.

2.2 Energy Sector Profile

The overarching objective of the Government's energy policy is to ensure secure and sustainable supplies of competitively priced energy to all consumers.

It is important that Ireland's energy supply is resilient to external shocks related to climate events or associated events, and focusses on reducing emissions to support national and international efforts in climate mitigation in line with the Paris Climate Agreement and EU Climate Obligations.

Large energy infrastructure projects typically have long investment cycles, but the on-going development and renewal of the energy networks is essential to ensure Ireland's energy system is safe and secure and ready to meet demand. A safe, secure energy system is also critical to Ireland's ability to attract inward investment, support domestic investment and retain and create jobs. This Climate Change Adaptation Plan focusses on the electricity and gas networks and an overview of this infrastructure, and its capacity for resilience to recent extreme weather events, is set out below.

2.3 Electricity Infrastructure

Electricity Generation

Electricity generation is fully open to competition in Ireland, with a number of generating companies providing bulk power to the wholesale market. ESB Generation and Trading (ESB GT) is the largest participant in the market.

A diverse range of power generation assets contribute to the energy mix, including thermal plant (coal, peat, biomass, gas and oil), hydro generating stations and onshore wind. This diversity is an important factor in delivering energy security, reducing Ireland's dependence on any one source. Table 2 on the next page shows fuel mix data in Ireland for the period 2000 to 2016.

Table 2 - Electricity Fuel Mix in Ireland as Percentage of Demand

Fuel Mix Ireland	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Coal	28.7%	29.0%	26.9%	23.8%	23.3%	23.1%	20.4%	18.8%	16.9%	13.9%	12.3%	14.2%	18.2%	15.4%	14.2%	17.0%	15.60%
Peat	7.4%	9.0%	8.2%	7.8%	5.6%	8.9%	7.4%	7.4%	9.0%	9.2%	7.4%	7.5%	8.7%	8.0%	8.8%	8.6%	7.70%
Oil:	19.5%	21.3%	14.7%	9.4%	12.0%	12.1%	9.8%	6.6%	5.6%	3.2%	1.9%	0.7%	0.7%	0.6%	0.7%	0.9%	1.00%
Gas Oil	0.3%	0.2%	0.1%	0.4%	0.2%	0.8%	0.9%	0.2%	0.2%	0.1%	0.3%	0.1%	0.1%	0.0%	0.1%	0.3%	0.20%
Fuel Oil	19.0%	20.9%	14.4%	8.8%	11.6%	11.1%	8.8%	6.2%	5.3%	2.9%	1.4%	0.5%	0.4%	0.4%	0.5%	0.5%	0.70%
Refinery Gas	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	0.2%	0.1%	0.1%	0.1%	0.1%	0.2%	0.10%
LPG	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.00%
Natural Gas	39.0%	37.5%	42.7%	50.1%	48.1%	41.8%	47.7%	53.0%	55.1%	56.7%	64.0%	56.5%	51.9%	47.8%	45.8%	44.0%	50.60%
Renewables:	5.0%	4.2%	5.5%	4.4%	5.2%	6.8%	8.6%	9.6%	11.8%	14.3%	12.9%	19.4%	18.9%	20.1%	22.7%	27.0%	24.90%
Hydro	3.6%	2.4%	3.6%	2.3%	2.4%	2.3%	2.5%	2.3%	3.2%	3.1%	2.1%	2.5%	2.9%	2.1%	2.5%	2.8%	2.30%
Wind	1.0%	1.4%	1.5%	1.7%	2.4%	4.0%	5.6%	6.7%	7.9%	10.3%	9.7%	15.7%	14.4%	16.2%	18.2%	22.6%	20.40%
Solar PV	0.0%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Other Renewables	0.4%	0.4%	0.3%	0.3%	0.4%	0.5%	0.4%	0.6%	0.7%	0.9%	1.1%	1.2%	1.6%	1.7%	1.9%	1.6%	2.30%
Non-Renewable Waste	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.2%	0.2%	0.2%	0.20%
Net Imports	0.4%	-1.0%	2.0%	4.5%	5.9%	7.4%	6.2%	4.6%	1.5%	2.7%	1.6%	1.8%	1.5%	8.0%	7.6%	2.3%	*
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source:SEAI * Ireland was a net Exporter of Electricity in 2016

Electricity Generation (continued)

As Ireland transitions to a low carbon future, in line with the ambition set out in the Energy White Paper[4] "Ireland's Transition to a Low Carbon Energy Future 2015-2030", and in meeting climate policy objectives, renewable energy will become an increasing part of the energy generation mix. To date, wind energy has been the largest driver of growth in this area, contributing most towards the achievement of Ireland's 2020 target[5]. According to the Irish Wind Energy Association IWEA, there are approximately 228 operational wind farms in Ireland, and current grid connected and operational installed wind capacity is 2764.7 Megawatts (MW).

While not currently a significant element of the fuel mix in Ireland, it is noted that there are applications amounting to approximately 3,800 MWs of solar capacity seeking connection to the distribution grid, with solar having the potential to play a notable part of the fuel mix in the period under consideration in this Adaptation Plan.

The electricity transmission and distribution companies, which are State owned, are responsible for transporting electrical power to customers over their extensive networks. These networks comprise a mixture of overhead lines, underground cables, and transmission/distribution substations (where voltage transformation takes place and switching and control equipment are located).

Electricity Transmission System

EirGrid plc. is a state-owned commercial company with full responsibility for the Transmission System Operator (TSO) and Market Operator (MO) functions in Ireland. EirGrid's role is to operate and ensure the maintenance of, and develop a safe, secure, reliable, economical, and efficient electricity Transmission System and to explore and develop opportunities for interconnection of its system with other systems, in all cases with a view to ensuring that all reasonable demands for electricity are met and having due regard for the environment.

4 Ireland's Transition to a Low Carbon Energy Future 2015-2030

5 The 2009 EU Renewable Energy Directive 2009/28/EC set Ireland a legally binding target of meeting 16% of our energy requirements from renewable sources by 2020.

The electricity transmission network as managed by EirGrid in its role as TSO consists of approximately 7,000km of 400kV, 220kV and 110kV (predominantly overhead) high voltage lines, and over 100 transmission stations that provide the physical link between generators, large demand customers and the distribution network. The network design aims to ensure that power can flow freely to where it is needed and that if one power station, power line or transmission station is non-operational, whether due to a fault or maintenance or other reason, there are other options or routes available.

The transmission systems of Ireland and Northern Ireland are connected via one high capacity double circuit 275kV overhead line between County Louth and County Armagh and two low capacity 110kV single circuit overhead lines between counties Donegal and Tyrone and counties Cavan and Fermanagh.

A new high capacity North South Interconnector is currently proposed, which will comprise of a single circuit 400kV overhead line to connect the electricity grids of Ireland and Northern Ireland. The proposed overhead line will run through counties Monaghan, Cavan, Meath, Armagh and into Tyrone. The project was granted planning approval in Ireland in December 2016 and in Northern Ireland in January 2018. Both of these decisions are currently the subject of legal challenge in the courts. Assuming these legal challenges are overcome, construction is expected to commence in early 2020 with completion in 2023.

