seai SUSTAINABLE ENERGY AUTHORITY OF IRELAND

SMARTGRID
Roadmap

Introduction to the Smart Grid Roadmap to 2050

Ireland faces the same long term energy challenges as the rest of the world: a need to move towards competitively priced, environmentally sustainable, low carbon energy sources; and an insecure supply of conventional fossil fuels on which we are now dependent.

A smart grid can help us address these challenges by maximising our use of indigenous low carbon renewable energy resources. A systems-based approach that optimises energy supply with demand for energy services and maximises our use of indigenous renewable electricity is central to ensuring Ireland meets its long term target of a secure and low carbon future.

While Ireland has plentiful wind and ocean energy resources that can produce low carbon electricity, they are variable in nature. Being an island nation with small amounts of interconnection to other electricity markets creates significant technical challenges to utilising these variable resources. However, if we can find ways of moving some of our electricity demand to periods when renewable supply is available, we will increase our ability to use our indigenous low carbon resource. This requires significantly increased information flow between producers, users, and system and infrastructure operators. The combination of systems, infrastructure, policies and technologies that enables a shift away from the traditional model of electricity supply following demand towards a model where demand follows the availability of low carbon, but variable, renewable supply can be collectively called the "smart grid".

Building on work done by the International Energy Agency, this roadmap explores how the smart gird can contribute towards increasing the amount of renewable energy on the electricity system, improving our energy supply security and meeting Ireland's long term emissions reduction targets. It was developed in conjunction with a roadmap for wind energy and electric vehicle deployment in Ireland, and consistent assumptions are used across the three. The roadmap has been developed with input and advice from a wide range of stakeholders and experts in the smart grid arena. It identifies a number of key steps required to achieve a smart grid scenario resulting in 13.4 million tonnes of CO_2 emission reduction by 2050. These include developing market structures and policies that encourage: increasing electrification of potentially flexible loads (residential and commercial space heating and cooling and water heating), demand side management, and deployment of technologies that provide greater system flexibility such as energy storage, distributed generation and load aggregators. This in turn will require equipment, control systems and communications networks to operate on harmonised protocols.

A number of key actions required are already in train. Communication systems between generation and networks and transmission system operators are already advanced and continuing to improve. The national smart meter rollout, scheduled to be completed by 2018, will enable real time monitoring of the system at the low voltage network level which will allow the participation in the market of distributed generation and virtual power plants. More importantly, it will allow electricity suppliers to offer pricing packages that provide customers with options and incentives to manage their electricity usage and costs. This increased level of customer participation is essential as it is this which creates the opportunity to shift electricity consumption to periods where variable renewable energy is available.

Ireland is well positioned to lead in the deployment of the smart grid. The key energy sector actors are already engaged and looking to benefit from the application of a smart grid. Many key ICT and energy equipment sector companies are looking to Ireland as a possible market in which to test smart grid products and concepts. Ireland has world leading research capacity in integrating large amounts of variable renewables into power systems. Now is the time to capitalise on this position, develop the expertise and technologies that will enable us to become world leaders, and develop an enterprise and innovation sector around smart infrastructure.

Finally, I want to thank the organisations, listed on the back cover, for their participation in steering the group that supported the development of this roadmap.

Prof. J Owen Lewis
Chief Executive, SEAI

Smart Grid Key Points

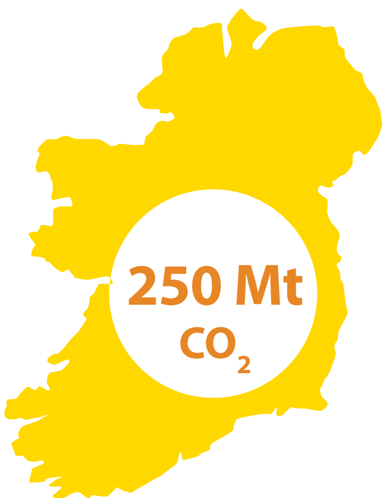
This roadmap explores how a smart grid can be operational in Ireland by 2050 and examines the contribution this will make to the decarbonisation of the electricity supply.

"A Smart Grid is an electricity network that can cost efficiently integrate the behaviour and actions of all users connected to it – generators, consumers and those that do both – in order to ensure an economically efficient, sustainable power system with low losses and high levels of quality and security of supply and safety."[1]

The smart grid is an electricity network which has advanced monitoring systems and two-way communication between generators and suppliers, and can intelligently balance the varying electricity demands of end users with the transport of electricity from all generation sources. In Ireland, these generation sources will seek to maximise our abundant natural resources and will therefore be dominated by the integration of wind generated electricity. The variability of wind requires the establishment of a system to match availability of supply with load so that the maximum amount of renewable electricity is utilised on the system at all times. A technical annex to this document, providing details on the analysis and assumptions included, will be available on the SEAI website.

Key Findings

By 2050, smart grids will see an accumulated reduction in energy related CO_2 emissions of 250 million tonnes.



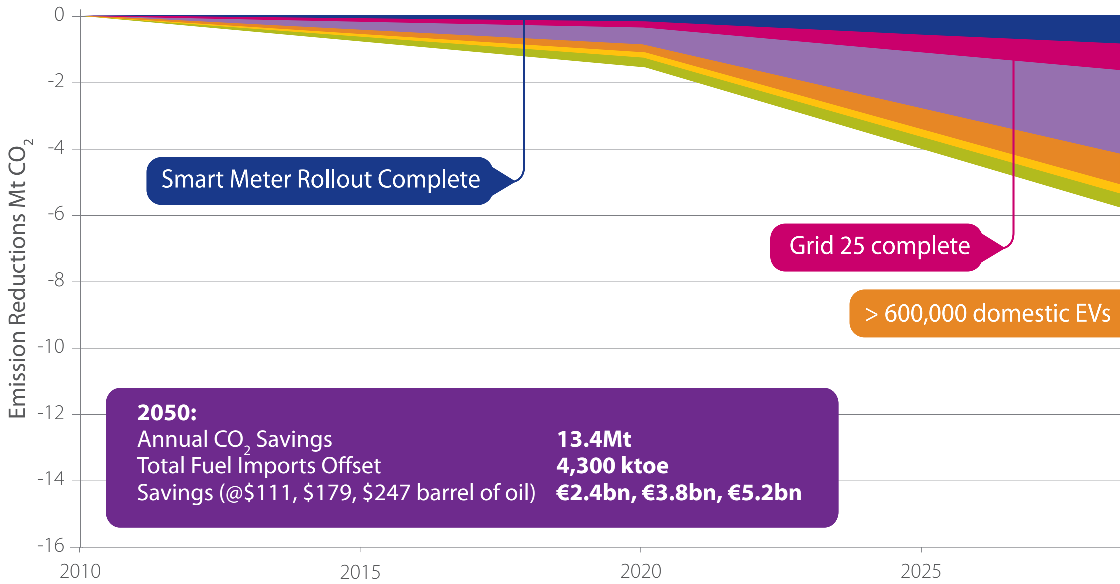
- Decarbonisation of electricity in the Irish system will result in annual savings of over 13 million tonnes of CO_2 by 2050. Eight million tonnes of this will be derived directly from the implementation of smart grid. A further five million tonnes will come from the displacement of fossil fuels due to the electrification of transport and thermal loads, facilitated by the smart grid
- Greater integration of indigenous renewable energy sources will see a net reduction in energy imports of over 4.3 Mtoe, [equating to savings of €2.4 - 5.2bn in direct fuel offset by 2050]
- Increasing the electrification of thermal loads in the residential and services sector will see an annual demand in this sector in excess of 28,000 GWh by 2050
- Electrification of transport, predominately in the domestic sector, will be expected to provide an annual demand close to 8,000 GWh by 2050
- Overall annual electrical final energy demand will be in excess of 48,000 GWh by 2050 with a corresponding peak demand of 9 GW. Onshore wind generation will be able to supply up to 33,000 GWh of the total demand
- By 2025 Ireland will have 1.4 GW of interconnection. Our analysis indicates that a further 1.6 GW of interconnection will be required by 2040
- More than 10,000 Irish jobs will be created by the implementation of smart grid infrastructure and its associated technologies