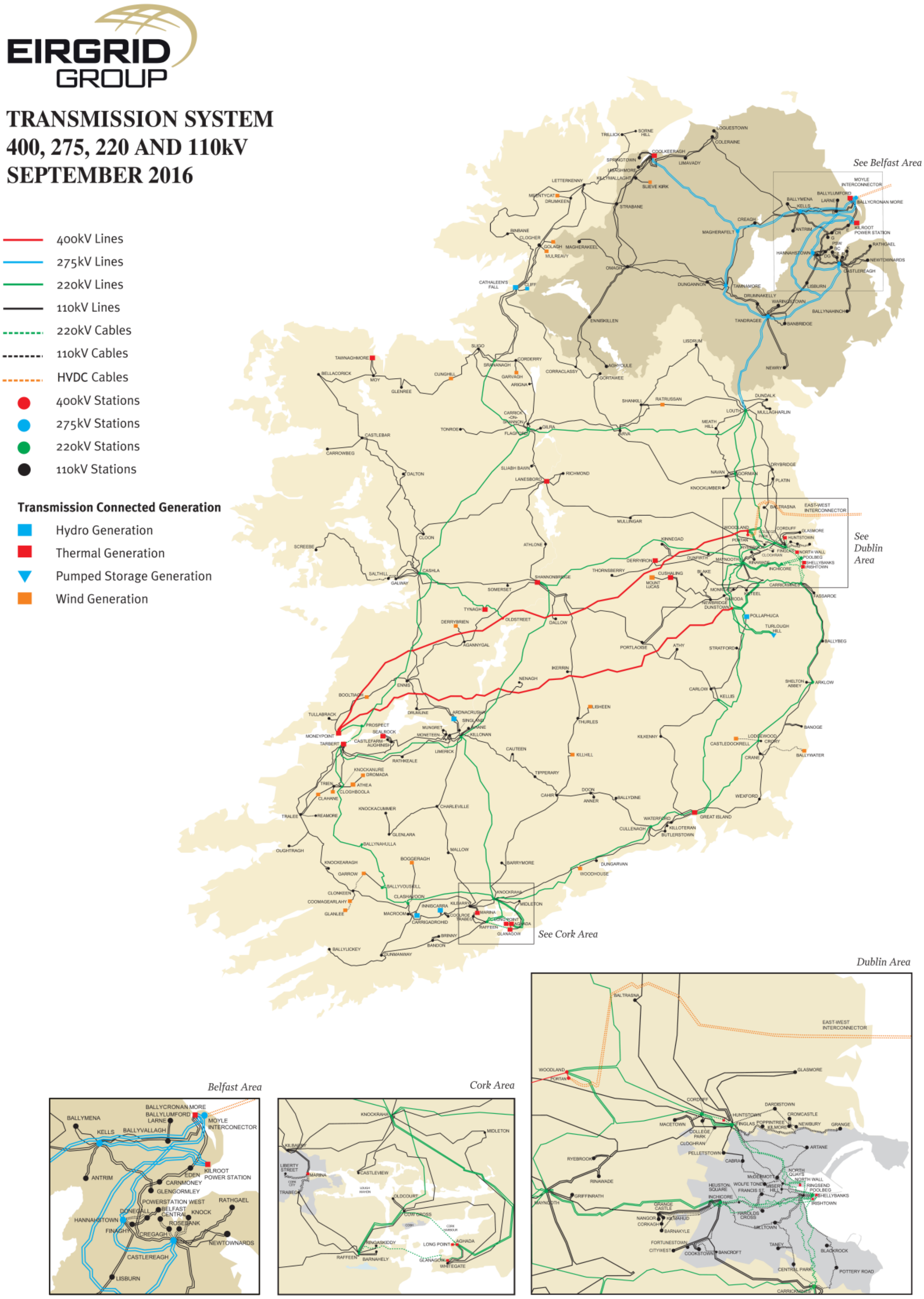
ESB is the licensed Transmission Asset Owner (TAO), with responsibility for delivery of the capital work programmes related to the transmission system as determined by EirGrid. This includes the construction of new high voltage substations, and their associated overhead lines and underground cables. Their responsibility also involves responding to network faults and carrying out planned maintenance and refurbishment on these assets.

Interconnection

The electricity transmission systems of Ireland and Great Britain are connected via the East West Interconnector (EWIC) which is a high-voltage direct current submarine and underground power cable. It has a power rating of 500 MW and uses Voltage Source Converter technology. The EWIC is a fully regulated interconnector which was developed and is owned by EirGrid Interconnector Designated Activity Company (EIDAC), part of the EirGrid Group. It has a total length of 261 kilometres, of which 186 kilometres is submarine cable and 75 kilometres is land cable. The link connects Portan converter station in County Meath, Ireland, and Shotton converter station in North Wales.

In the longer term, a proposal is also under consideration for an electricity interconnector between Ireland and France, known as the Celtic Interconnector, as part of proposals toward a more integrated EU Energy Union. Realisation of the Celtic Interconnector project would achieve direct connectivity between Ireland and continental Europe. Separately the Greenlink interconnector project proposes to link Ireland and Wales.

Figure 2 - EirGrid Transmission System Map September 2016



2.4 Electricity Distribution System

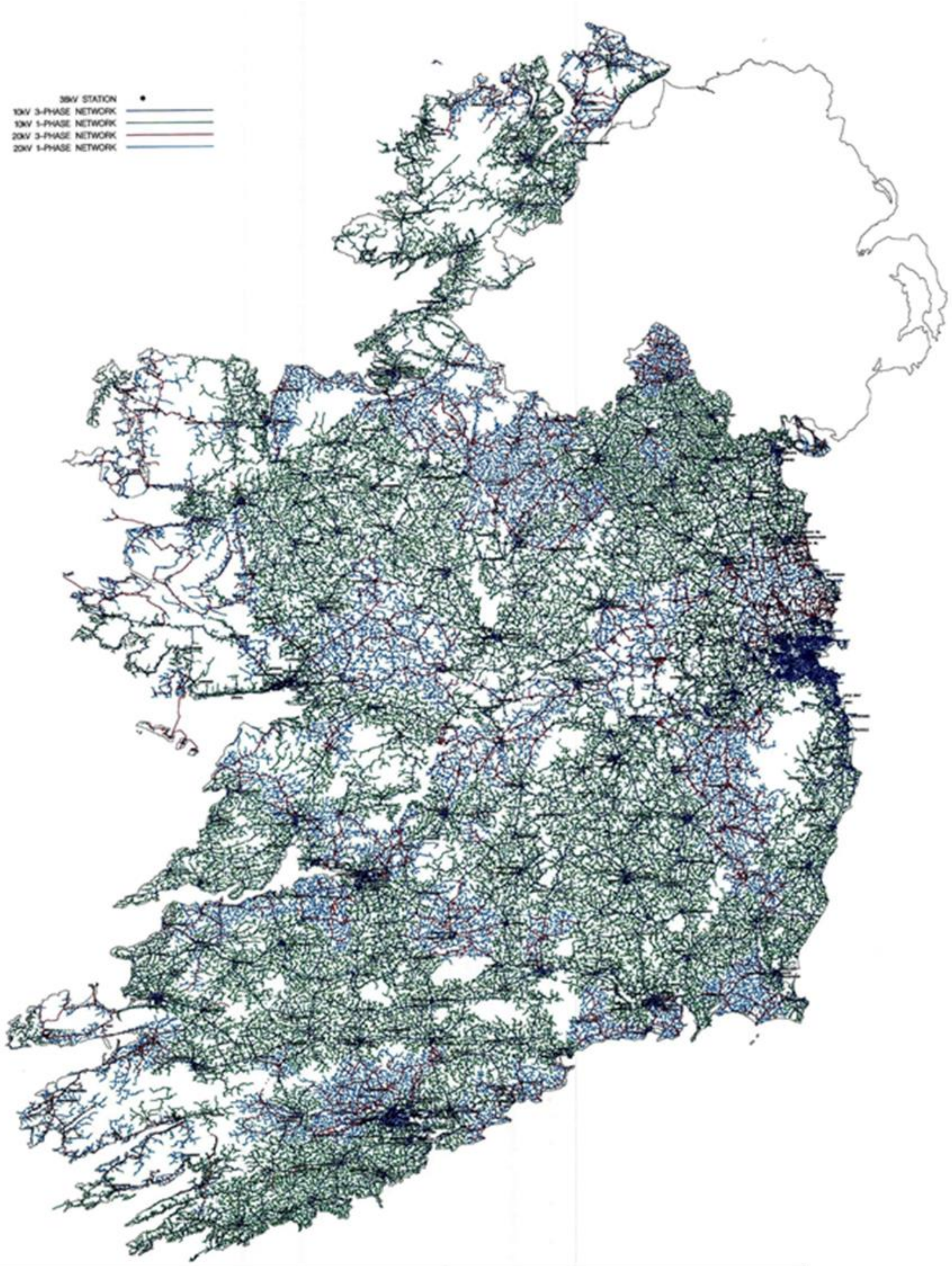
Power is transmitted from the transmission system and transformed at distribution stations into medium (38kV, 20kV, 10KV) voltages which feed into the lower (400/230V) voltage distribution networks or directly to larger industrial customers.

The distribution system is managed by the Distribution System Operator (DSO), ESB Networks (a ring-fenced subsidiary within the ESB Group), and brings power directly to Ireland's 2.3 million domestic, commercial and industrial customers.

The distribution network includes all distribution stations, overhead electricity lines, poles and underground cables. In contrast to the transmission system which is characterised by small quantities of high value assets with high loading through which all power to customers flows, the distribution system has the opposite characteristics – over 250,000 transformers many of which feed 1-2 customers, over 70,000km of Low Voltage (LV), 90,000km of Medium Voltage (MV) and over 7,000km of 38kV networks. The transmission assets are inherently more resilient as their operation in an interconnected mesh provides alternative feeds in the event of damage to a circuit.

Conversely, weather damage to distribution networks affects the customers connected to that particular network, but the numbers of customers in each instance is less. Obviously climate-related or extreme weather events over larger geographic areas can create considerable damage to large amounts of network. Damage to MV networks can result in relatively large numbers of customers losing supply e.g. say 2,000 – 3,000 customers for loss of a MV feeder. However, once the fault is fixed supply can be restored quickly. In contrast, large scale damage to LV networks such as occurred in Storm Darwin in 2014 generally affected large amounts of LV networks, with each individual LV fault requiring repair before supply could be restored to each group of customers.

Figure 3 - ESBN MV Distribution Network



As shown in figure 3 above the distribution network is much more extensive than the transmission network as it connects to every house and building in Ireland – the above map illustrates the Medium Voltage system alone – at Low Voltage there is a second system which is nearly as extensive again.