1. DEFINITION, EXPECTED SERVICES, FUNCTIONALITIES AND BENEFITS OF SMART GRIDS – European Smart Grid Taskforce: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=SEC:2011:0463:FIN:EN:PDF

Reduction in electricity related emissions vs. Base Case

2010 2020

- Peak and load shifting & DSM
- Reduced line losses, infrastructure improvements, volt / var management
- Integration of renewables
- Electrification of transport
- Electrification of heating, cooling, hot water
- Electrification of industrial heating / cooling loads



POLICY, FRAMEWORKS & SUPPORTS

- National rollout Smart Meters
- Building regulations reviewed to stimulate infrastructure for electrification of residential heat and EV cha
- Introduce appropriate incentives to encourage uptake of EVs and electrical residential
- CO_2 rating of buildings introduced
- Develop standard contract structures between aggregators and capacity providers
- Market development facilitating demand side participation including appropriate capacity payments and system serv
- Technical standardisation, regularisation of communication protocols
- Address privacy, ownership and security of customer usage information
- Tackle cyber security issues proactively through standards, regulation and best practice

INFRASTRUCTURE

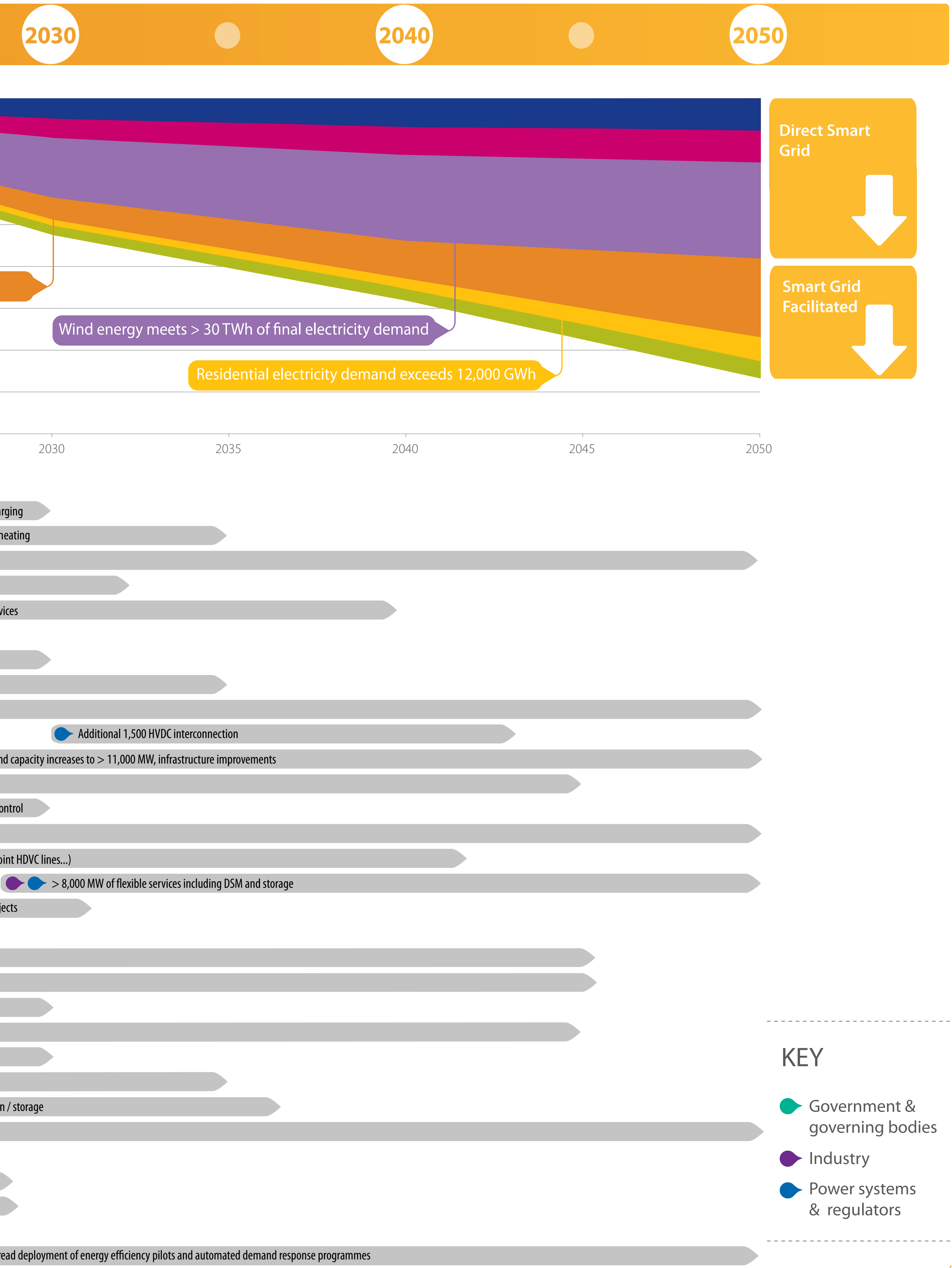
- Continuing Investment in Grid / Network communication systems
- Grid25 – 60% increase capacity, 1,400MW interconnection
- Installed Wi
- Enable market entry of "virtual power plants" and facilitate active participation from distributed generation
- Investment : Distribution Network visualisation and control systems
- Phasor Measurement Network, Volt/Var c
- Investment in generation from bioenergy, increasing contribution from ocean energy
- TSOs / DSO to investigate and incentivise appropriate system-wide stability mechanisms (storage, DSM, multip
- 1500 MW biomass, 800MW gas CCS capacity installed