2.5 Gas Infrastructure

Gas Networks Ireland (GNI) owns, operates, builds and maintains the natural gas network in Ireland. GNI is part of Ervia, a commercial semi-State company with over 688,000 natural gas customers (over 650,000 homes and 27,000 businesses) who rely on the network for their energy needs.

Pipelines

The gas pipeline network is comprised of high pressure cross-country and trans-national transmission pipelines and a lower pressure distribution network to transport gas to end-users. The overall network consists of circa 14,172km of a combination of high pressure steel transmission pipelines (circa 2,500km) and lower pressure polyethylene distribution pipelines (circa 11,000km).

Installations

GNI's pressure reduction installations include transmission pressure reduction installations and distribution pressure reduction installations.

Transmission installations reduce gas pressure for onward transport to other transmission installations, to transmission pipelines, to transmission customers or on to the distribution system. Distribution installations reduce the pressure for onward transport by the medium and low pressure networks, for consumption by industrial or commercial customers or onto domestic customers.

Compressor Stations

Compressor stations are used in the high pressure transmission network in order to raise the pressure of the gas within the network. This enables the gas to flow in adequate quantities to all parts of the network. Currently, GNI operates three compressor stations in its transmission network, two of which are located in the UK and the other in Cork. Compressor Stations consists of three primary components: Turbo Compressor Units, Above Ground Installations (AGI) and Ancillary Systems.

Domestic & Small Industrial/Commercial Installations

Domestic and Small Industrial /Commercial Installations comprise Non-Daily Metered (NDM) gas supply points and Daily Metered installations. The high level primary function of all metering assets is to accurately measure, record and display the volume of gas consumed at a gas supply point in a safe-manner.

Transmission Network

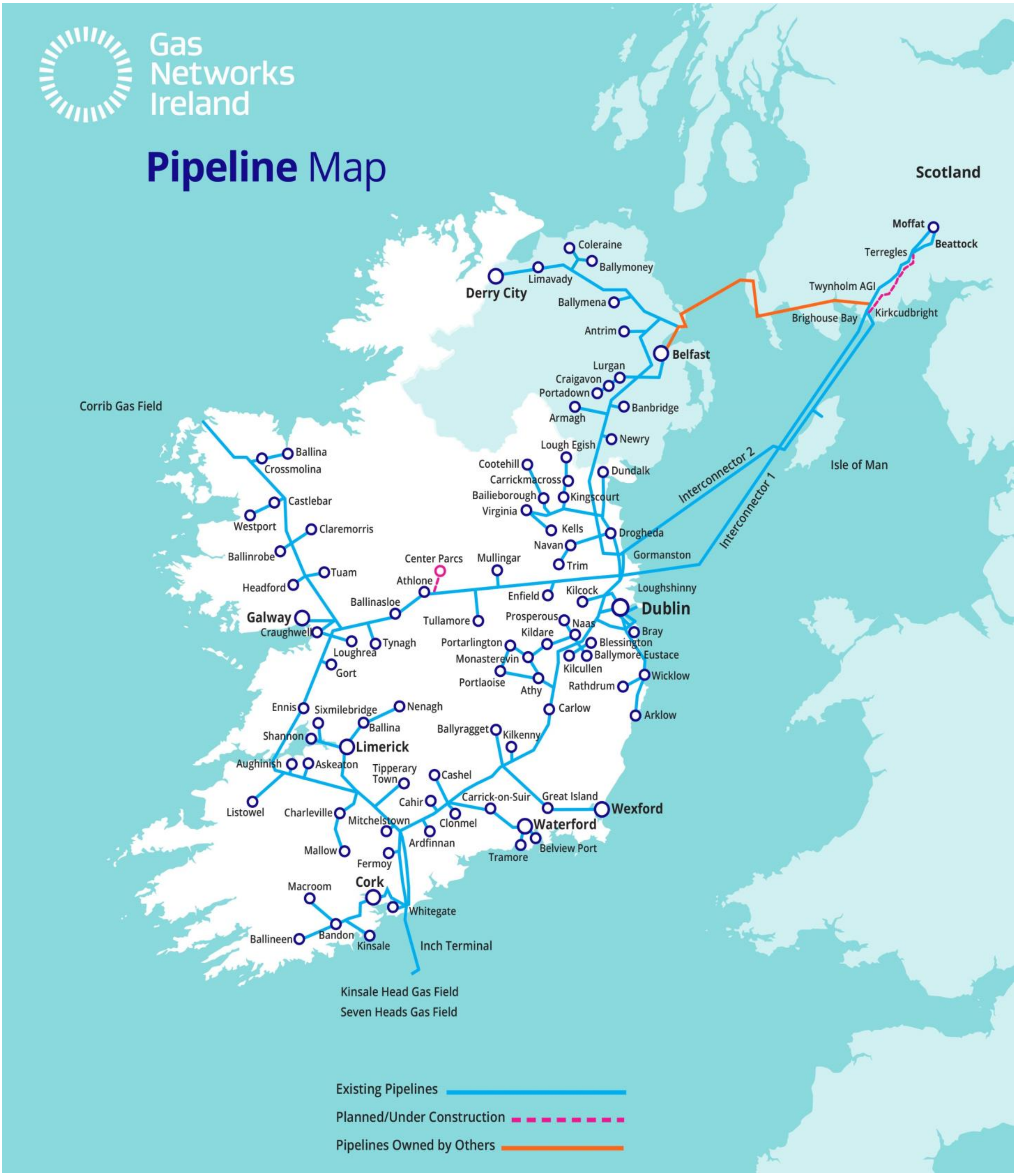
Transmission pipelines transport gas into Ireland from offshore gas fields and from GNI transmission infrastructure in the UK. The transmission system operates at a variety of pressures.

The transmission network connects to large industrial and commercial customers and to the distribution network via the use of pressure reduction installations. These units serve to filter and modulate the gas pressure from transmission pressures to suit the downstream application.

Distribution Network

The distribution network supplies gas to most of GNI's customer base. This network consists of steel and polyethylene pipes and operates at a number of pressure tiers. The interface between pressure tiers is managed using distribution pressure reduction installations (DRI's). These installations, much like their transmission counterparts, filter and reduce the gas pressure for use in lower pressure networks. In addition to DRI's, GNI also has a large number of Industrial and Commercial (I/C) pressure reduction facilities. These units filter, meter and modulate the upstream pressure to a pressure specified by the customer.

Figure 4 – Gas Networks Ireland pipeline map



2.6 Cross Sector interdependencies

It should be noted that the reliability of the gas network is dependent on the reliability of the associated electricity supply to pumps and other electrical devices in customers' premises which require electricity to allow gas to be used. In turn, the electricity network is reliant on gas for generation when renewables are not available and that is likely to remain the position in the medium term.

The efficient functioning of the electricity and gas sectors are key to the functioning of much of Ireland's critical infrastructure and the overall resilience of many sectors of the economy (powering industry, agriculture, transport, communications, enabling heating and cooling, food production, etc.). Decisions taken at sectoral level may potentially also affect other sectors indirectly.

In addition, weather events are unlikely to affect one sector in isolation. Critical infrastructure is often clustered in close proximity, which can concentrate impacts and, on occasion, impede contingency plans and responses to extreme events.

The co-location of telecommunications equipment on overhead energy networks e.g. fibre on ESB lines, or telecommunications in transmission and distribution stations, are examples of where one event could disrupt both power and telecommunications. Communication with customers and the general public is critical both for safety and confidence in energy related emergencies.

Similarly, in the event of a much 'Smarter' grid where operation of the Grid may depend on a robust telecoms system, disruption to telecoms from weather could also have a significant impact.

There are mitigators however against such telecommunications disruption, such as the fact that telecom networks are nearly always designed with multiple alternative communication paths, as it is only a signal that needs to be transported and this can be done by microwave, radio or on other wires.

Climate change adaptation options must therefore be considered in the context of such interdependencies. A holistic/co-ordinated approach to climate adaptation is required to identify instances where multiple potential points of failure exist and to take steps to prevent these failures from occurring.

In addition with significant changes in generation sources Climate Change may have unexpected manifestations e.g. a high pressure area over much of Ireland, UK and the continent could result in a significant reduction in Wind Generation, and an eclipse would have a similar impact on solar. In particular, unusual combinations of weather events either together or in succession may occur which could exacerbate the overall effect e.g. high tide; low pressure and strong onshore wind would increase risk of coastal flooding.

2.7 The Regulation of Energy Networks

The Commission for Regulation of Utilities (CRU) is Ireland's independent energy and water regulator. The CRU was established in 1999 and has a wide range of economic, customer protection and energy safety responsibilities. The CRU's mission is to regulate water, energy and energy safety in the public interest.

It is the vision of the CRU that public interests are protected by ensuring:

- the lights stay on,
- the gas continues to flow,
- the prices charged for energy and water are fair and reasonable,
- energy and gas are supplied safely
- a reliable supply of clean water and efficient treatment of wastewater, and;
- regulation is best international practice.

As time goes on the energy network companies will need to continue to develop and optimise their systems to specifically target the adaptation of energy networks to climate change. Allowed revenues for the energy industry are currently set by the CRU in periodic price reviews and therefore any costs associated with adaptation to climate change will need to be approved by the Regulator.