TECHNOLOGY & RESEARCH

- Establish SG test bed facility
- Engage with large scale international R&D proj
- Training and upskilling programmes for smart grid workforce (engineers, electricians, scientists)
- Smart meters enable realtime CO_2 intensity monitoring of electricity
- Smart meters enable dynamic time of use tariffs, home/ office automation
- Small scale demand side management pilot trials, automated control
- Research projects: ICT, communications, monitoring, controls, international collaboration
- Commercial-scale, system wide demonstrations addressing key costs, security and sustainability
- Storage system pilots
- Research into Hydrogen productio

CUSTOMER ENGAGEMENT & POLICIES

- Customer engagement and education
- Address special consumer classes that may not easily benefit from smart grids
- Develop and demonstrate customer based enabling technologies
- Develop electricity usage tools and business models that incentivise consumers to respond to changes in electricity markets and regulation
- Standards and subsidies to encourage uptake of smart appliances
- Codify best practice on automated demand response and energy efficiency
- Encourage widespr



KEY

- Government & governing bodies
- Industry
- Power systems & regulators

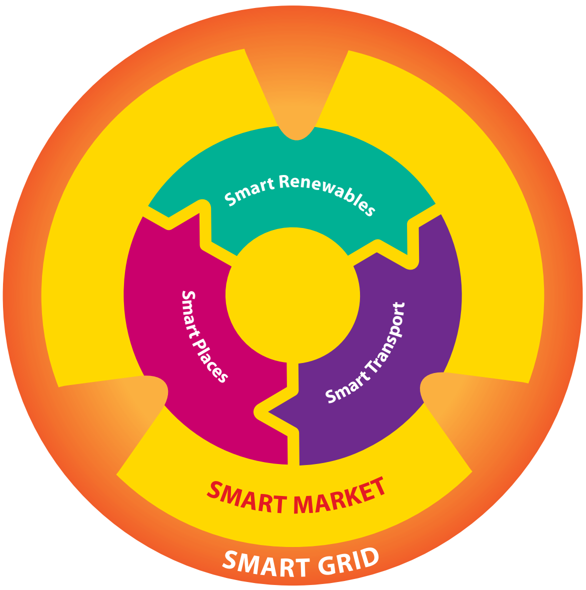
Matching demand to supply

By enabling demand response, load balancing, load shifting and reduction, the integration of electrical storage and the management of the import and export of electricity, the smart grid will enable large amounts of distributed generation and renewable wind electricity onto the system, thus improving security of supply. However, the asynchronous, variable nature of wind means that demand must be matched to meet supply. This will require putting strategies and mechanisms in place to shift, store or export excess generation in order to maximise the amount of total final energy that can be delivered from wind and other distributed generation sources.