3. Climate Impact Screening

Climate change impacts will vary between electricity and gas networks and their associated infrastructure, and impacts may also vary depending on location. It may be difficult to determine the precise extent to which climate change will impact on the networks in the coming years but the sector has significant data in relation to the impacts of severe weather events on infrastructure and services, particularly since 2009. While this is not an extensive timeline by which to gauge trends, it does however, form an important basis upon which informed discussions can begin.

Through consultation with the stakeholder team a range of impacts from observed and projected changes in key climate parameters and extreme weather events was identified.

The key climate impacts for the energy sector are:

- Flooding / change in precipitation / extreme events
- Temperature rise
- Sea level rise
- Changes in wind energy content

The following key infrastructure types were identified as being particularly vulnerable to the climate change impacts identified: electricity generation plants, overhead electricity transmission and distribution lines, underground cables and stations, large wind farms, gas pipelines and gas substations, with secondary impacts on other infrastructure, staff, customers and the economy.

Figures 5 and 6 demonstrate schematically the flow of electricity and gas through their respective networks.

Figure 5 – End to end electricity network

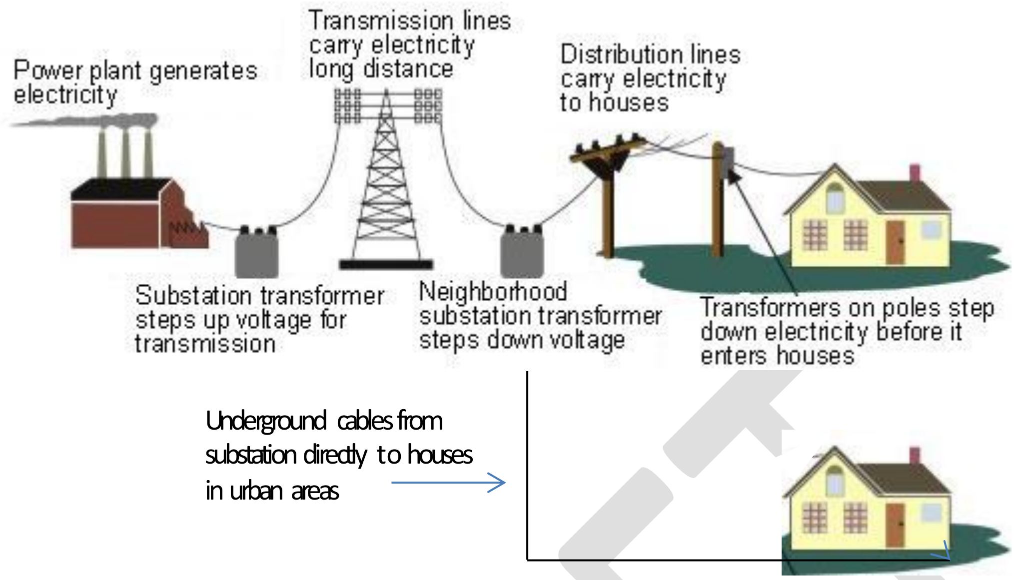
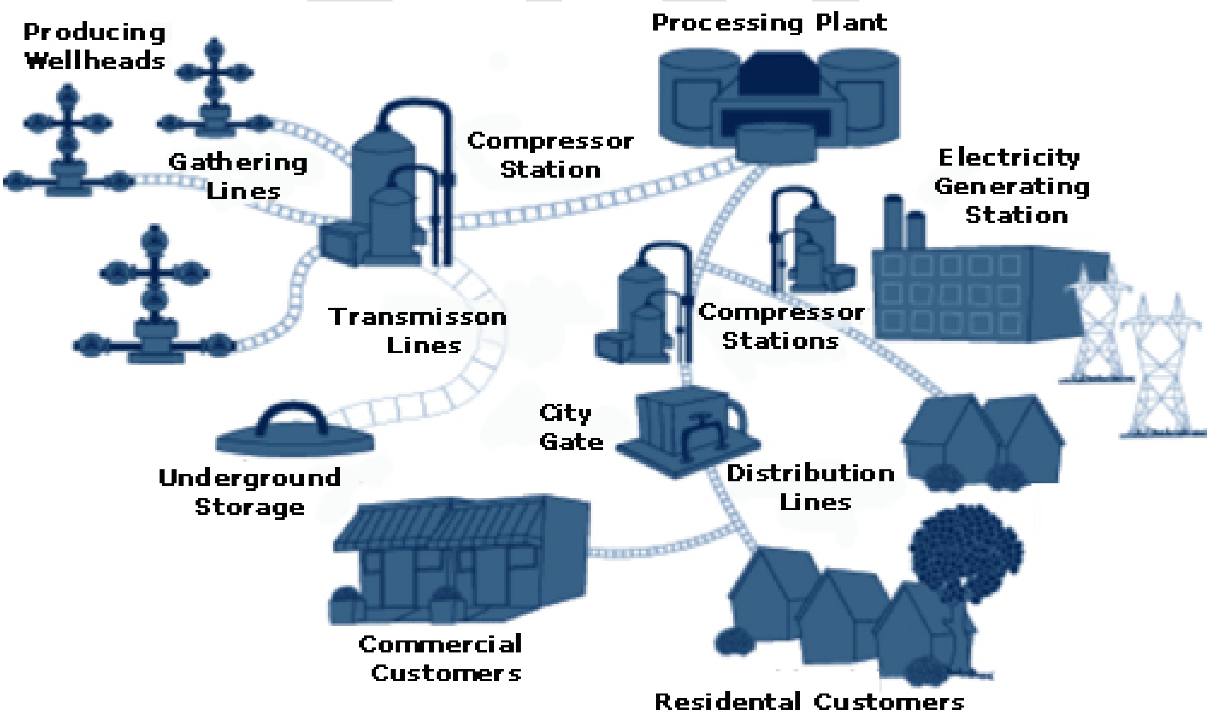


Figure 6 – End to end gas network



Energy networks vulnerability assessment

The following sets out the impacts on the energy networks from observed recent weather events and the likely impacts from projected climate change variables. See Table 3.

3.1 Electricity Generation

The generation sector is relatively resilient to weather events (compared to, for example, overhead networks), both in terms of the robustness and enclosed nature of conventional generation assets and the diversity of the portfolio of the types of generation station (coal, gas, peat, wind, hydro). The period to 2050 will likely see fundamental changes in power generation technologies, with most existing power plants having been retired, and considerations based on the current power generation landscape may be less relevant.

Extreme wind events are unlikely to directly affect the operation of a thermal power station. However, damage to transmission assets may indirectly result in a generating station being unable to operate for a period of time.

Increased variability of wind generation will increase requirements for backup generation and/or storage. Changes in wind energy content may lead to increased incidence of wind-farm power unavailability due to wind speeds above the design shutdown levels of wind turbines (typically 25 m/s for current equipment); and may also lead to increased risk of mechanical damage to wind turbines.

High pressure weather systems such as experienced in summer 2018 may well lead to a reduction in wind generation due to low wind speeds. This can potentially be mitigated against with a large capacity of solar generation. However even Solar can be affected by events such as eclipses, although such events can be predicted and planned.

In the longer term, the projected rise in sea level, while not sufficient to permanently flood existing generation sites, will see an increased risk of intermittent flooding and coastal erosion. Wind farms tend to be on high ground and therefore less impacted by flooding events, but heavy rain or drought conditions may impact on foundations.

Seasonal changes in rainfall distribution will result in reduced hydro generation at certain times of year. ESB hydro stations have a role in managing water levels on the rivers where they are located. They can offer some flood alleviation downstream of dams in rainfall events while also prioritising the safe operation and protection of the dams. The alleviation provided by the dams will vary from flood to flood and may be imperceptible in very large events.

Conventional electricity generation uses significant amounts of water (primarily cooling water). Water shortages and elevated water temperatures in summer are acknowledged as a likely outcome of climate change and have consequences for the available output from thermal generation plants[6]. For example, an extreme heat wave in Poland in the summer of 2015 put additional pressure on the Polish power system, with a lack of water for cooling contributing to blackouts in August 2015. The heat wave across Europe in late July 2018 required some generation plants to reduce electricity after cooling water was affected by high temperatures. [7]

High ambient temperatures during heat waves reduce the output capacity and efficiency of gas-fired combustion turbines.[8]

Solar Photovoltaic (solar PV) is not yet a significant source of generation in Ireland. However, it is expected that solar PV at various scales (utility-scale, community-scale and at the domestic level) will play a role in delivering Ireland's contribution to an EU-wide renewable energy target, out to 2030. Typically, solar PV panels are mounted on higher (less shaded) areas, so are less impacted by floods.

3.2 Electricity Transmission and Distribution

The transmission system (overhead lines, underground cables and stations) and the distribution system need to be resilient, with enough capacity to ensure that extreme weather events resulting in outages can be accommodated without severely restricting the supply of electricity.