Smart Grid

Smart Grid:
The smart grid provides the infrastructure, policy and market conditions that will efficiently and intelligently integrate the behaviour and actions of all users connected to it…

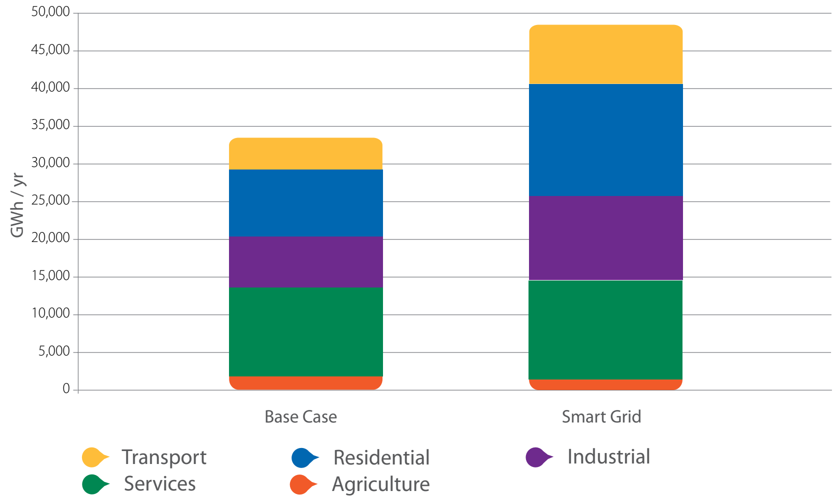
Smart Places:
Smart Meter enabled Automated Load Control / Smart Appliances / Demand Side Management / Variable Tariffs; Home Area Networks / Building Energy Management systems; EV charging; Renewable electrification of Space and Water Heating and Cooling systems; Renewable electrification of industrial heating and cooling process loads…



Smart Renewables:
Maximised renewable generation; Matching demand and load to wind availability; Enabling micro generation (CHP / PV); Enabling prosumers; Virtual Power Plants…

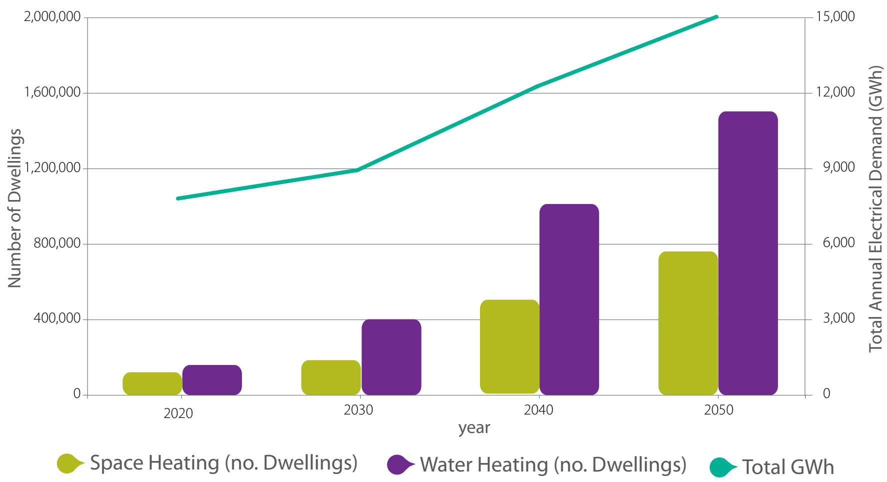
Smart Transport:
Smart Meter enabled electric vehicle (battery, plug-in hybrid) charging; Vehicle to Grid charging (V2G); Large scale electrification of transport…

Projection of Electrical Final Energy Demand (GWh)