The main risk to the transmission system is from flooding, arising from river or drainage system channel/infrastructure capacity exceedances, storm surges, sea level rise and also extreme precipitation levels. This affects all infrastructures on the grid.

6 At least one conventional plant had capacity reduced by up to 50% due to cooling water issues arising from the heat wave in Ireland in summer 2018.

7 EDF halted four nuclear reactors at three power plants in France in August 2018 because of the heatwave then affecting Europe. High temperatures registered in the Rhone and Rhine rivers, from which the three power plants pump their water for cooling, led to a temporary shutdown of the reactors.

8 CCGT plants in Ireland had available output reduced by around 8% during the heatwave in Ireland 2018.

Increased wind speeds are also identified as a risk to transmission assets. Lightning, if sufficiently severe, may also impact on transmission operation, although the inherent grid design incorporates lightning protection for all expected levels.

Temperature rise, high temperature extremes and heat waves may have an impact on asset life and equipment ratings. Salt fog has also been identified as a risk to transmission assets. Increased wintry showers with snowfall and ice accretion may cause increased mechanical loading. An increased growing season will increase the risk of tree damage caused by high winds on transmission system.

Distribution networks are normally very extensive geographically and consist of many near individual connections, so that climate change is more likely to affect multiple independent clusters of customers through breakdown of their particular connection to the networks.

Damage from falling trees is a particular problem as the extensive nature of the distribution network (100,000km) exposes it to such damage. Similarly severe lightning could cause widespread outages of small groups of customers.

Flooding of larger stations is another potential risk, although distribution stations are normally limited in size to 2 x 10MVA (say up to 10,000 domestic customers) and standby arrangements may be available for up to 50% of this load from adjoining substations.

3.3 Gas Transmission and Distribution Networks

The gas transmission and distribution networks need to have enough capacity available to ensure that extreme cold weather events can be accommodated without restricting the supply of gas.

Climate change may have an impact on the level of degradation of critical gas assets that are above ground. This would reduce the life of assets and therefore increase the required frequency of refurbishment and replacement of the affected assets.

The gas transmission network is, in the main, very resilient to weather events as it is an underground network. However, an increase in extreme flooding events may impact transmission pipelines traversing flood plains.

Interconnector transmission pipelines may, as they come onshore, be subject to the effects of the projected rise in sea levels and the associated increased risk of coastal erosion which may result in a requirement to install additional coastal defences. Increased river bank erosion where a pipe traverses a river can cause depth of cover and exposure issues for transmission pipelines which require remediation works to reinstate the appropriate depth of cover over the pipeline. In very extreme cases of summer drought there may be a potential risk that soil compaction and ground movement may occur that could impact both transmission and distribution pipelines.

Gas transmission and distribution installations and compressor stations located in areas prone to flooding in extreme weather events face potential risks and those located in coastal areas face risks in the longer term from intermittent flooding and coastal erosion as a result of the projected sea rise.

Case Study: Gas Network Response to Extreme Cold Weather

The natural gas network has demonstrated resilience and reliability through recent severe winter weather conditions. Ireland experienced two extremely cold winters in 2009/2010 and 2010/2011. For winter 2009/2010, the most notable freezing conditions occurred in January 2010, particularly on the 7th and 8th of January 2010, with an average temperature of circa. -5.0°C. The result of this extremely cold weather was that there was an all-time record peak demand for the gas transmission system as a whole (including onshore Scotland, onshore Ireland and Northern Ireland), as well as that for the onshore Irish system on the 7th of January 2010.

In terms of natural gas supplies from the UK, no difficulties were experienced and there was sufficient gas available at all times to satisfy gas demand on the island. As regards the operation of gas network infrastructure such as compressors, pressure reduction installations and pipelines, the assets operated effectively over the period of cold weather and peak demand was met.

For winter 2010/2011 the coldest period was the month of December 2010. It was the coldest December on record since records began in 1942, with the coldest average 24 hour temperature of -8.6°C being recorded at Dublin Airport on the 24th December 2010. Over this extended cold period, both gas supplies and the gas network infrastructure were again sufficient in meeting the demand requirement.

Case Study: Flood Assessment and Mitigation for ESB HV Substations

Figure 7 - Flooding in an outdoor HV Station

Background:

ESB Networks are built with resilience so that in the event of a fault on a circuit or within a substation, standby is generally available.

The resilience levels designed are proportionate to the numbers of customers which would be affected by a fault and the time required restoring supply.

Flooding of HV Substations is a particular risk because by its very nature flooding will affect the Substation for a considerable time, and in many cases the standby available is for loss of up to half the substation, whereas a flood could involve loss of the complete station.

Consequently assessment and mitigation of Flood impact on HV Substations is an important part of Climate Adaptation for both the Transmission and Distribution Networks.

Approach:

The approach adopted is as follows:

(a) Identify critical HV Substations which are at risk of flooding

(b) Assess the likelihood and extent of flooding

(c) Identify an optimal sequence of measures required to mitigate the impact, up to and including the relocation of the HV Substation.

Figure 8 - Extract from OPW CFRAM PFRA

(a) Identification of HV substations at risk of flooding

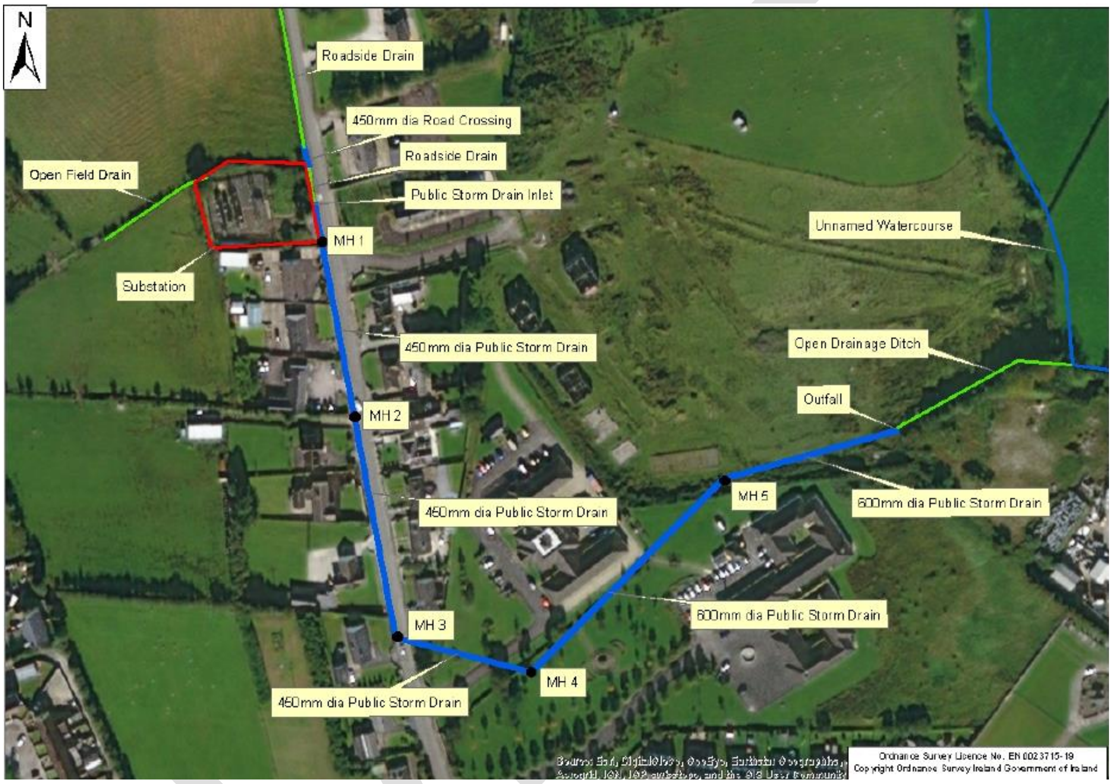
As an initial screening exercise the OPW Catchment Flood Risk Assessment Management Studies (CFRAMS) and associated Preliminary Flood Risk Assessment (PFRA) would be reviewed if available for the specific substation site (see Figure 8).

(b) Assess the likelihood and extent of flooding

A review of historic records of flooding in the area generally, taking into account local knowledge of ESB staff and changes which may have occurred in the locality which could alter drainage patterns.