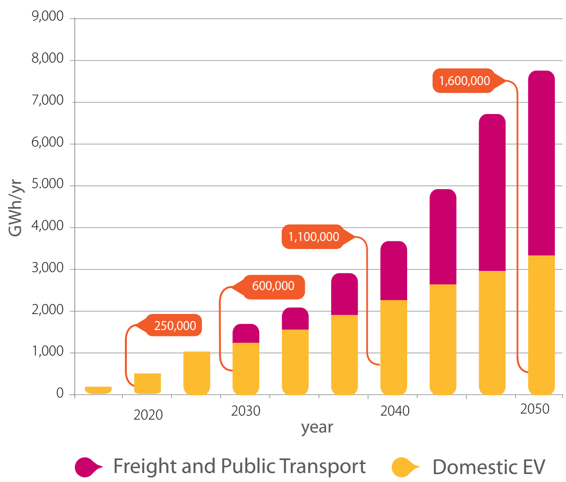
Increasing the electrification of thermal and transport loads, much of which can be shiftable and controllable, facilitates much greater quantities of variable supply (e.g. wind / ocean energy).

Electrification of Residential Heating

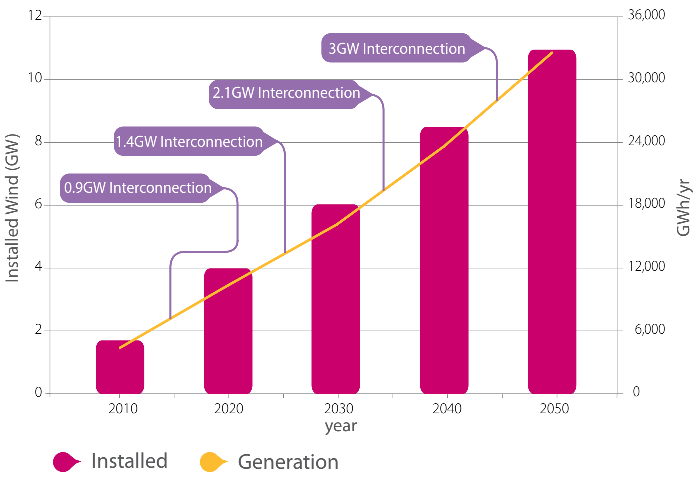


Automating and increasing the electrification of domestic space and hot water heating, coupled with the CO_2 monitoring of energy consumption, creates a flexible and supply responsive load maximising the penetration of renewable electricity.