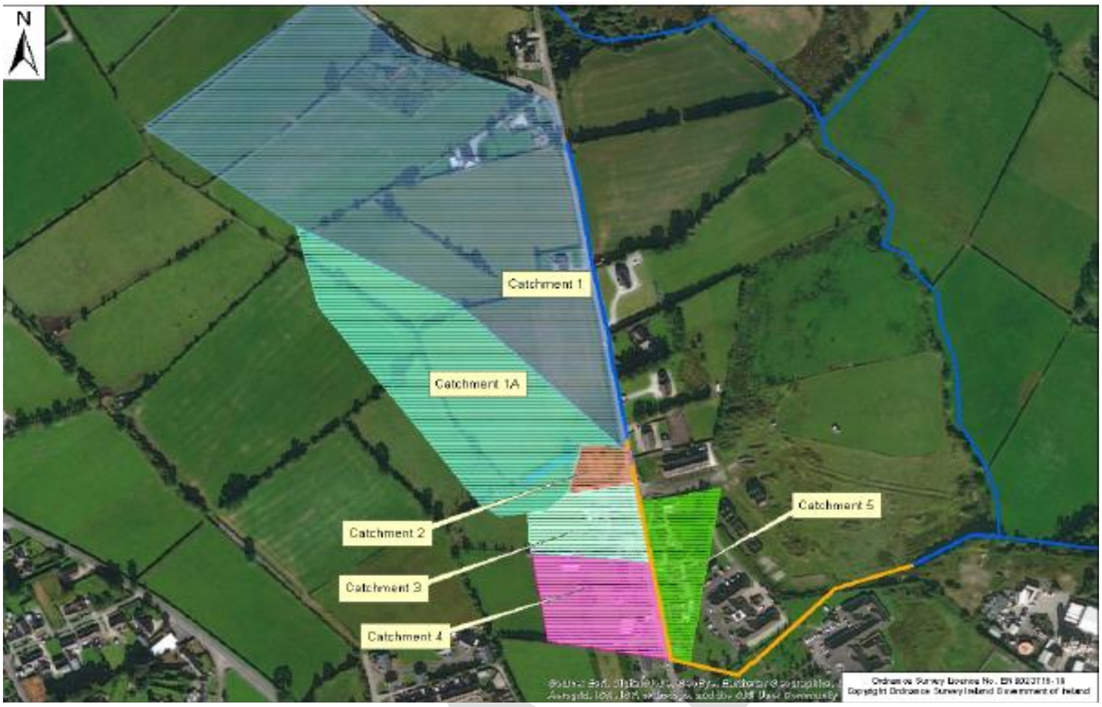
Existing drainage plans would also be reviewed (see Figure 9).

Figure 9 - Existing Substation (outlined in red) and public storm drainage network



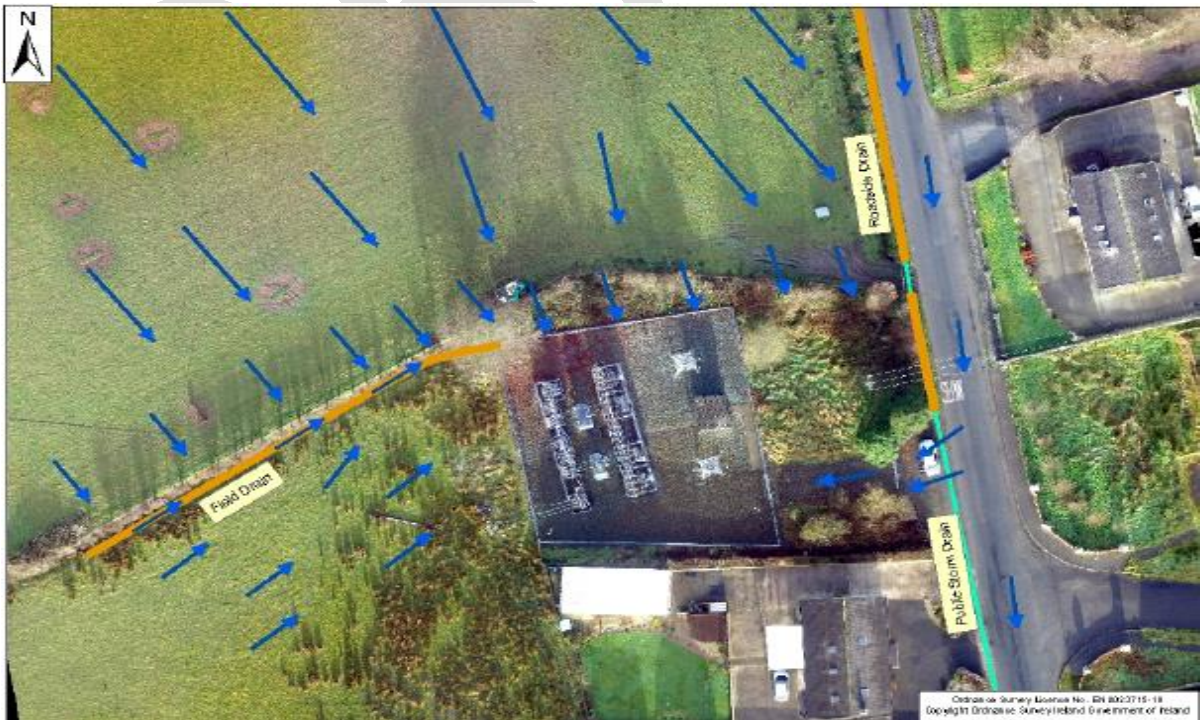
Catchment areas which would contribute to runoff would be mapped using Arc GIS contour mapping and topographical Survey data (see Figure 10).

Figure 10 - Contributing Catchments draining to the public storm network



The likelihood of the Substation being flooded would then be assessed using the US EPA Storm Water Management Model (SWMM) software to combine the capability of the existing drainage to cope with expected levels of runoff water assessed.

Figure 11 - Flood routes into Station



(c) Identify optimal sequence of measures required to mitigate the impact, up to and including the relocation of the HV Substation.

HV Substations are the nexus around which the Distribution and Transmission networks grow over many years. Consequently the area around the substation is often well developed and as it is very expensive to relocate a Substation, the lifetime of the Substation can be very long e.g. 80 years plus.

This means that mitigation works need to be planned in sequences to take account of other developments which may occur in the future, such as large scale Flood Relief schemes for the areas, or enlargement of the existing public drainage system, which would also protect the HV Station.

A sequence of such measures would be examined in sequence to allow implementation in advance of expected flood levels:

i. *Short term remediation measures:*

Typically these would include:

- Raising the level of critical electrical elements
- Bunding critical areas/ sealing cable ducts to prevent water ingress (see Figures 12 & 13)
- Ensuring existing drainage is clear and installing screens for debris
- Adding extra drainage including pumps in the Substation

Figure 12 - Bunding of Control Buildings Figure 13 - Bunding of Electrical Equipment

ii. Long Term Remediation Measures:

- Provide a flood storage pond to attenuate discharge rate into existing drainage network
- Relocation of the HV Station to higher ground.

Future Approaches:

ESB Networks new GIS system is a modern, industry standard platform which stores all of ESB Networks equipment in an open spatial format which facilitates access to the latest and most advanced spatial analysis and data mining capabilities. It is expected that the recent development by the OPW of improved and more open datasets and information relating to Flood Risk Management will further improve ESB Networks capabilities to plan for and mitigate against flood events.

The following table outlines the vulnerabilities of the Energy networks (electricity and gas) in Ireland.

Table 3 – Energy networks (electricity and gas) vulnerability assessment

Priority climate impact	Sector	Infrastructure	Observed / projected impacts
Temperature	Electricity	Generation Transmission & Distribution	Water shortages or elevated water temperatures may affect availability of cooling water for generation plants High pressure weather systems may lead to reduction in wind generation due to low wind speeds. High ambient temperatures reduce the available output from gas turbines. Temperature rises or extremes may impact on asset life and equipment ratings Increased growing season may increase risk of damage by trees to overhead wires Temperature rises or extremes may impact on asset life and equipment ratings Extreme summer drought leading to soil compaction may impact

			underground cables
	Gas	Transmission & Distribution	Extreme summer drought leading to soil compaction may impact transmission and distribution pipelines.
Precipitation / extreme events	Electricity	Generation	Changes in rainfall may lead to increases or decreases in hydro generation Hydro stations may offer some flood alleviation in rainfall events
		Transmission & Distribution	Flooding arising from river or drainage system channel/infrastructure capacity exceedance, storm surges and extreme precipitation events Snowfall and ice accretion may cause increased mechanical loading Salt fog is a risk to transmission assets Severe lightning – may disrupt transmission
	Gas	Transmission	Extreme flooding events and river bank erosion may impact gas

			transmission pipelines, installations and compressor stations
		Distribution	Distribution installations in areas prone to flooding a risk from extreme weather events
Sea level rise	Electricity	Generation Transmission	Plants may, in the longer term, see increased flooding or coastal erosion Some risk to transmission assets
	Gas	Transmission	Interconnector transmission pipelines, transmission installations and compressor stations may be affected by coastal erosion and sea level rises
Changes in Wind energy	Electricity	Generation Transmission & Distribution	Increased variability of wind will increase need for generation backup and/or storage and stronger winds may lead to turbine shutdown or mechanical damage. Reliance on gas generation when renewables are not available (absence of wind or high wind speeds) can increase gas demand High wind speeds pose a risk to transmission and distribution network from falling trees

4. Prioritisation

The future climatic conditions to which the energy sector will have to adapt have been projected with various levels of confidence by Met Éireann and a number of research groups nationally. These include:

- Temperature: Average temperatures will rise by about 1.5 degrees Celsius by mid-century
- Precipitation: wetter winters and drier summers
- Extreme Events: increased frequency of heavy rainfall
- Sea level rise: a rise of 50cm by 2100 is predicted
- Energy content of wind: increased energy content in winter and a decrease in summer months.