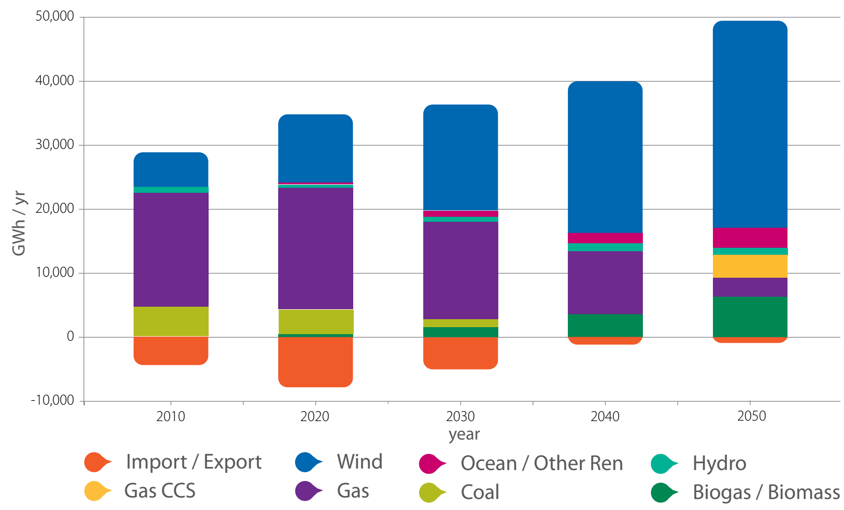
Electrification of Transport



Electricity from Onshore Wind

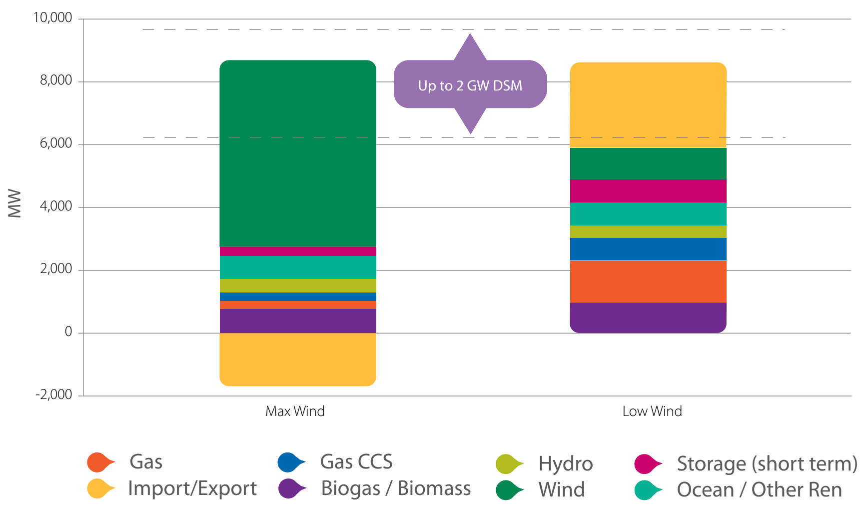


Generation Fuel Mix to meet Final Electrical Energy Demand (GWh)

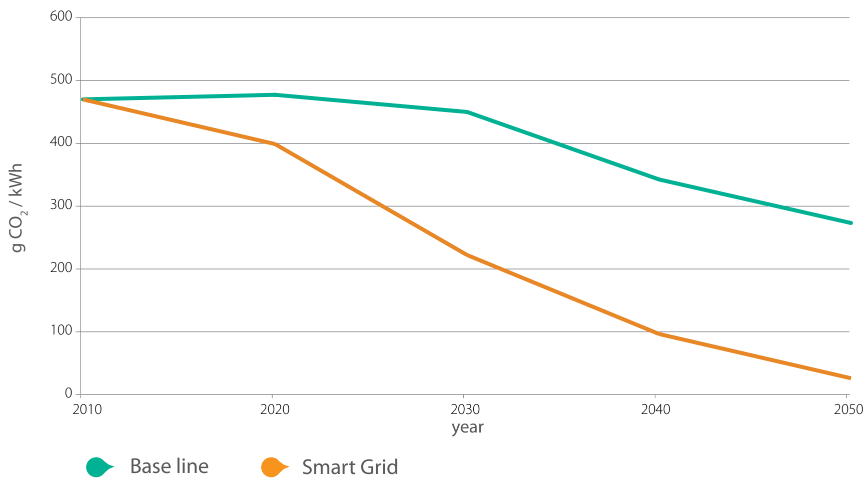


The projected final electrical demand will be around 48,300 GWh by 2050. Over 88% of this can be supplied from renewable sources.

Generational Mix at Peak Demand



Carbon Intensity - Generated Electricity g CO_2 / kWh



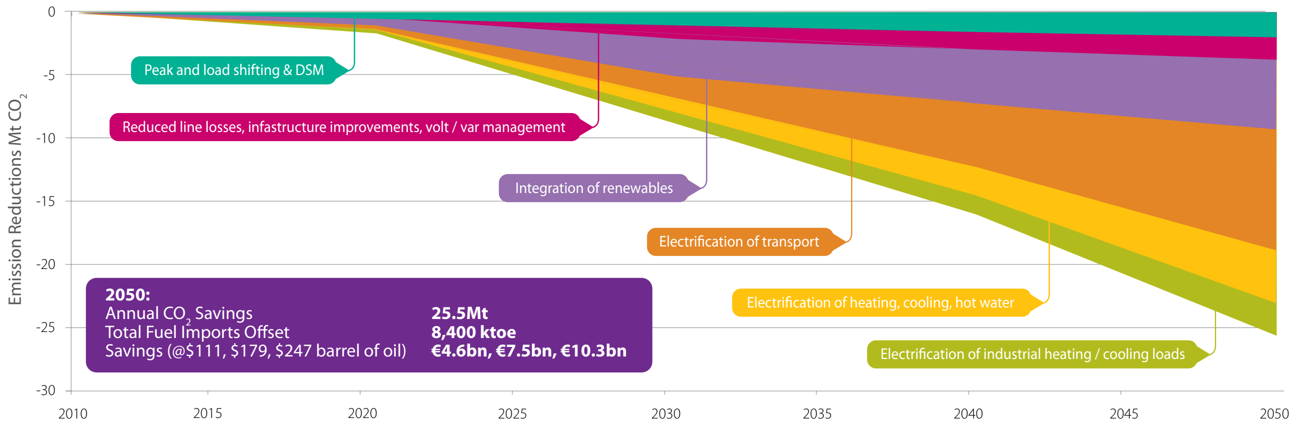
Requirements for the next 10 years:

- Establish a test bed facility, strengthening Ireland's position as a leader in smart grid technology research.
- Develop and deploy training courses in smart grid systems and technologies.
- Review of policies dealing with energy and CO_2 ratings of buildings to encourage electrification.
- National rollout of smart meters with DSM and variable ToU tariffs.
- Develop interoperability standards and secure communications and data protocols.
- Continue grid investment programmes, Grid-West, Grid 25.
- 'Develop an overlay of secure, high speed communications onto the electricity system.

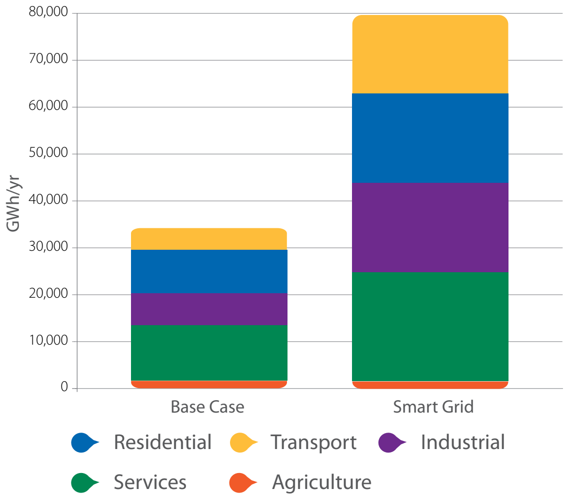
Smart Grid – the ambitious scenario

Predictions indicate that Ireland's total wind resource could generate up to 140,000 GWh by 2050 (see SEAI Wind Roadmap). More than a third of this could be consumed domestically by aggressively increasing demand in the transport sector and built environment. By electrifying up to 50% of the transport fleet and over 90% of building thermal loads, the annual electrical demand could be increased to 80,000 GWh. This would enable over 50,000 GWh of variable wind generation to be accommodated on the system. When added to increases in generation from ocean energy and biomass, nearly 65,000 GWh of this demand could be met by renewable resources. This would represent an annual reduction in CO_2 emissions of 25 million tonnes with a corresponding reduction in fuel exports of 8.5 Mtoe. In a medium price scenario where oil is at $179 / barrel this equates to savings of over €7.5 billion per year.

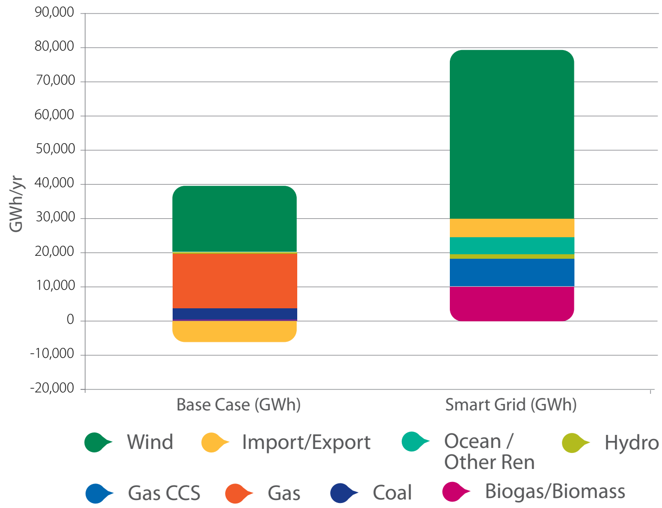
Reduction in Electricity Related Emissions Ambitious (Mt CO_2/year)



Projection of Electrical Final Energy Demand (GWh)



Generation Fuel Mix to meet Final Electrical Energy Demand (GWh)



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