Understanding potential future impacts is essential for informing and developing adaptation strategies and actions. While the information available is, in the main, at a high level and not local area specific, the energy networks stakeholders have, based on their experience and expertise, considered these projected climatic conditions and table 4 sets out how these elements might impact on the various gas and electricity network components.

Table 4 – Future climate change impacts on energy infrastructure

Impacts of Climate on Components of Energy Infrastructure	Overhead Ines	Underground Cables	Transformers	Substation Sites	Control Systems	Network Access	Thermal Generation	Hydro Generation	Onshore Wind	Marine	Gas Transmission Pipelines	Gas Distribution Pipelines	Gas Compressor Stations	Gas Pressure Reduction Installations	Offshore Wind	Solar
Climate Risks																
Increased Temperature	*	*	*	*			*									*
Summer Drought		*		*			*	**			*	*				*
Prolonged Growing Season	*															
Increased Sea Level Rise		*	*	*		*	*						*	*		
Increased Coastal Erosion		*		*			*				*		*	*		
Increased River Erosion		*		*				**			*					
Increased Lightning	*		*	*												
Increased Rainfall\Flooding	*	*	*	*	*	*		**			*		*	*		*
Increased Wind Speed	*			*					*						*	
High Pressure Weather Systems									*							

5. Priority Impact Assessment

Climate change adaptation can be defined as the ability of a system to adjust to climate change (including climate variability and extremes), to minimise potential damage, to take advantage of opportunities, and to cope with the consequences. Proposed adaptation actions and measures would therefore be expected to reduce vulnerabilities and increase resilience of energy systems.

Generally, actions can be grouped under three headings: Technological or Engineering (Grey), Environmental (Green) and Policy / Behavioural (Soft) actions.

- Technological or engineering solutions to climate impacts may include for example construction of sea walls in response to sea level rises. Actions of this nature are usually easy to quantify but can be very costly.
- Environmental actions are usually responses of an ecological nature, for example efforts to reinstate dune systems to act as buffers against coastal storm damage; Sustainable Drainage Systems (SUDS), wetland creation, planting in flood zones, better planning. These options can have very long lead times.
- Policy (soft) actions, including Government actions and changes in human behaviour. These options can be relatively inexpensive to progress but they require a lot of commitment and on-going support. They can also include the provision of information, mainstreaming, capacity building, etc.

Sections five and six outline energy network climate vulnerabilities and put measures in place to minimise negative impacts, while section seven aims to set out potential future risks and challenges. This section now aims to set out potential additional / future adaptation options to address climate change impacts.

The challenge is to identify additional worthwhile and economic improvements which can be made to networks when carrying out routine maintenance and upgrades to increase network resilience to climate change and improve customers understanding of how predicted climate changes might impact upon the energy networks sector. A distinction here will help to establish the fact that climate change is real and that the service provider may need to take additional steps to protect the networks from damage. Such additional steps may impact on the landscape and may increase the cost of the energy service accordingly. In this way, if a network failure should occur during an extreme weather event, the requirement for a more robust solution may be more readily accepted. If the basis for network investment can reflect the additional cost associated with climate adaptation in a transparent way, this will help the energy networks utilities to justify the extra investment by demonstrating the benefits achieved.

Energy sector climate research should therefore be supported. Improved knowledge of climate change impacts will also allow risks to be routinely factored into investment decisions and policy developments across all energy policy areas. Low-cost techniques, based upon an improved understanding of risks and potential costs, can be deployed to continue the process of building resilience into our electricity and gas networks sector, and to predict the likely impact of imminent weather events.

In the long term, the energy network companies need to optimise on or put systems in place as part of network planning to monitor and assess emerging financial requirements, to specifically target the adaptation of energy networks to climate change. Allowed revenues for the energy industry are currently set by the Commission for Regulation of Utilities (CRU) in periodic price reviews and therefore any costs associated with adaptation to climate change would need to be approved by the CRU.

Communications and awareness building efforts to ensure public understanding of the potential effects of climate change should also be brought to the fore. A December 2015 survey of Irish people carried out by the Sustainable Energy Authority of Ireland (SEAI)[9] showed that just 49% of Irish people believe climate change is a serious problem.

Public acceptance, understanding and awareness around adaptation efforts are important factors in the national approach to climate change adaptation.

Tackling the challenge of climate change impacts on the electricity and gas networks sector can be enhanced through collective efforts and cooperation between all stakeholders. The following represents a suite of general adaptation options available to the electricity and gas networks sector:

- Energy sector climate research

[9] http://www.seai.ie/News_Events/Press_Releases/2015/Only-half-of-citizens-convinced-that-climate-change-is-a-serious-problem.html

- Collaborative research across stakeholder bodies e.g. EPA research on Critical Infrastructure Vulnerability to Climate Change

- Auditing energy infrastructure to identify vulnerabilities and implement optimum adaptation measures

- Effective cooperation and communication between Departments, agencies, state bodies and other stakeholders to ensure that energy infrastructure is prepared for changes to climate; this should include the sharing of information that will assist with adaptation such as climatic data
- Mainstream climate change adaptation into all energy policies
- Climate change to be incorporated into engineering management practices

- Energy infrastructure planners and designers to take climate change projections and impacts into account

- The development of Ireland's abundant, diverse and indigenous renewable energy resources

- Optimal combination of increased energy efficiency and increased use of renewable (low carbon) energy sources

Building on adaptation measures already in place, the following outlines some system specific options for the electricity and gas networks.

5.1 Electricity Generation

Further consideration of weather events and climate change trends in the planning and design of new infrastructure. For example, site selection would take account of the possibility of flooding. Where replacement generation is built on coastal sites, enhanced flood protection may be required or critical assets may be elevated or otherwise protected.
- In the context of possible water shortages in summer, water management and resource preservation features in the design of thermal generation infrastructure.
- Solar generation as a hedge against low wind generation

5.2 Electricity Transmission and Distribution

- Further consideration of weather events and climate change trends in the planning and design of new transmission and distribution infrastructure. For example, the risk of flooding arising from river or drainage system channel/infrastructure capacity exceedances, storm surges, sea level rise and also extreme precipitation levels assessed at the constraint stage of route and site selection for new projects.
- More detailed identification of vulnerable areas where existing critical transmission and distribution infrastructure is located.
- More detailed risk assessment of existing critical transmission and distribution networks for impacts from climate change.
- More detailed consideration of climate change impacts on asset management and maintenance approaches and policies.
- Continued improvements in transmission and distribution systems resilience to cater for effects of extreme weather events, including line outages or outages of large generators.
- The deployment of solar PV, coupled with increased battery storage and distributed generation, will, over time, lead to less dependence on a single renewable technology that of onshore wind. Increasing technology diversity will increase Ireland's security of supply and will be part-delivered under the new Renewable Electricity Support Scheme (RESS).

5.3 Gas Networks

- More detailed network development planning, taking into consideration scenarios which include the effects of climate change.
- Design and planning of all assets taking into consideration the current and potential future effects of severe weather and climate change when developing the design and reviewing potential locations.
- On-going adherence to all relevant Irish and European gas standards when designing and planning assets noting that these standards have in-built tolerances which ensure that gas infrastructure is capable of comfortably enduring severe weather events.
- Inclusion of additional requirements in the design where location specific issues are identified e.g. flood protection, gabions.

- Implementation of mitigation measures where climate change issues are identified as part of the operation or maintenance of an existing asset, e.g. a change in local topography or drainage results in flooding of an asset.

6. Develop Your Plan

The following actions when, taken together, represent the Adaptation Implementation Plan for the Electricity and Gas Networks Sector to 2050. This first high level plan will inform the preparation of the first statutory sectoral Adaptation Plan for the electricity and gas networks sector due under the Climate Action and Low Carbon Development Act, 2015.

Table 5 – Actions representing the Adaptation Implementation Plan for Electricity and Gas Networks Sector to 2050

Objective	Potential Action
1. Energy sector climate change research	Identify energy specific climate research required
2. Continue to build on adaptation measures already in place	Identify measures that are working well in other jurisdictions and assess whether they can also be deployed in Ireland.
3. Mainstream climate change adaptation into general energy policy, and strategic objectives to 2050	Assess level of climate change adaptation in energy policy and make recommendations, as appropriate Submit regular Adaptation Plans to Government
4. Diversification of the electricity generation portfolio	Increased diversification of the energy fuel mix, including increased use of renewable and indigenous resources
5. Harmonised collection of baseline data and costs to business and the public arising from past extreme weather events	Develop justification criteria for mitigation measures by utilities based on avoided costs to wider economy from such mitigation measures

Objective	Potential Action
6. Enhance cooperation and communication between Departments, agencies, state bodies and other stakeholders on a national and international level to ensure that energy infrastructure and services are resilient to the impacts of climate change	Identify areas of additional cooperation and any missing communication channels. This should include information / data sharing to assist with adaptation measures.
7. Energy network companies to continue to ensure climate change is taken into account in planning and design standards and engineering management practices	Inventory of existing specific standards and practices Elaboration of climate change related amendments Full integration of climate-change related amendments into standards and practices
8. Identification of areas vulnerable to impacts of climate change	Energy network companies to continue to identify vulnerable areas where assets are located
9. Identify measures required to adapt to climate change impacts on vulnerable infrastructure. These measures should be tailored to the particular utilities infrastructure.	➢ Monitoring; ➢ Enhanced Maintenance; ➢ Refurbish / Upgrade; ➢ Installation of Flood Defences; ➢ Relocation e.g. ESB Networks plan to implement the following (a) Develop mitigation plans for assets which form part of the Critical National Infrastructure and are likely to be affected by severe climate related events such as flooding and wind e.g. flood barriers at HV Stations and greater Timber Cutting

Objective	Potential Action
	(b) Improved automatic restoration of supply to customers in the event of existing networks through better networks automation and control (c) Increased resilience of networks through advanced maintenance and selective 'hardening' of specific assets when carrying out network reinforcement e.g. for EV and electrification of heat (d) Faster repair of circuits through use of Smart Analytics to identify the most significant faults whose repair will restore supply fastest to the greatest number of customers, in the overall context of the DCCAE Govt Emergency Plan (e) Provide increased network resilience to specific identified critical locations of economic activity
10. Continue to develop and improve timely communications to customers during weather events including information provision to users on status of infrastructure, how they will be affected and when normality will be restored. Increase public awareness of measures being taken to ensure resilience to ensure public support for the benefits being provided by Climate adaptation actions.	Assess existing communications procedures; identify gaps and make recommendations as appropriate

7. Implement Evaluate and Review

This Adaptation Plan represents a high level approach to climate change adaptation planning for the energy networks (gas and electricity) sector. It is a first step to set the energy networks sector on a pathway to robust climate change adaptation planning. It will lead to improved understanding of how best to adapt the sector to climate variability, which is essential given the energy sector's role at the centre of the commercial and social heart of the country.

As part of the process to establish a robust plan, it will be important to establish a system for monitoring, reporting and evaluating the measures identified in the Plan.

Performance indicators will be used to establish whether adaptation measures are being achieved and if they are considered to have value in terms of improving the future outcomes of an adaptation action.

It is also even more important to identify where climate adaptation measures will be needed in the future based on the risks and consequences associated with climate change effects in that location, so that the process is forward looking.

Monitoring will inform requirements for additional adaptation measures under subsequent plans. The monitoring system will also help to support communication and learning and to indicate progress towards the goals of adaptation.

The stakeholder team established to scope out and develop this Plan, led by the DCCAE and involving key electricity and gas network stakeholders, will continue to meet periodically after the Plan is finalised, to review the measures identified to ensure effectiveness and efficiency, and to share information and experiences of recent weather events. Looking forward, the following indicators may help to demonstrate progress towards an ultimate goal of building resilience into the energy networks system against the impacts of climate change:

- Baseline monitoring
- Recognition of adaptation needs within sectoral work programmes (mainstreaming)
- Level of adaptation research
- Launch of adaptation measures/level of spending collected
- Cooperation with other sectors/sub national levels is planned/happening
- Periodic reviews /evaluations are planned

In the long term however, there will be recurring National Adaptation Frameworks and sectoral plans as provided for by the Climate Action and Low Carbon Development Act, 2015.

Climate Change Energy Networks (Electricity and Gas) Adaptation Implementation Plan				
Action	**Deliverable**	**Lead Authority**	**Stakeholders**	**Timeframe**
1. Energy sector climate change research	Identify energy specific climate research required	EPA, Met Éireann	Energy network companies, electricity generators; SEAI	Short - medium term
2. Continue to build on adaptation measures already in place	Identify measures that are working well	Energy network companies, private generators & agencies	DCCAE Energy Networks Climate Change Adaptation Working Group	Short term
3. Mainstream climate change adaptation into general energy policy, and strategic objectives to 2050	Assess level of climate change adaptation in energy policy and make recommendations, as appropriate Submit regular Adaptation Plans to Government	DCCAE DCCAE	Energy network companies; SEAI DCCAE Energy Networks Climate Change Adaptation Working Group	Short - medium term Every 5 years
4.Diversification of the electricity generation portfolio to ensure resilience at an economic cost.	Increased diversification of the energy fuel mix, including increased use of renewable and indigenous resources	DCCAE, and other Government Departments, to facilitate the Government's commitment to diversification and increased use of renewable energy	Energy network companies, electricity generators Developers of energy infrastructure projects	On-going

Climate Change Energy Networks (Electricity and Gas) Adaptation Implementation Plan				
Action	**Deliverable**	**Lead Authority**	**Stakeholders**	**Timeframe**
5. Harmonised collection of baseline data and costs to the economy related to past extreme weather events.	Establish best approach for collating climate change related data for the energy sector (harmonised with other sectors)	EPA, Met Éireann to lead	Energy network companies & agencies	Short – medium term
6. Enhance cooperation and communication between Departments, agencies, state bodies and other stakeholders on a national and international level to ensure that energy infrastructure and services are resilient to the impacts of climate change	Identify areas of additional cooperation and any missing communication channels. This should include information / data sharing to assist with adaptation measures.	DCCAE, EirGrid, ESB Networks, Gas Networks Ireland	Energy network companies and agencies, other stakeholders Inter-Departmental Steering Group on Climate Change Adaptation; DCCAE Energy Networks (Electricity and Gas) Working Group on Climate Change Adaptation Plans, Government Task Force on Emergency Planning, Planning authorities	On-going

Climate Change Energy Networks (Electricity and Gas) Adaptation Implementation Plan				
Action	**Deliverable**	**Lead Authority**	**Stakeholders**	**Timeframe**
7. Energy network companies to continue to ensure climate change is taken into account in planning and design standards and engineering management practices	Inventory of existing specific standards and practices Elaboration of climate change related amendments Full integration of climate-change related amendments into standards and practices	Planning authorities to ensure that utilities take account of climate change and its impacts on energy infrastructure, and hence on the economy, in how networks are planned, maintained and developed CRU to facilitate and enable, within the context of its existing regulatory remit, utilities taking account of climate change and its impacts on energy infrastructure, and hence on the economy, in how networks are planned, maintained and developed	Energy network companies National Standards Authority of Ireland (NSAI)	Short term / On-going

Climate Change Energy Networks (Electricity and Gas) Adaptation Implementation Plan				
Action	**Deliverable**	**Lead Authority**	**Stakeholders**	**Timeframe**
8. Identification of areas vulnerable to impacts of climate change	Energy network companies to continue to identify vulnerable areas where assets are located	Planning authorities to ensure that utilities take account of climate change and its impacts on energy infrastructure, and hence on the economy, in how networks are planned, maintained and developed CRU to facilitate and enable, within the context of its existing regulatory remit, utilities taking account of climate change and its impacts on energy infrastructure, and hence on the economy, in how networks are planned, maintained and developed.	Energy network companies; SEM Committee	On-going
9. Identify measures required to adapt to climate change impacts on vulnerable	Monitoring Enhanced Maintenance Refurbish / Upgrade	CRU to facilitate and enable, within the context of its existing regulatory remit, utilities taking account of climate change and its impacts on	Energy network companies	On-going

Climate Change Energy Networks (Electricity and Gas) Adaptation Implementation Plan				
Action	**Deliverable**	**Lead Authority**	**Stakeholders**	**Timeframe**
infrastructure	Defences Relocate	energy infrastructure, and hence on the economy, in how networks are planned, maintained and developed		
10. Continue to develop and improve communications and information provision to users, and public awareness	Assess existing communications procedures; identify gaps and make recommendations as appropriate	Energy network companies with appropriate regulatory oversight from CRU and DCCAE to ensure utilities take account of climate change impacts on energy infrastructure and hence on the economy, in how networks are planned, maintained and developed	Energy network companies & SEAI	On-going

8. Conclusion

This first Adaptation Plan has examined the impacts of climate change and weather related events, both past and projected, on the energy networks (electricity and gas) sector. As these changes continue and if, as predicted, increase over the coming decades, the energy sector must prepare for, and adapt to, these new conditions. By identifying areas of vulnerability now, steps can be taken and measures put in place to avoid or minimise future adverse impacts within the sector and to exploit opportunities.

Ultimately this Adaptation Plan can be viewed as a first step towards reducing vulnerability and building resilience in the sector. It has been useful in stimulating discussion and thinking from the public and interested stakeholders on the very important area of climate change adaptation in the energy networks sector, a sector at the very centre of the commercial and social heart of the country.

The setting out of a high level policy for energy infrastructure in relation to climate change adaptation based on our current understanding of climate change and its consequences for Ireland, will be useful in informing future iterations of an Adaptation Plan under the Climate Action and Low Carbon Development Act, 2015 and the National Adaptation Framework (NAF) agreed in December 2017.